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Proceedings of the International Conference on Sustainable Futures

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CIOB THE CHARTERED INSTITUTE OF BUILDING
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International Conference on Sustainable Futures
ICSF 2017
Kingdom of Bahrain

This proceedings is dedicated to Prof Waheeb Al-Khaja, Chairman of the Board of Trustees of Applied Science University, for his vision and tireless efforts in transforming the University.

International Conference on Sustainable Futures - ICSF 2017 Kingdom of Bahrain

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Preface

Sustainable futures issues are expected to be looked at in a very integrative and holistic way in addressing the three sustainability pillars namely technology, environment, and economics taking into consideration future studies and changes within the global context. A platform has been provided to discuss the most serious problems affecting sustainable futures in many countries in the world. Specialized researchers and practitioners shared their views and made their contributions in a range of subjects related to sustainable futures. Decision makers, researchers, and practitioners, interested in the subjects of sustainability, futurology, energy and scenario planning will need to integrate their efforts in order to provide state-of-the-art research findings for the benefit of academic institutions, government departments and private sector organizations on such topical and important areas. This conference provides an opportunity for researchers and practitioners to share best practices, develop and promote a network of experts who are passionate about the future and its sustainability.

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Introductory Paper

Citizens of Tomorrow: "A New Common Sense" Deploying Strategic Foresight to Promote Anticipatory Leadership

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Abstract

This paper advances the view that the trinity of challenges facing sustainable futures for the world's citizens of tomorrow, towards 2050, in the fields of Technology, Environment and Economics are largely threatened by a lack of proper leadership and enlightened education. Such guidance and instruction should be equipped and framed to guide communities along the perilous pathways of change towards preferred futures in a common sensical way that is widely understood, mostly accepted and generally put into practice. It does so by posing five crucial questions. Where do we want to be? Where are we now? Where are we going? What might happen? And, what must be done?

Given the scale, complexity and time-horizons involved, the paper concludes by proposing that the common thread weaving throughout the connected issues of Technology, Environment and Economics towards "Sustainability" is the fundamental aspiration of "Transforming Education" towards a more imaginative, systemic and foresightful mind-set supporting "Anticipatory Leadership" at all levels and across all sectors of humankind. A new common sense.

Keywords: Strategic Foresight, Leadership, Sustainability, Sustainable Futures, Technology, Environment, Economics, Education.

1. Prelude

Almost half a century ago, as a young academic in Oxford, I was privileged to attend a lecture, and later a lunch, with the man I now regard as being perhaps the only true 'genius' I have ever met. At the lecture he portrayed the Earth as a spaceship flying across the cosmos having a finite amount of resources with no chance of resupplies, and also spoke about "Anticipatory Leadership", to which we shall return. At the lunch, he left me with two thoughts that changed the way I viewed the world—then and now. First, he advised: "Everything affects everything else". And second, he suggested: "Small things can have large effects". Prosaic, yet profound. That was Buckminster Fuller. Ever since, I have proselytized the primacy of taking an holistic approach to the analysis of any issue that focusses on the way in which a system's constituent parts interact and interrelate, and how particular systems work over time within the framework of larger systems. Probably more than ever, indeed, I presently promote the study of complex problems, policies and projects through the disciplinary lens of systems dynamics.

In similar vein, following the familiar injunction of George Santayana (1906): "Those who cannot remember the past are condemned to repeat it", an innate sense of historicism has invariably led me to revisit and review the past before I explore and envisage the future on behalf of clients seeking a forward strategy. Foresight, thus, is dependent not just on insight, but also on hindsight. With this in mind, I remain somewhat sceptical when reading repeatedly that we live in: 'extraordinary'/ 'singular'/ 'fractured'/ 'revolutionary'/ 'disruptive'/ 'transformational'/ 'unprecedented' times. For looking back: agricultural, religious and industrial revolutions recreated societies; colonisation, urbanisation and globalisation processes have a centuries long heritage; and successive transportation, communication and medication advances have constantly changed the way we live and work. Learning, moreover, about Kondratiev's curves and 'supercycles', first described in 1925, and serially rediscovered ever since, personally convinced me, in the early 1970's, that there are macroeconomic waves affecting all sectors of society resulting in significant change across continents, countries, cities and communities. Many pundits proclaim, nonetheless, that the 'technological revolution' we

are embarked upon is unique. In that all such transformations are in some way 'sui generis', this might be true, but in others it seems that there is nothing new under the sun. (Where did I first hear that?—Oh yes! Ecclesiastes 1:9!).

Reflecting, consequently, on what lies ahead for humankind, we seem to be faced with two contrasting and conflicting convictions. The one, that of "prevailing pessimism", with doom-laden prognostications regarding climate change, demographic deficits, energy crises, crime and corruption contagions, food and water shortages and heightened troubles surrounding safety and security everywhere. And the other, pronouncing a "rational optimism", based on poverty reduction, increased life expectancy, raised literacy levels, female emancipation, lower child mortality, the spread of democracy, reduced violence, and generally much greater freedom, connection and equality. All too often, moreover, conditioned by current events and the findings of the moment, we project forward trends, customs and dispositions of the day to portray a chimera of tomorrow depending upon reigning moods and present mechanisms. Far less frequently do we imagine ahead to picture a preferred future of where we want to be, and then plan backwards to determine what it takes to get there.

There abounds a surfeit of seers rallying us towards a new dawn with such sobriquets as 'Grand Transformation', 'A Global Manifesto', 'Necessary Revolution', 'Great Transition', 'Deep Disruption' and '21st Century Enlightenment'. Contemplating yet another contribution to this graphic litany of longing, I unexpectedly came to the cheering conclusion that what we really and refreshingly required, above all else, was a "New Common Sense". Curiously recalling one of my favourite quotes, coined by Thomas Paine, that: "We have it in our power to begin the world all over again", I also suddenly realized that he, of course, had been there before, in 1776, with his celebrated pamphlet "Common Sense", whose opening paragraph fittingly ends with the sagacious sentence: "Time converts more than reason."

Sufficiently humbled, what follows is an attempt to identify the driving forces of change determining a preferred future for humankind, coupled with a 'cri de coeur' for developing, at all levels and across all sectors, the crucial kind of leadership endowed with those anticipatory skills and foresighting capabilities needed to navigate our way towards tomorrow (2050!).

2. Where do we want to be?

In the grand order of affairs, 2050 is not that far away. Colloquially, what was half a lifetime in the nineteenth century is fast becoming a third now, and though my generation will just about be gone, our grandchildren will still be contemplating marriage and the pursuit of family life. Many things in 2050 will be remarkably similar to how they are today. Others will have changed dramatically. What is most significant, however, is that the periods between early indicators of change, recognition of a trend and the impact of a full-blown transition are shorter than ever before, and consequently longer-term forecasting and prediction are becoming more convoluted and perilous. Greater global connectivity and sectoral interdependence, moreover, means that minor events can indeed have major consequences. Our world, in that well-worn phrase, is increasingly volatile, uncertain, complex and ambiguous, with a crazed kaleidoscope of critical, yet confused, dynamics diversely drawn from the domains of culture, politics, economics, technology and nature. Inevitably, we need to think long-term, exploring the possible futures that lie ahead and organizing ourselves for the threats, challenges and opportunities of the future. And yet, it is hard to make sense of tomorrow's tidings when today's turmoil is so profoundly perplexing. What then is our vision for 2050?

2.1 Utilizing Utopia

Candidly, I was going to dismiss the concept of Utopias in the context of real world perception and planning for a preferred future. The very term 'utopian' has become synonymous with impossible, fantastical or impractical aims and aspirations. However, contemplating the recent quincentary of Thomas More's fictional political philosophy, and the somewhat lesser 50th anniversary of my own professional career, I quickly came to realise the value of utopian thinking and the important part it plays in futures studies and strategic foresight. Looking back, for example, at the hundreds of scenarios I have orchestrated over the past few decades in many scores of foresight studies, I recognized the profusion of utopian ideals and ambitions that so evocatively brought them to life, provoking insightful debate among participants and

prompting decisive action by policy-makers. Perhaps, therefore, we should more proudly celebrate and reclaim 'Utopias' as an invaluable futures tool.
Here then are a dozen utopian yearnings randomly and indulgently drawn from various studies of tomorrow I have conducted over the years. It will be a world where:

1. We are moving more towards being defined by our values, our ethos and our social networks and milieu.
2. A significant shift is observed from conspicuous consumption to conscientious consumerism.
3. Growth is becoming defined by measures of sustainable wealth in its truest form, not purely economic productivity (GDP).
4. Movement is registered towards smaller, nimbler, sensitive and more localized systems of governance for many civic services, and away from big, unwieldy and inefficient command and control structures.
5. A new morality emerges across society based on community, responsibility, transparency, accountability and integrity.
6. A transition is witnessed throughout business from corporate social responsibility to collective responsible behaviour.
7. More financial models and agencies like Grameen Bank, Zopa, Kiva and other Rotating Savings and Credit Associations flourish.
8. The design and implementation of a new global financial architecture materializes, providing a framework for stability, certainty, legality, security, growth and development.
9. A fresh form of 'anticipatory leadership' surfaces at all levels, across all sectors, curious about the future and with the capacity to think systemically.
10. The notion of an 'inclusive economy' is embraced providing more opportunities and fairer rewards for more people.
11. Proper processes, places and protections are provided for mass migration.
12. The rationality of liberal humanism holds greater and greater sway over doctrinaire religious intolerance.

Well, we all have our dreams! More realistically, and mundanely, perhaps, in seeking a propitious pathway forwards for future generations we must always accept one major tenet – 'institutions matter'.

As Peter Senge (2008) sagaciously states:

"Today's world is shaped not by individuals alone, but by networks of businesses and governmental and non-governmental institutions that influence the products we make, the food we eat, the energy we use, and our responses to problems that arise from these systems."

To this, I would add that by 2050 'partnership' will be our watchword. In particular, we will have witnessed the successful maturing of 'public-private partnership' in providing a well-designed, highly efficient and properly balanced regulatory environment with a better allocation of risk, capacity and competence.

Above all, however, reverting to more Utopian, yet necessary, mood, 2050 will have seen a modern Metanoia. A new mind-set. For, ultimately, all real change is founded in fresh ways of thinking and perceiving. As Albert Einstein (1931) familiarly averred:

"The world as we have created it is a process of our thinking. It cannot be changed without changing our thinking."

Moreover (*ibid*), and favoured, as countless audiences of my own would confirm:

"Imagination is more than knowledge. For knowledge is limited, whereas imagination embraces the whole world, stimulating progress, giving birth to evolution."

To shape the future, therefore, we need to foster fundamental shifts of mind across communities of all kinds. Shifts from those who view the world as constrained and comprising merely of "things", to those who envisage a world that is unrestricted and consisting primarily of "relationships".

2.2 Global Goals

Probably the most well-known, and possibly the most gallant, attempt to guide and enhance human development was the United Nations 'Millennium Development Goals (MDG)' initiative. To remind ourselves, they targeted eight key areas – poverty, education, gender equality, child mortality, maternal health, disease, the environment and global partnership. Each goal was supported by more specific targets and indicators, and the programme had a time-frame of fifteen years from 2000 to 2015. Unsurprisingly, the results and reviews were mixed. On the one hand, the project was heralded as: "The most successful anti-poverty movement in history." On the other: "Despite many successes, the poorest and most vulnerable people are being left behind." Both statements emanating from the UN. Arguably, to an interested observer, given the short target time, the ambitious objectives and the turbulent economic climate, the initiative was a very considerable achievement. Difficulties regarding the justification of the chosen goals, the lack of analysis, problems of measurement and uneven progress were really only to be expected – as was the 'begrudgery' of certain beholders.

The MDG's, as we know, were replaced by the 'Sustainable Development Goals (SDG's)' in 2016. Officially entitled: "Transforming our world: the 2030 Agenda for Sustainable Development", it is a set of seventeen aspirational "Global Goals" with 169 targets between them. 'Aspirational' might be an understatement, as the aims include: ending poverty in all its forms everywhere; attaining zero hunger, food security and sustainable agriculture; achieving gender equality and empowering all women and girls; taking urgent action to combat climate change; conserving and sustainably using the oceans; and, ensuring healthy lives and wellbeing for all. Laudable enough in theory, but, in all likelihood, naively idealistic. Whilst governments might be demonstrating a worthy commitment, there is grave danger in the credibility and continuance of a plan that manifestly fails.

2.3 Global Governance

It has oft been stated that the 20th century was the era of international institutions. A clearing house for information on international institutions registered, in 1909, some 37 bodies, which, by the end of the century, had grown to more than 6,400. Many of us had forecast, somewhat sanguinely, that the 21st century would witness an inexorable movement towards world governance. A belief strengthened by the end of the Cold War, the multi-polarity of world affairs, greater connectivity and the rise of globalization. How wrong we were! The past couple of decades has been a period of disruption, disquiet and dilemma. More recently still, we have experienced heightened tribalism, retreat to the nation state, revolt against globalization, terrorist outrages, a resurgent Russia, frightening fundamentalist fanaticism, and even the partiality of 'post-truth'.

Global governance, of course, should be distinguished from global government. Indeed, the former can be defined as the management of global processes in the absence of the latter. 'Global governance' –which can be good, bad or indifferent – refers to concrete co-operative policy framing or problem solving arrangements, often under the auspices of a UN body or similar (e.g. IMF, World Bank, WHO, WTO).

Given the turbulence that presently besets the world, and the likelihood that the self-styled anti-globalization movement, in all its guises, will dominate the global scene for the next period of time (5-10 years?), then 2050 would seem a sensible time-line to edge towards effective global governance. For the nature of modern reality dictates that no agency, institution or power completely controls its own fate. Self-sufficiency is more of a mirage than ever. The requisites of daily existence, and the solutions to most of the challenges we face, require international co-operation. Whether it relates to investment, development, trade, taxation, crime, currency or communication; let alone climate change, mega-disaster, nuclear proliferation, pandemic or world peace, it is an age that increasingly demands global understanding, collaboration and ultimately governance.

Ironically, perhaps, the same forces and factions that resist globalization by political agencies and transnational corporations whom they characterize as 'ruling elites', harnessing the levers of power to serve their own interests, might just be the drivers, brokers and conduits for a different form of globalization throughout the next few decades to 2050. Instead of 'globalization from above', these revolutionary movements of social reaction and communal

transmission could actually be the means by which we create a collaborative and confederal world through 'globalization from below'. This is, after all, an age of contradiction!

2.4 Global Awareness

If I had to pick one word which could help guide us to where we want to be, it would be 'awareness'. Arguably, the first step toward change of any kind is awareness, and a necessary next step, both individually and collectively, for humankind to benefit from such an awakening, is 'acceptance'. Within the domain of awareness, moreover, I like to discern several other salient elements which contribute towards the task of shaping tomorrow in a form we favour. They are 'empathy', 'sentience' and, naturally for a futurist, 'foresight'.

'Empathy', at its simplest, is the key component of 'emotional intelligence' and describes an appreciation of the feelings of others. Daniel Goleman (1996) identifies five constituents of empathy – understanding others, developing others, having a service orientation, leveraging diversity and deploying political skills. These can readily be transmuted from the individual to the collective, so that we can match the new global reality that we face with a new global empathy that we need. Current connectivity and continuing convergence require that everyone's interests increasingly overlap with everyone else's. Whilst it would be foolish to imagine the collapse of self-interest and close affiliations, our sense of 'we' and 'they' will remorselessly mingle and merge into a more collective consciousness of 'us'. There is less and less room for 'ours' and 'theirs'. How long this takes, and in what manner, is a matter of considerable conjecture, but though we have begun to globalize our economies and our cultures, we have scarcely started to globalize ourselves.

Strongly related to empathy is the concept of 'sentience' and, for that matter, its sister trait of 'sensibility'. Sentience is the capacity to feel, perceive or experience subjectively, and is distinct from other aspects of the mind and consciousness such as creativity, intelligence, sapience, self-awareness and intentionality. The relevance of sentience in the context of shaping tomorrow's world is the looming epoch of the Artificial Intelligence (AI) Revolution where universal information is hierarchically ordered to create what is, ostensibly, consciousness, but with intelligence greater than every living human on the planet. Indeed, it is often claimed that success in creating AI will be the biggest event in human history, and if only half of what the 'techies' foretell comes to fruition, then the way we navigate our waking world into the future is about to undergo the biggest transformation that any single generation has ever experienced (*ibid*). But how subjective will it become?

For a futurist to unfold the potency of 'foresight' in just a few words is taxing. There are, moreover, many different forms and generations of foresight. Definitions also abound, but succinctly it has been described as follows (Slaughter 1999):

> "The ability to create and maintain a high-quality, coherent, and functional forward view and to use the insights arising in organizationally-useful ways."

3. Where are we now?

Addressing an EU Council audience just over 10 years ago, and considering "The World Today" at that time, I commenced by commenting that people around the globe were becoming healthier, wealthier, better educated, more peaceful, increasingly connected and living longer. At the same time, I observed that the world was more corrupt, congested, warmer, dangerous, divided and unemployed. Little, it seems, has changed, and one wonders whether a decade further on such a level of generality will still persist to describe the human condition?

In similar vein, probably the most authoritative agency researching and reporting on the key issues of the early 21st century is The Millennium Project with its annual "Global Challenges for Humanity" report, now in its twentieth year, where the hazards ahead concerning sustainable development and climate change, sufficiency of clean water, population growth, democratization, global foresight and decision-making, convergence of IT, gap between rich and poor, health concerns, education and learning, peace and conflict, status of women, organized crime, energy resources, science and technology and, global ethics remain remarkably little different, except in the detail, over two decades. The obvious question being – will it be very much different ten or even twenty years from now?

Reflectively, and dispassionately as possible, I would contend that humankind is actually undergoing a "grand transformation"; possibly the most profound inflexion point in history since the Enlightenment. We are not just living through an "age of change", but experiencing a "change of age". One which opened at around the turn of the century, and will conclude towards 2050. So we are about a third of the way through, with two thirds to come. In that time, the collective choices and actions of people, businesses, organisations and governments everywhere will define and shape global civilization for the many generations that follow. These are truly powerful times.

3.1 Disruptions and Dislocations

It has recently been argued, very convincingly, by the McKinsey Global Institute (2015) that humanity needs to reset its collective intuition as a result of a coterie of forces transforming the global economy and civic life. Their research identifies four disruptive forces that they predict will form a radically different world with a rewritten operating system. These are: an age of urbanisation; accelerating technological change; responding to the challenges of an ageing world; and, greater global connections. Any one of these disruptions, by itself, would likely rank among the most potent economic forces the world has ever seen. Taken together, they suggest, the product is a period of monumental change – "no ordinary disruption".

In like fashion, The Futures Academy, recognising over the past decade or so that something old is coming apart at the seams and something new is beginning to emerge, has identified five disruptive "force fields" that will transform the global scene. Unsurprisingly similar, they are governance, urbanisation, demography, technology and, connectivity; all explored through the lenses of culture, innovation, economy, environment and, political thought. Alongside these forces driving great disruption, however, we also identify a set of "major dislocations" which compound the complexity of the situation and confuse the ready devising of solutions. These dislocations can simply be listed as follows:

1. Between short and long-term thinking.
2. Amid public and private sectors.
3. Among and between professions.
4. Within the fields of teaching, research, consultancy and, practice.
5. In the space between strategy and decision-making.

Across the different communities of the world, and the various sectors of the global economy, there is an urgent imperative to adjust to fresh realities and construct new mind-sets to face the future being forged by these forces of disruption. But first we have to consider a few other factors, a trifle eclectically, to understand more fully where we are now.

3.2 A New Global Power Shift

Humankind has witnessed a number of monumental transitions when governmental power has switched from one great hub of transcending dominion to another. From Greece to Rome; thence to a concert of old European powers; across the Atlantic to the United States of America; and, for a while now, from West to East. There has even been talk, more recently, regarding the surreptitious globalization of power. Not so much through formal international organisations concerned with cooperation, regulation, accountability and the rule of law, but through evidently more suspicious and seemingly immune vehicles of influence and control such as the internet, satellite broadcasters and money changers, where people appear to act in a global space relatively free of constraint. Power, therefore, has not just been shifting laterally from nation to nation, it has also been moving vertically from sphere to sphere. Now, we talk again of balance with a return to 'great power competition'.

History tells us that where power goes governance must follow, so one of the challenges we face at the moment is to bring governance to the global space – vertically as well as laterally – and to do it with large measures of common sense.

3.3 Triumphant Tribalism

With the divisive confrontations of Brexit and Trump raging around us; but with the portentous shadow of populist protest and the rise of 'outsiders' looming larger and darker ahead; the tortuous tribulations of the Middle East ever lengthening and enlarging; and the unpredictable

transition of power in China; perhaps it is propitious to ponder how best we might understand these discordant passions and their disruptive repercussions.

To begin with, the deep divisions fracturing societies cannot be simply a matter of political or religious disagreement. Good people everywhere have always differed about politics and religion. It is more basic than that -- it is 'tribal'. Whether it is our kin, our community, our company, our city or our country, we are all, at heart, tribal. Such inherent tribalism has helped us combine, collaborate, compete, govern, and evolve – but, most of all, of course, survive. It does, however, give rise to eternal conflict, and, through the historic passage of time, inevitably erupts into bitter hostility and savage struggle. Now seems to be an especially significant period of dissonance and disruption. Why – I wonder?

First, and perhaps foremost, we have to accept and understand the cultural schisms caused by difference and diversity. These distinctions most notably manifest themselves in issues surrounding 'migration'. Diversity and variance unquestionably engender huge benefits in terms of creativity, innovation, growth and progress. Arguably, no great civilization, society or city has prospered without immigration. Nevertheless, on the other side of the coin, ethnic diversity and mass migration reduce social capital and erode human trust. The more people are the same, the more they trust each other and are willing to share through public redistribution of wealth and access to opportunity. Scandinavia, with its civic minded sentiment, progressive welfare states and liberal attitude towards world affairs has long been heralded an exemplar. Even Scandinavian enlightenment, however, is likely to be sorely tested over the next few years as their erstwhile homogeneity is diluted and their social capital cut.

Second, aligned to the notion of tribalism is the precept that intuition overrides reason. I think the moral psychologists call it "confirmation bias". This is the tendency to search for, interpret, favour and recall information in a way that supports and confirms one's own pre-existing beliefs while downplaying alternative views and possibilities. We are pretty good at challenging other people's opinions, but if it is our own belief system in dispute, we are naturally very adept at protecting it, even in the face of strong contrary evidence. Being immersed in the world of strategy and policy formulation, I am only too well aware, in my more sceptical moments that moral thinking is closer to a politician searching for votes than a scientist searching for truth.

Third, to compound the current and continuing clash of cultures is the escalating connectivity afforded by the Internet. An easy commonplace, no doubt, to blame the Internet for disinformation, distortion and demonization, but we are only just beginning the battle between freedom of communication and selective censorship of the medium. Whilst we can all abhor some of the fanatical racist, sexist and downright xenophobic material that abounds in cyberspace, I, for one, worry about knowing what might be censored; for surely, we face the very real threat of a future where software surreptitiously deletes our thoughts, views and voices.

Nonetheless, wherever we think we are, we need to take hold of our future, or it will take hold of us.

4. Where are we going?

Nobody, of course, knows. Last year's (2016) 'shenanigans' clearly confirmed the perils of political prediction in the same way that the financial crash of 2008 verified the failure of economic forecasting, and many of the grand promises of the much vaunted technological revolution are already broken (Albrecht, 2014). Nevertheless, it is not only imperative that we explore what lies before us , it is inherently ingrained, even if it tells us more about our own times and current concerns than it does about the future.

More important than accurately predicting particular events, however, as I learned myself from 'war-gaming' in the early 1960's, is being aware of all possible outcomes, the risks and rewards attached to each, and then the preparation of a suitable frame of mind and proper response to every one of them. Indeed, as an aside, anyone involved in strategic thinking and anticipatory leadership would do well to refer, or re-visit, Carl von Clausewitz's treatise **On War**, (1832), despite it being rooted in a world of the nation state.

Of one thing we can be certain, however, that there will always be more surprises. Most of them we can anticipate and take care of, even whilst we cannot know the consequences in advance, but, trite though it sounds, we must constantly monitor and study the driving forces of change that affect us.

4.1 Why Foresight?

Leading any organisation or agency, (or even oneself!), in the 21st century is complex and challenging. Can we contend with 'disruption' in an age of increasing urbanisation, accelerating technology, ageing population and growing connection? Are we prepared for 'convergence', imagining for a moment that such fears as the disintegration of the Euro, a global pandemic far worse than Ebola or SAR's, the dramatic slowing of the North Atlantic Drift (Gulf Stream), or the assassination of a world leader by an extremist group, not just happened, but actually coincided?

What, on top of ideological intolerance, migratory flows and regional disparity, will be the new landscape of global conflict – water, energy, the Arctic, sea trading routes, the riches of the earth, or the breakdown of law and order in the inner cities – and how will we cope? Is capitalism itself at the crossroads – witnessing the end of 'mercenary' capitalism and the dawn of a new age of sustainable, stakeholder based capitalism? Can the world be governed by means of multilateralism and the pursuit of a new politics? Would 'localization' be the answer – customising legal, economic and political frameworks and decision-making powers more towards local and regional social cultures and geographic locales? And, above all, can we develop a set of shared values for the future? These and a host of other doubts and dilemmas beset us. Swamped by uncertainty, constrained by short-term orientations, impoverished through lack of an integrated approach, impeded by the obsolescence of 'predict-and-provide' models and limited by inadequate collaboration of stakeholders, we need a methodology to help. For me, unsurprisingly, that methodology is 'strategic foresight'.

The purposes and practices of foresight are well documented elsewhere in a growing literature far too long to list, and fairly familiar to those concerned. Like many other practitioners I devised my own variation of the Foresight Process around a settled theme inescapably common to all. Unashamedly though, I now adopt the approach advocated by Andy Hines and Peter Bishop in **Thinking About the Future: Guidelines for Strategic Foresight**, (2015), which I wholeheartedly commend and portray below.

Table 1 Strategic Foresight.

STAGE	OBJECTIVES	OUTPUT
Framing	Scoping the project: attitude, audience, work environment, rationale and purpose, objectives and teams.	Focal Issue
Scanning	Collecting the information: the system, history and context of the issue and how to scan for information regarding the future of issue.	Information
Forecasting	Describing baseline and alternative futures: drivers and uncertainties, tools, diverging and converging approaches, and alternatives.	Baseline and Alternative Futures
Visioning	Choosing a preferred future: implications of the forecast, and envisioning desired outcomes.	Preferred Future
Planning	Organising to achieve the vision: strategy, options and plans.	Strategy and Plans
Acting	Implementing the plan: communicating the results, developing action agenda and institutionalising strategic thinking and intelligence systems.	Action

In any foresight exercise, and assaying where we are going, trends materially matter, and the stage in the foresighting process – 'Horizon Scanning' –is worthy of special mention. Indeed, individually it is part of our very psyche, and collectively should be a capability formally structured within any organisation worth its salt. Generally, it can be defined as discovering, examining and translating global thinking, information and research into insights for risk, strategy, innovation and policy processes. More particularly it comprises:

- Looking ahead – beyond usual timescales.
- Looking across – beyond usual sources.
- Gazing beyond a single 'expected' future to a range of alternative 'possible futures'
- Considering implications for today's decisions.

- Promoting 'resilience' and 'adaptability' in strategy.

Recognising that events do not always move in tidy, linear or gradual ways, Strategic Foresight is progressively being used in a wide realm of endeavours, from policy formation, change management, risk appraisal, threat identification and programme prioritisation, to decision-making, innovation research, enterprise development and my own bailiwick of city planning and development. All too often, however, it is performed on a one-off basis, whilst its real value is as a continuous, habitual process that becomes the nervous system, spirit and intelligence of an organisation.

4.2 Harbingers of Change

In almost 25 years of conducting formal strategic foresight studies, several clear auguries seem repeatedly to herald the transfiguration of our time for me. Furnishing a form of future backcloth for human development they can be characterised as follows.

- **A Confluence of Powerful Trends**: huge, extraordinary universal trends, any one of which could impact upon our present way of life are coming together.
- **Problems Seem Increasingly Intractable**: all taxing the capacity and competence of bureaucracies and administrations which seem incapable of collaborative thinking and action.
- **The Demographics of Discord**: populations across the world are growing, declining, ageing and moving – all at the same time.
- **The 'New Players'**: the relative political and economic clout of many countries, cities, corporations and communities will shift over the next few decades. Yesterday it was BRICS, today it is ISIS and populism, tomorrow it could well be 'the crowd', 'the corporation' and 'smart cities'.
- **The Predicaments Are Structural**: they are deeply systemic, and constantly producing a complex set of interrelated situations not capable of ready understanding or solution.

Likewise, scores and scores of our scenarios reflect a perplexing mixture of 'prevailing pessimism' on the one hand and 'rational optimism' on the other. On the gloomy side there are questions regarding:

- The carrying capacity of the earth, with the planet's population forecast to reach 10 billion by 2050.
- Overwhelming evidence of global warming with much discussion about mitigation and amelioration, but little about adaptation.
- Demand for food and water exceeding supply, with the need for agricultural produce increasing by up to 85% by 2050 and the call for fresh water up by anything from 35% to 85%.
- Safety and security considerations predominating, with fear and violence permeating the globe, and terrorism likely to become the hallmark of the century, along with organised crime becoming one of the biggest growth industries.
- An energy deficit looms large in most participants' perception, (though not mine!), with demand predicted to rise by at least 50% by 2050.

On the cheerier side, resisting the rhetoric of: "We're all doomed!" - the following hopes and aspirations are voiced:

- An urban prospect where informal settlements, chaotic to the planner yet organic to the ecologist, are seen as catalysts of innovation and income generation; producing economies of agglomeration, productivity of connections, minimisation of energy consumption, maximisation of density and optimisation of proximity. Slums, indeed, are "green"!
- Developing technologies of all kinds – cyber, bio, nano, info and geo – where the present hysteria and hyperbole surrounding such issues as 'GM' food subside and the potential of geoengineering emerges.
- A 'natural step' towards enlightened local leadership is taken with the more widespread adoption of the concept of eco-villages, towns and cities, all embracing 'asset-based community development' ideals.
- A 'new economy', internalising the externalities, to produce a form of 'natural capitalism' focusing on resource productivity, not human, arises.

- Renewable energy, including 'new nuclear', as well as solar, wind and wave, becomes the predominant source of power.

What most of our foresight work through scenario thinking tells us is that while the remaining first half of the 21st century will be an extraordinary time, a period of extremes perhaps, there are solutions to most problems, but the longer they are delayed the worse the situation will become. A common sense approach towards such matters as: education, equality, participation, time, work, tax, privacy, pay, shelter and quality of life could produce a set of shared values for the future.

4.3 Five Crucibles of Transition

Not long ago, The Futures Academy conducted a worldwide exercise called "Just Imagine!" for the Royal Institution of Chartered Surveyors to explore their global ambition. From it, we identified five 'crucibles of transition' which help understand how the world's economy might be restructured over the years to 2050. Organisations that understand them will most likely have the best chance of shaping it. Those that don't, do so at their peril. Put very simply, they are characterised by their 'crucible' headings below.

4.3.1 Financial Markets and a New Economics

(On the cusp of the next industrial revolution)

- An age of sustainable living in a resource constrained world.
- The further 'depletion of the West' with a 'great rebalancing' from West to East to continue for the foreseeable future.
- From an energy to an information economy, with a technological infrastructure to support and promote new viable business models.
- The restoration of trust; in governments, banks, corporations, news agencies and institutions of all kinds, together with a better understanding of reputational risk.
- The advent of 'behavioural economics', once almost heretical, now promising a journey to the mainstream through socionomics, neuronomics, natural capitalism and even reflexivity.

4.3.2 Global Governance and Social Disparity

(The great 21st century paradox – as the world grows together, it also grows apart)

- Addressing the widening gap between rich and poor, drawing, perhaps, on some of the ideas of the 'Bottom of the Pyramid' school of thought.
- Strengthening the capacity and quality of global infrastructure, given the $70 trillion deficiency across the developed and developing worlds.
- Responding to the conditions of a 'multi-polar' world and the increasingly decentred nature of decision-making.
- Combating the illegal economy, where illicit trade and organised crime are estimated to account for almost 10% of the global economy, and surreptitious corruption erodes steadfast structures of governance.
- Regulating the world's supply of capital, with demand set steadily to exceed supply over the next few decades.

4.3.3 Planetary Stewardship in an Age of Scarcity

(Five familiar and recurring themes)

- The worsening of climate change toward dangerous levels of global warming, and the threatening onset of tipping-points and thresholds.
- The process of urbanisation as a defining feature of the first half of the 20th century with the associated challenges of planning and managing of more and more mega-cities.
- Energy deficits loom as demand escalates and the clamour for sustainable sources of power intensifies.

- A food system in crisis, necessitating the shift in Europe from a 'precautionary' to a 'cautionary' stance regarding GM produce.
- Water scarcity, with water tables falling, and the wet areas of the earth getting wetter as the dry areas get drier; alongside the outbreak of a succession of 'water wars'.

4.3.4 Creative Cities with Connected Communities

(City building surfaces as the ultimate expression of mankind's ingenuity)

- Quality of life becomes paramount, with an accent on 'place-making' offering social cohesion, authenticity and distinctiveness.
- Competitiveness through 'creativity' is a clarion call.
- A shared vision based on such values as utility, security, order and beauty is formed, and a common identity capitalising upon cultural, social economic, physical and historic strengths forged.
- Connectivity – in every way – blossoms; giving actuality and achievement to the 'smart city' notion.
- Effective civic leaders and leadership flower – articulating a vision, harnessing the power of new ideas and mobilising municipal energy to engender a fresh spirit of collaborative democracy.

4.3.5 Productivity, Partnership and People

(Sometimes the world seems upside-down, inside-out, counterintuitive and confusing)

- Boosting productivity and promoting innovation by leading and managing 'clever' people fruitfully and feelingly succeeds.
- Balancing the role of the state and market capitalism – the one providing a reliable regulatory framework within which the other can efficiently flourish.
- Promoting public-private-partnership beyond the present procurement based process towards a new and rich diversity of equitably based models of shared risk and responsibility.
- Global companies working within and across multiple regulatory environments with greater social corporate behaviour.
- Localism and a strengthened community based democracy as a fresh force in town.

The thoughts above, of course, simply scratch the surface. They are assembled eclectically, if not idiosyncratically. And for every driver, harbinger, trend or transition there is a counterpart. We live in a pluralistic, multi-track and counter-intuitive world. Nevertheless, the more we can all strive to understand where we want to go, the general direction of travel, the terrain we must cross and the highway code to be respected, in a more concerted, co-operative and constructive manner than presently promises to be the case, the better!

5. What could happen?

My bookshelves proverbially groan with a profusion of prognostic publications about the future, and the foregoing text has touched on a plenitude of possibilities that might play out. To place my own partial observations of what might happen to humanity towards 2050 into a more universal context, however, mention must initially be made of the 'existential risk', the threat to the future of humankind itself, we all fatefully face. Having survived such time-honoured 'natural' existential risks as asteroid strike, gamma-ray bursts or super-volcanic eruption for several hundred thousand years the likelihood of extinction due to these kinds of risk is extremely small over the next 50 to 100 years. Probably the biggest existential risks ahead are 'anthropogenic', related, thereby, to human activity in general, (since 1946, nuclear holocaust, for example), and more recently to the potential of advanced technology and the prospects of artificial intelligence (AI) in particular. The moral case, indeed, can be made out that existential risk reduction is strictly more important than any other global good or goal (Bostram, 2013).

Nevertheless, in the context of consistently scanning the horizon at The Futures Academy, and resulting from my own personal reflections upon the forces of change driving us toward 2050, two fundamental fault-lines materialise in my mind. The one, a longer-term 'Singularity',

much proclaimed and prospected. The other, a 'Seismic Shock', much sooner to befall, and with much less certainty or consensus attached to it.

5.1 The 'Singularity'

Encountering Ray Kurzweil at a World Futures Society Conference around the Millennium first introduced me to the concept of the 'Singularity', (where a variable becomes infinite, and normal rules break down), describing his law of accelerating returns which predicts an exponential increase in technologies from the fields of computing, robotics, genetics, nanotechnology and artificial intelligence. This, he maintained at the time, would lead to a 'technological singularity' by the year 2045, when we reach a tipping-point where progress is so rapid it outstrips the ability of humans to understand it, and machine intelligence will be more powerful than all combined human intelligence. Initially, I placed his prophesy in the realms of science fiction or distant times. But, year by year, ever since, I have progressively been persuaded roughly to his viewpoint, and consequently shortened my own time-horizon accordingly.

In the setting of this tract, the singularity caused by the rocketing rise of artificial intelligence (AI), to a new age of 'superintelligence', relates to the nature of work and the impact on employment. Neatly, though somewhat spuriously, the jobs of the future do not exist today, and the jobs of today will not exist in the future. And, as we are all aware, there has been a veritable paroxysm of publications prophesying: 'the end of work', 'the death of capitalism', 'the age of the machine', 'the rise of the robots', 'the coming convergence', 'connexity', 'technology v. humanity', and the like. Also a fresh lexicon along such lines as: digitization, mobilization, screenification, disintermediation, datafication, cognification, virtualization, robotization, de-humanisation, and so forth, used to describe the puzzling revolutionary forces at play.

In more everyday parlance, however, we are all only too aware that changing attitudes, living patterns and personal expectations, as well as ingenious technologies, are transforming our relationship with work in such fundamental ways, that the workplace of 2050 will be barely recognisable. In unsentimental terms, it is a silent and surreptitious revolution in social behaviour that requires careful understanding and some simple, commonsensical solutions to be set in train as soon as possible.

Nevertheless, we do face something of a watershed. Various studies predict that the automation of work through the advent of AI will displace anything from 25% to 50% of existing jobs. Call it a third! Not just from the 'factory floor' and 'service industry', or the middle-class 'beadledoms', but amongst the professional 'elites'. Conversely, there are those who convincingly contend that the prospects of disruptive technological unemployment are akin to revivalists of the 'Luddite Fallacy'. They maintain that: humans are complemented and enhanced by machines; automation increases productivity and general wealth, consumption, effective demand and consequently more jobs; humans are creative, will be better at 'ideas' for some time to come; can think laterally 'out-of-the-box'; and, there are many jobs awaiting workers that have not yet been discovered. All that defeatist stuff about 'robots', they state, is nothing but a distraction. You cannot exceed human intelligence, ever, it is argued, though you might asymptotically approach it.

Work, therefore, is here to stay; whilst there is little doubt that the nature, duration and rewards will alter. We have, however, the time to prepare, plan and adjust to a new world of 'occupation', saving us from those three great evils voiced by Voltaire – boredom, vice and need. Ideally, there should be somewhere higher up the value chain, or elsewhere in the creative milieu, to go. And, as automation takes over our jobs, we need to decide how we value and reward creativity, innovation, art, and social contributions to the welfare of society.

5.2 A 'Seismic Shock'

Currently, I am experiencing a strong sense of 'déjà vu' – all over again! Having first been badly burnt by the property collapse caused by the secondary banking crisis of 1973, I was then living in Ireland in 2006 when I began to feel 'in my bones' that all was not well with the financial architecture of the world. This was reinforced by a prescient paper produced by the Economist Intelligence Unit at the time which introduced me to the troubled territory of sub-prime, credit default swaps, derivatives and collateralized debt obligations. Subsequently, I then spent a couple of years on the international conference circuit proclaiming: "Get out of real estate!"

Fortuitously, for once, I heeded my own advice, selling my house in Dublin in 2007. Redolently, I am getting that feeling again – only more so. This time, however, I fear the problems run deeper, stronger, and potentially longer.

My sense, not so uncommon, is that there will be a 'seismic shock' reverberating around the world in the near future, and a global economic recession. If not in the next couple of years, then sometime before 2025. In doing so, I am conscious that it is always possible to concoct a crisis from a selective sampling of factors and situations. Mix, for example, an assortment of ingredients picked from the following: overwhelming global bank debt; stock market bubbles bursting; central bankers running out of options; implosion of the Euro; China's economy in turmoil; turbulence of Trump; the EU disintegrates; Russian Federation in fragments post-Putin; Eurosceptic Germany; a fragile France veers sharply to the right; new isolationist chauvinism enthrals the great powers; terrorist outrages multiply; migratory movements surge; populist politics predominates – the list of imagined horror could continue. Equally, I accept, one could conjure-up a contrasting counterfactual foretelling peace, prosperity, happiness and freedom among and within all nations and people.

In accepting the lack of concrete evidence for my own prophesy, I can only plead the power of 'foresight' and a singular lack of 'confidence' in leaderships across the world, deficient, as they are, in the systemic thinking and anticipatory mind-set so necessary to address future uncertainty and guide us through the change that lies ahead. But then, of course, I would!

More positively, however, it is commonly accepted that real change of a profound and lasting nature only occurs through crisis, and is invariably preceded by chaos. So an economic 'seismic shock' over the next few years could be precisely the opportunity and stimulus required to make the fundamental reforms to our social and political, as well as our economic, systems, so essential for humanity towards 2050. If, that is, we have the collective common sense to comprehend and grasp it.

6. What must be done?

The period of effortless prosperity, relative peace and environmental awareness experienced over the past 50 years is seemingly past. Most pundits agree that global economic growth will slow by almost half, the world's ageing population grow by another 2.3 billion, and our planetary environment face a few perilous tipping-points. At the same time, the clash of civilizations, the greater scarcity of resources, and the fragility of complex systems, conspire to create a new landscape of global conflict. Terror, error and environmental disaster menace humankind.

As a young man in the 1960's, I placed great hope and trust in the promise of the United Nations, lauding their incontestable objectives of: maintaining international peace and security; promoting human rights; fostering social and economic development; protecting the environment; and, providing humanitarian aid in cases of famine, natural disaster, and armed conflict. Securing, above all, a strong shift from a unilateral to a multilateral world. Undeniably, it has accomplished a great deal, and helped the world become a more hospitable place to live, but it has never truly fulfilled the desires of its founders. Critics, indeed, have frequently accused the UN of bureaucratic inefficiency, waste and corruption; and few believe that any meaningful reform will materialize over the next few decades.

In predicting a 'seismic shock', quite soon, where the flawed social, economic, political, environmental and technological systems of the world converge to produce a massive malfunction and serious recession, I also diagnosed this imminent disruption as offering a singular opportunity to fix these systems. Otherwise, being too used to running things in sightless straight lines, we could remain trapped in the dogmatic thinking of yesterday, and too attached to the ideologies, policies, plans, programmes and practices of the present. We have, however, everything before us if we wish, so long as those who lead us through disruption towards a transformation of the framework and structures that shape the future and determine the condition of humankind face-up to the fundamental challenge of 'changing minds' – including their own!

6.1 Promoting Anticipatory Leadership

Lack of leadership figures third in the top ten issues identified by the World Economic Forum as having the biggest impact on the world, after deepening income inequality, and persistent jobless growth. Predictably, perhaps, I would place it top – by a mile!

Whilst diverse definitions of leadership and leaders abound, quintessentially, to my mind, leadership is about anticipating the future, and all leaders have to be futurists. People will only follow leaders when they believe in their vision of a better future. And yet, so little in the literature or the learning relating to leaders and leadership looks to the concepts, methods and techniques of 'futures studies' or its prime methodology 'strategic foresight'. To redress this manifest omission, I have been proselytizing my own concept of 'Anticipatory Leadership' over the past few years by developing "five linked literacies" that connect anticipation and enlightened leadership with strategic foresight and futures thinking. Put very simply, they are (Ratcliffe & Ratcliffe, 2015):

1. **Awareness.** Linking "emotional intelligence" with "framing, horizons and scanning".
2. **Authenticity.** Linking "centred leadership" with "weak signals, ethnographic frameworks and strategic conversations".
3. **Audacity.** Linking "visioning" with "prospective and preferred futures".
4. **Adaptability.** Linking "adaptive organisational learning" with "scenario thinking and planning".
5. **Action.** Linking "unified action, responsibility and resilience" with "foresight intelligence systems, connected communities and continuing conversations".

Linking these literacies to perceive and portray a preferred future also enables everyone responsible for leadership, even at the personal level, better to comprehend and control the systems at play in any situation, as well as conceive and manipulate the networks operating within and between them. With the added ingredients of 'empathy' and 'mood' mentioned earlier, it will also help them nurture a rapport with that supreme sense, common to everything human, of 'emotion'. Emotions, invariably, are more significant than events.

6.2 Deploying Strategic Foresight

Ever since I was introduced to the concept of 'futures thinking' by reading Peter Swartz's (1991) magisterial **Art of the Long View** in the early 1990's, and inducted to realms of 'Strategic Foresight' by meeting Richard Slaughter a little later, I have wondered why the doctrine has not spread farther, wider and deeper than it has. It is so much common sense. Rather like the prose of Moliere's 'Bourgeois Gentilhomme', I was surprised and delighted to learn that I had been speaking 'prospective' all my life without knowing it.

Foresight, as we know, is the art of anticipating what might happen next, and strategy the skill of preparing to do something about it. The preferred process has been outlined earlier, and the challenge of embedding futures thinking into organisations, its purpose, participants, procedures, implementation and techniques, one many of us have faced over the years. (Where would we be without it?). There are, however, a few thoughts worth sharing from the experiences of The Futures Academy over that time in terms of: 'what must be done'? We have found the five most important elements of a successful Strategic Foresight exercise to be:

- Continuous environmental scanning.
- Linking strategy to outcomes.
- Invocation of crisis.
- Commitment of leadership at all levels.
- Developing competitive advantage.

Likewise, the five most significant obstacles are:

- Overcoming resistance to change.
- Convincing organisations that long-term thinking is possible and useful.
- Extracting organisations away from a reliance on facts and predictions.
- Building an understanding of what futures and foresight can accomplish.
- Remembering why futures practitioners are there!

In my own field of the built environment, and I suspect with so many others, the proper cultivation and true embedding of a 'futures' and 'foresighting' approach is extremely rare. Only one major firm springs exceptionally to mind – Arup. Though the global cities movement is

proving fertile ground at last. Collectively, civilly, corporately, and individually, we must all stay "Futurewise" through strategic foresight.

6.3 Fostering Creative Governance

Clearly, the world's economic structure is outgrowing its political structure. Power should go upwards to supranational authorities and agencies, and downwards to cities and communities. The latter, felicitously, is happening; but the former will take much longer than many of us would have hoped only a few years ago. Setting aside, therefore, the herculean task of reforming global institutions, the following list of 'top ten' issues was identified at a recent workshop, I hosted for erstwhile respected colleagues to consider what 'practically' must be done over the next few decades.

1. **Summit Reform.** The vacuum at the apex of the international system for implementing a global agenda must be filled through a set of treaty-based institutions governing the global space.
2. **A Framework of Forums.** In the absence of formal multilateral governance, and to guard against the extremes of cultural and economic nationalism, a network of communities globally concerned with prevalent issues and a shared destiny for humankind should convene and compose collective visions. This could lead to a 'new politics' of trust and common sense.
3. **Inclusive Growth.** Widespread social and economic inequality must be tackled by promoting opportunities for all segments of the population and distributing the dividends of any increased prosperity, both in monetary and non-monetary terms, fairly across society.
4. **Universal Basic Income.** The merits and demerits of deploying more widely the policy of regularly providing all citizens with an unconditional sum of money to support their staple cost of living should be considered. Also, the alternative of a negative income tax. (Interestingly, Thomas Paine, outlined just such a plan in his 1797 essay "Agrarian Justice").
5. **Climate Diplomacy.** Although limiting global warming to 2 degrees centigrade above pre-industrial levels is more a political target than a scientific one, it must be maintained as it focuses minds and seems to occasion unity.
6. **Resource Resolve.** Toward 2050 we must generate all the energy we can get, including 'new nuclear', as well as from the more 'correct' sustainable sources; as water supply becomes more scant, we must conserve it, use it more efficiently and establish clear rights over who owns the stull; and managing food security for all, despite uncertain weather patterns, will be a taxing task that must be tackled.
7. **New Financial Architecture.** Confronting, in the world of international banking, defective risk appraisal, unwarranted leverage in multiple forms, monumental debt, misplaced reliance on apparently sophisticated maths, hard-wired pro-cyclicality, imbalance between liquidity and financial stability -- not to mention a general lack of regulation and the proliferation of corrupt and unprofessional practices – must be commenced. It has been taking too much time, and lost both trust and confidence. There are also the questions and challenges of the shadow economy, global tax avoidance, a new crypto-currency (bit coin) supported by 'blockchain', the potential of a Tobin Tax, and much, much more.
8. **Cities of Tomorrow.** Paradoxically, place will assume more prominence in a connected world, so that more creative governance with a shared, sensible understanding of civic values, vision, quality, competitiveness, sustainability, communication, welfare and enterprise must surely witness the emergence of the 21st century as the century of cities. Mayors, moreover, in Benjamin Barber's evocative words should; "rule the world"; and local leadership provide a path to global solutions. Most notably, the philosophy and practice of Asset Based Community Development (ABCD), long advocated by the remarkable John McKnight, will spawn.
9. **Partnership.** In all its forms and guises must flourish.
10. **Return of 'The Master'.** As an unreconstructed Keynesian, I believe we must restore John Maynard Keynes's view that capitalism is a means rather than an end, and ought to aim at allowing populations the leisure to pursue the 'good life'; chiefly living ethically, having prudence, stimulating confidence, and having time for the appreciation of beauty and the pleasure of human intercourse.

It is, indeed, a world of problems and possibilities, but one where the facility to envision and think imaginatively is the greatest virtue of all.

6.4 An Overarching Strategy

Having completed the first draft of this thought-piece, I conducted a 'strategic conversation' with collegial cognoscenti to try to identify a single unifying strategy to sustain humankind into the future. The overwhelming consensus diagnosed **"Transforming Education"**. A scholarly platform is being built by others (Gidley, 2016), asserting the obsolescence of the current universal model of education and the compelling need for a new approach to preparing succeeding generations for global uncertainty, accelerating change and unprecedented complexity. Somewhat haphazardly, however, the following ten propositions were proffered by my own coterie to pump-prime a fuller disquisition in due course.

1. **Chaos Theory.** Together with an appreciation of the sciences of complexity, an understanding of chaos theory is crucial to the systemic transformation of our educational systems themselves. Helpful concepts include: co-evolution, disequilibrium, positive feedback, perturbance, transformation, fractals, strange attractors, self-organisation and dynamic complexity.
2. **Systems Thinking.** An emphasis should be placed across all sectors and levels of education toward an understanding of complexity, networks, and patterns of organisations, leading to an essential kind of 'systemic ' reasoning.
3. **Progressive Mind-set.** Arming us with a fivefold array of cognitive abilities to produce a progressive mind-set that is: disciplined, synthesizing, creative, respectful and ethical.
4. **Connected Learning Environments.** Supporting problem-based learning and robust collaboration on today's complicated and multi-disciplinary issues, that require both quantitative and qualitative skills, new educational technologies can provide advanced and accessible lifelong learning.
5. **Post-Modern Universities.** Moving from an age where so much energy is absorbed in operating existing silos of conventional knowledge within a bureaucratic edifice of bricks and mortar, to one of more radical and collaborative 'polyphonic' universities possessing a fresh approach to furthering wisdom, intellect and edification. There would, moreover, be mandatory modules, at successive stages, of 'systems thinking', 'sustainability', and 'values and ethics'.
6. **Business School Reinvention.** Always seeming, like the military, to be preparing for the last campaign, the world's top business schools will have to change. Far greater insight into the future panorama within which organisations will operate, alongside an ability to design, forge and lead complex teams with a shared purpose in a connected world, is becoming crucial.
7. **Management Consulting.** A disruption is already taking place where the freelance and independent consultancy model works best in an on-demand economy. Specialization, integration, automation, collaboration, agility, implementation, and, of course, imagination, will be the keynotes.
8. **Multi-faith Ecumenism.** Even for myself, a liberal humanist, the value of extended dialogue between different religious belief systems co-operating in securing the betterment of humankind is patently obvious. A modern-day Peace of Westphalia for the near- and middle-east would be a good start.
9. **Restoring the Teaching Profession.** Attracting better, more diverse, highly talented, perceptive, inspirational, and committed people, at different stages of life and career, with much enhanced pay and conditions, should be an overriding objective of societies at large.
10. **Institutes of Foresight.** It was H. G. Wells, in 1932, who first proposed such a thing, and his prescient visions of the future, evidenced in his 1901 book **Anticipations**, really remain unsurpassed.

7. Epilogue

As a penultimate thought, it's "back to Bucky". In contemplating change, Buckminster Fuller (1969) stated: "I always say to myself: what is the most important thing we can think about at this important moment?" Not simply a platitude, for he advanced ten principles to give what he

described as: 'comprehensive anticipatory design leadership'. These were: think comprehensively; anticipate the future; respect gestation rates; envision the best possible future; be a 'trim-tab' (small rudder) mover of big ships; take individual initiative; ask the obvious and naïve questions; do more with less; seek to reform the environment, not the man; and, solve problems through action.

But my own final musing comes from an incident just recently. Having concluded a Strategic Foresight exercise for a group of local clinics contemplating merger, I was asked what single word should be their maxim for the time ahead, and, eschewing all my customary jargon, commonsensically conjured up the word "cheerfulness!" Nobody wants to face a future lacking in good cheer.

It is all, therefore, simply a matter of "Common Sense"; so the very last word must go to Thomas Paine.

"The most formidable weapon against errors of every kind is reason", Age of Reason, (1794).

John Ratcliffe (2017)

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Section 1

Sustainable Design and Sustainable Environment

Sustainable Futures: Making Cities Resilient in the MENA Region

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Abstract

According to the United Nations (UN) Population Division's projections, urbanisation rates will escalate to reach an estimation of five billion people by 2030. Heavily concentrated in Asia and Africa low and middle-income countries, achieving the Sustainable Development Goal (SDG) No. 11 'Make cities and human settlements inclusive, safe, resilient and sustainable' remains a priority to build resilience in our cities. As part of an ongoing PhD, this study aims to identify the indicators for making cities resilient, mainstreaming Disaster Risk Reduction (DRR) into sustainable development in Middle East and North Africa Region (MENA). In 2010, the United Nations Office for Disaster Risk Reduction (UNISDR) launched the Scorecard Ten Essentials for 'Making Cities Resilience' global campaign to increase understanding and encourage commitment of DRR and resilience policy by local and national governments. With forty cities identified as role models to share knowledge and learn lessons from, only four cities from three MENA countries were reported by the UNISDR in 2012. With the launch of the New Ten essentials at the 2017 global platform, this study will compare between the 2010 and 2017 Ten Essentials indicators for 'Making Cities Resilient' in relation the SDG Goal 11.b across the disciplines of climate change, conflict and displacement. Academic literature on resilience in this paper was reviewed in the contexts of risk management, hazards, climate change adaptation and sustainability to (1) trace the theoretical origins of resilience theory and development in the field (2) identify the MENA region urban risk profile in relation to hazards, exposure and vulnerability (3) map the existing regional disaster risk policies and strategies for building city resilience (4) The outcomes of this study will contribute to building coherence between the 2015-2030 Sendai Framework for Disaster Risk Reduction (SFDRR) and the Sustainable Development Goals (SDGs), identifying the challenges to and priorities for achieving the 2030 global targets at the MENA Region local level.

Keywords: cities, climate change, disaster, hazards, resilience, sustainability.

1. Introduction

According to the United Nations (UN) Population Division's projections, urbanisation rates will escalate to reach an estimation of 5 billion people by 2030. (HABITAT III Issue Paper – Urban Resilience, May 2015). Heavily concentrated in Asia and Africa low and middle-income countries, the unconditional distribution of habitation density levels in coastal economic centres, along hazard prone and rivers corridors culminates in the loss of human lives and economic assets in large numbers, and increase the risk of exposure to natural hazards.

Over the past 30 years approximately 40 million people were affected by disasters globally, with financial losses about US$20 billion (World Bank, 2015). With a population of 355 million, 60 million people live in the Middle East and North Africa (MENA) region coastal areas presenting about 17 percent of the region's total population (World Bank, 2015). The 2016 World Bank Development Indicators reported an increase in MENA population up to 436,720 million (World Bank, 2017).

Exacerbated with climate change extreme environmental conditions of high temperature and water evaporation levels, the frequency of natural disasters and severity of catastrophic events increases to become threat multiplier. 'Climate change may not be responsible for the recent skyrocketing cost of natural disasters, but it is very likely that it will impact future catastrophes' (Nasa, 2016)

In April 2007 Climate Change was first established as a security issue by the United Nations Security Council. The United States Department of Defence reported that 'Climate change can act as a threat multiplier for instability in some of the most volatile regions of the world

(Nordås, R. and Gleditsch, N.P., 2007). This theory is strongly embedded in the MENA Region. Here, the interaction between disaster risk, conflict and social vulnerability is distinctly outlined in the contexts of poverty, human rights violations, and incompetent institutional disasters risk management. "There were 19.2 million new displacements associated with disasters in 113 countries in 2015, and several of these countries are no strangers to conflict which gave rise to 8.6 million new displacements in 28 countries last year" (Glasser R., 2015).

According to the Global Report on Internal Displacement "disasters triggered by natural hazards caused twice as many new displacements in 2015 as conflict and violence". (Cited by Glasser R., 2015). This report brings into attention the significance of conflict and violence as drivers of 'climate-change induced migration' (Parry M.L et al, 2014), (Reuveny, R. (2007). As the term migration by Reuveny R (2007) provides the choice of relocation, this paper suggests the term of 'climate-change induced displacement' as defined by the United Nations Educational, Scientific and Cultural organisation (UNESCO) 'displacement of people refers to the forced movement of people from their locality or environment and occupational activities. It is a form of social change caused by a number of factors, the most common being armed conflict. Natural disasters, famine, development and economic changes may also be a cause of displacement'. (UNESCO, 2017).

2. Research Methods

In the context of building resilience, it is important to consider the 2015-2030 Sendai Framework for Disaster Risk Reduction (SFDRR) UN member states perspective on conflict-sensitive economics, displacement geographical and social scope of climate change impact. "By consensus among UN Member States there are no explicit references to conflict in the text, which articulates guidance on reducing mortality and numbers of people affected by disasters". (Glasser R., 2015).

With the aim to address this gap, the study suggests the following research question: How can the SFDDD new Ten essentials for 'Making Cities Resilient' capture the disaster data losses gap for climate change, conflict and displacement nexus, to build sustainable development in the MENA Region? To answer this question, the academic literature on resilience was reviewed in the contexts of risk management, hazards, climate change adaptation and sustainability, to trace the theoretical origins and development in the field based on the Meerow S. et al literature review of 172 publications. Guided by climate change studies and UNISDR (2016) Terminology on hazards, a proposed structure of hazards origin, effect, types and interrelated effects was developed to identify the MENA region urban risk profile in relation to exposure and vulnerability.

As the successor instrument to the Hyogo Framework for Action (HFA) 2005-2015: Building the Resilience of Nations and Communities to Disasters, the study developed a timeline for regional DRR strategies for mapped before the 2015 SFDRR. Aimed at learning lessons from HFA, the study revealed attempts to compare between the HFA and SFDRR scorecard Ten Essentials in relation the SDG Goal 11.b 'By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels' across the disciplines of climate change, conflict and displacement. This study offers main contribution to building coherence between the 2015-2030 Sendai Framework for Disaster Risk Reduction (SFDRR) and the Sustainable Development Goals (SDGs), identifying the challenges to and priorities for disaster data losses for climate change induced displacement. And achieving the 2030 global targets at the MENA Region local level.

3. Urban Resilience: Definitions

With variations in defining resilience between the engineering, psychology and disasters literature, this study will build evidence on the Meerow S. et al literature review of 172 publications. The literature on urban resilience over a 41-years period was identified using the Elsevier's Scopus and Thompson Reuters Web of Science on Holling's socio-ecological system framework (Walker, Holling, Cartpenter and Kinzig 2004) applied across the fields of risk

management, hazards, climate change adaptation, international development and planning (Cited in Meerow S. et al 2016).

Table 1 Urban Resilience: Definitions (Cited in Meerow S. et al 2016).

Focus Areas	Literature	Definition
Risk Management	(Rose, A., 2007). Economic resilience to natural and man-made disasters: multi- disciplinary origins and contextual dimensions. (Cited in Coaffee, J. 2008)	The ability of an entity or system to maintain function (e.g. continue producing) when shocked'' (Rose, 2007, p. 384). It describes the ability of nation states and governance agencies to develop disaster mitigation processes and 'hardened' critical national infrastructure to ensure it can continue operating within the global economy at its regular capacity.
Hazards	(UNISDR, 2016) Terminology on Disaster Risk Reduction. Geneva. (Cited in Gaillard, J. C. 2010).	The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions. (UNISDR, 2016)
Climate Change Adaptation	(IPCC, 2007) Tyler, S., & Moench, M. (2012). (Cited in Tyler, S., & Moench, M. (2012).	The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity of self-organization, and the capacity to adapt to stress and change. (IPCC, 2007).
Sustainability	(Mileti D. S., 1999). Mileti, D.S., 1999. Disasters by design: a reassessment of natural hazards in the United States, Natural hazards and disasters. (Cited in Cutter et al 2008)	The ability to tolerate—and overcome—damage, diminished productivity, and reduced quality of life from an extreme event without significant outside assistance (Mileti D. S. , 1999,p.4).

4. MENA region urban risk profile

Referred to as the 'MENA' Region, the Middle East and North Africa Region is divided into four sub-regions, the Mashreq (Eastern) consisting of(Egypt, Iraq, Jordan, Lebanon, Palestine (West Bank and Gaza), Syria, Iran, the Maghreb (Western) consisting of Algeria, Libya, Morocco, Tunisia, Mauretania, the Gulf Cooperation Council (GCC) countries in the Arabian Peninsula consisting of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, and the Southern Tier countries: Somalia, Sudan, Comoros, Djibouti and Yemen.

MENA countries classification differs between international organisations following the span of operational networks and geographical scope of activities. For example, the World Bank report (2014) 'Natural Disasters in the Middle East and North Africa: A Regional Overview' excludes Sudan, Somalia, while including Djibouti and Malta (World Bank, 2014). According to Majbouri, M (2015) MENA region countries listing extends to include Iran. This also applies to Waha et al (2017) studies for 'Climate change impacts in the Middle East and Northern Africa (MENA) region and their implications for vulnerable population groups'. For Choueiri E.M. et (2013), the MENA Region followed the Arab states geographical outline (Figure 1), which will be pertained to this study.

Figure 1 Arab States Map. Cited in (Choueiri E.M. et (2013) An overview of the transport sector and road safety in the MENA region.

5. Hazards

The region is exposed to two major types of natural hazards (Figure 2) (UNISDR, 2016). First, hydro-metrological hazards defined as 'atmospheric, hydrological or oceanographic origin, such as tropical cyclones, floods, drought, heatwaves and cold spells and coastal storm surges'. This is generated by the North Atlantic Oscillation (NAO), causing storm tracks and annual variations in rainfall in Western and Central North Africa (the Maghreb), most of the Mashreq and the Arabian Peninsula. For the MENA southern parts, the Inter-Tropical Convergence Zone (ITCZ) dominates causing the Indian monsoon system (Donat, M. G., et al. 2014).

The second hazard is geological generated by the internal earth processes in the northern Nubia-Somalia rift zone between Eritrea, Djibouti, Somalia and Ethiopia. This result in earthquakes and volcanic hazards in this region. Anthropogenic and man-made hazards also exist at lower levels of risk (Poggi, V. et al 2017). Seismic activity is also a hazard in the Arab region. For example, the Jordan rift valley system places a number of countries (Jordan, Lebanon, Palestine and Syria) at high risk from earthquakes. Similarly, some countries in the Maghreb region (Algeria, Morocco and Tunisia) have been exposed to seismic activity in the past. Devastating earthquakes have occurred in Palestine (1927), Lebanon (1956), Morocco (1960), Egypt (1992) and Algeria (2003) (UNISDR, 2013).

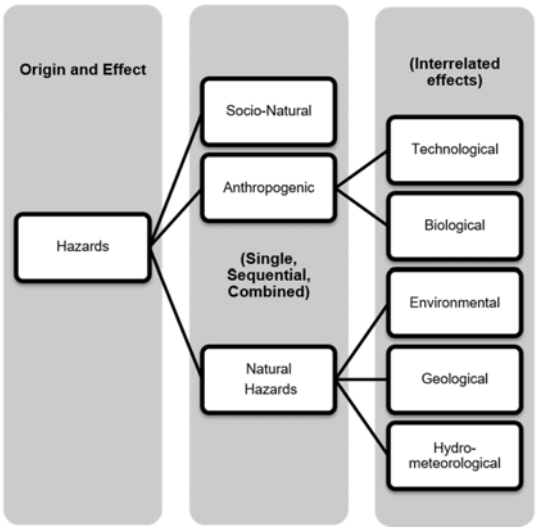

Figure 2 Hazards: Types, Origin and Effects.

6. Drivers of Disaster Risk and Vulnerability

Disasters result from a combination of hazards with their respective to vulnerability. Vulnerability is defined by the United Nations International Strategy for Disaster Risk Reduction (UNISDR) as 'the conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards (UNISDR, 2016).

Taking into account the impact of political, economic instability and social inequity factors, the MENA Region is highly vulnerable to socio-natural drivers of disaster risk caused by the decline of natural eco-systems, rising urban populations and increased density with poor integration of urban planning, infrastructure services, land use policy and enforcement of buildings construction codes. Weak urban governance is embedded in Arab states centralised governance system focus on investment in disaster risk management at the national level, weakening the participation of local communities in decision-making process.

7. Climate Change, Conflict and Displacement

Shaped by the type of hazards and degree of exposure, climate change extreme conditions exacerbate the impact of disaster risk drivers in the MENA region of and increase vulnerability to hazards. Evidence from the United Nations System Task Team on The Post-2015 Development Agenda indicates that 'migratory behaviours in response to climate and/or environmental change may exhibit considerable variation, ranging from massed forced displacement to gradual anticipatory 'adaptive' movement. Precise figures are lacking, but it is believed that the large majority of people whose migration is fuelled by environmental considerations move over relatively short distances and rarely across borders' (IOM, UNDESA 2012).

The history of conflict induced displacement in the MENA Region started with the occupation in 1967, followed with the twentieth century ordeals of Lebanon and Iraq, civil wars in Sudan and Somalia, and the Arab Spring turbulence in Egypt, Libya and Syria. As displaced people often settle in informal settlements that are especially vulnerable to natural and man-made hazards, there is a threat of further instability and displacement in these areas. (HABITAT III Issue Paper – Urban Resilience, May 2015).

8. MENA Disaster Risk Regional strategies

The 2020 Arab strategy for disaster risk reduction was first adopted by, the Council of Arab Ministers responsible for the Environment (CAMRE) in 2010. Arab States in the MENA Region committed to the implementation and follow-up on Hyogo Framework for Action 2005-2015, toward increasing the awareness and commitment to disaster risk reduction (UNISDR, 2015). (Figure 3). Recalling the 2010 World Disaster Reduction Campaign 2010-2015 Making Cities Resilient: "My city is getting ready!", observations were made in Aqaba regarding the variation in Arab cities capacities and resources to implement the declaration. Sharing equal commitments, a regional review was agreed to take place in 2015, to ensure consistency with the global disaster risk reduction framework to be adopted by 2015.

Approved by the Economic and Social Council of the League of Arab States at its session in September 2011.This was followed with adoption by Arab Heads of States Summit in the Baghdad Arab Summit in March 2012. In 2013, the Cooperation Council for the Arab Gulf States (GCC) announced its commitment to develop a road map to reduce disaster risks.

9. 2013 Aqaba Declaration on Disaster Risk reduction

On the same year, the Aqaba Declaration was signed at the First Arab Conference for Disaster Risk Reduction, 19-21 March in Aqaba, Jordan. Here a shift into wider collaboration at the local level was witnessed, with the engagement of Arab city mayors, local and national government representatives, working together to reduce disaster risk in Arab cities. With 16 targets set to be achieved by 2017, Aqaba Declaration recognised urbanisation challenges and opportunities associated with demographic population growth and economic development. Considering the significance of traditional knowledge in reducing disaster risk, this can be developed to

strengthens the resilience of local communities. The impact of climate change extreme weather events, and exposure to hazards in coastal cities and highly seismic zones is documented.

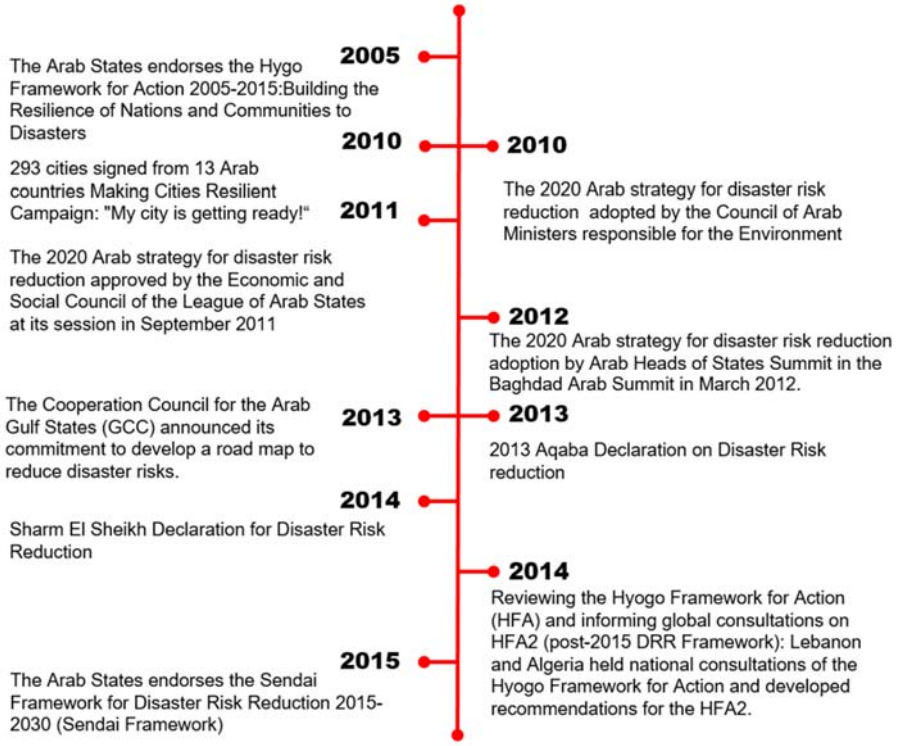

Figure 3 Disaster Risk Regional strategies in the Middle East and North Africa Region (MENA).

10. 2014 Sharm El Sheikh Declaration for Disaster Risk Reduction

Adopted at the Second Arab Conference on Disaster Risk Reduction, in Sharm El Sheikh, Egypt, 14–16 September 2014, similar growing challenges of the 2014 Aqaba declaration were recognised, with 19 actions to target the lack of disaster data losses and updated information on exposure, vulnerability and hazards affecting critical infrastructure, disaster risk mitigation strategies and early warning systems. Deeper interrelationship between climate change and migration was developed with understanding of water scarcity, desertification and land degradation long-term impact, supported with facts and figures 'Between 1980 and 2008, more than 37 million persons were affected by drought, earthquakes, flash and other floods and storms and the losses to the Arab economy were estimated at around US$ 20 billion' (UNISDR, 2014).

11. Making Cities Resilient

The United Nations University Centre for Policy Research Background identified several frameworks for measuring fragility, risk, and resilience (Bosetti L. et al 2016). Although relatively comprehensive, the context of displacement is missing, with focus on fragility at a National level, disconnected from climate change environmental and political drivers at the local level. 'Fragility continues to be analysed predominantly from a state-centric perspective, with a focus on state institution' (Bosetti L. et al 2016).

Accordingly, this paper will apply detailed analysis of the Making Cities Resilient Campaign ten essentials, with focus on climate change, conflict and disciplines to build resilience in the MENA Region. A comparison between 2010 and 2017 Scorecard will be applied to develop a holistic approach for disaster risk reduction science and close the gap between the 2015-2030 Sendai framework (SFDRR) and Sustainable Development Goals (SDGs). The translation of

target for Goal (SDG) No. 11 'Make cities and human settlements inclusive, safe, resilient and sustainable' will provide guidelines and implementation tools on building construction techniques, dams' architecture, flood defences and retrofitting codes, with greater understanding of displaced community needs in alliance to local resilience policies and spatial planning strategies.

The 'Making Cities Resilient Campaign' was developed by UNISDR and its partners to assist local governments in assessing their progress in building resilience to disaster. It is part of a series of tools for measuring the progress of nations and communities towards meeting the objectives of the Hyogo Framework for Action (HFA) to 'increase understanding and encourage commitment by local and national governments to make disaster risk reduction and resilience a policy priority and to bring the global Hyogo Framework closer to local need'.(HFA, 2005-2015).

This was followed with the launch of the Local Government Self-Assessment tool (LGSAT) in April 2012, in support to the global Making Cities Resilience Campaign, to enrich understanding of disaster risk, identify gaps in planning policies and financial risk investments. This is an online tool that identify main Ten Essentials. Wide in scope, more than 1850 cities participated from 95 countries globally, 293 cities signed from 13 countries in the MENA Region (Arab States). With forty cities identified as role models to share knowledge and learn lesson from, only four are reported by the UNISDR in the MENA Region, including Dubai (United Arab Emirates), Aqaba (Jordan), Beirut and Byblos (Lebanon). These figures proclaim the necessity to identify the gaps in processing the LGSAT tool in the Arab States; understand the methodological framework for progress in monitoring and feedback mechanism for local governments. (UNISDR, 2013)

The lack of accurate, updated and reliable data on disaster losses in the region plays have a significant impact on building resilience. The main regional resources are the International Disaster Database (EM-DAT) and the multi-stakeholder initiative on Disaster Information Management System – DesInventar. 'That enable countries to analyse disaster trends and their impacts in a systematic manner through the collection of historical disaster data'. Nevertheless, 'only nine out of the 22 Arab countries have either completed or initiated the development of national disaster loss' (UNISDR, 2013).

Having this in mind, New Ten Essentials were launched at the 2017 Global Platform for Disaster Risk Reduction in Cancun, Mexico, this paper main outcome is the development of a comparative analysis between the 2010 and 2017 Ten Essentials (Table 2), to identifying gaps and learning lessons from cities progress reports on the indicators for the HFA, and develop evidence based approach for reporting to the SFDRR indicators in the context of the MENA Region. The SFDRR was endorsed by the UN General Assembly, and adopted by 187 countries as a 15-year, voluntary, non-binding agreement with four priorities and global seven targets, which recognizes that the state has the primary role to reduce disaster risk but that responsibility should be shared with other stakeholders including local government, the private sector and other stakeholders.

From the comparison above, both 2010 and 2017 Ten Essentials provide a set of assessments to enable cities to understand how resilient they are to natural disasters. The New Scorecard provide detailed quantified indicators for measuring resilience in new fields such as risk modelling, and risk insurance in relation to urban development and natural ecosystems, facilitating a more cohesive approach for making cities resilient. Nevertheless, measures to quantify losses from 'climate change induced displacement' are note covered, calling for further investigation of how local governments in the MENA region conflict setting can achieve 'sustainable resilience'.

This study proposes the utilisation of the SDG Goal 11.b indicator 11.b.2 metadata (Table 3), to develop a method of computation based on the technical methodology applied in measuring resilience by the New Ten Essentials. Taking into account the lack of legislation for displaced people, the inclusion of sustainability indicators into the Making cities resilience tool will provide an opportunity to shift disaster risk reduction efforts from emergency to long-term development, to reduce the future risk of displaced people exposure to risk and vulnerability to hazards in un-planned resettlement of displaced people camps and emergency shelters.

Table 2 Comparison between the Ten Essentials for the HFA Scorecard 2010 and the 2017 SFDRR Scorecard 2017.

HFA Ten Essentials (2010)	SFDRR Ten Essentials (2017)
1. Institutional and administrative framework	1. Organise for disaster resilience
2. Financing and resources	2. Identify, understand and use current and Future risk scenarios
3. Multi-hazard risk assessment – know your risk	3. Strengthen financial capability for resilience
4. Infrastructure protection, upgrading and resilience	4. Pursue resilient urban development and design
5. Protect vital facilities: education and health	5. Safeguard natural buffers to enhance the Protective functions offered by natural capital
6. Building regulations and land use planning	6. Strengthen institutional capacity for resilience
7. Training, education and public awareness	7. Understand and strengthen societal capacity for resilience
8. Environmental protection and strengthening of ecosystems	8. Increase infrastructure resilience
9. Effective preparedness, early warning and response	9. Ensure effective disaster response
10.Recovery and rebuilding communities	10. Expedite recovery and build back better

As stated by Mochizuki et al. (2014) 'revisiting the disaster and development debate', sustainable development potentials are 'threatened by the accumulation of disaster risks'. (Mochizuki et al. 2014). Taking into consideration the wide range of definitions for the term 'sustainable development', providing the needs of future generations is the widely accepted target, and recently suggested in the guiding principles for the HFA (2005-2015) that 'sustainability of development depends on its ability to prevent new risk creation and the reduction of exiting risk'. (Cited in Saunders W. and Becker J. 2014).

Table 3 Metadata for Indicator 11.b (Resource: Sustainable Development Goal 11, A Guide to Assist National and Local Governments, UN HABITAT, 2017)

Target 11.b: By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, **in line with the Sendai Framework for Disaster Risk Reduction 2015-2030**, holistic disaster risk management at all levels.			
Indicators	**Level**	**Terminology**	**Method of computation**
11.b.1: Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015-2030.	National Government	Not Defined	Summation of data from National Progress Report of the Sendai Monitor .
11.b.2: Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies	Local Governments	Form of public administration at the lowest tier of administration within a given state, which generally acts within powers delegated to them by legislation or directives of the higher level of government	Not Identified "out of the scope of this Metadata"

12. Conclusions

The interface between climate change and urbanisation is considered to cause the shift in rural-urban migration patterns, emerging changes of social structures, and probably increases the exposure of humans and economic assets to extreme events, natural and man-made disasters. Coupled with economic instability and social inequity, the competition for diminishing resources, can trigger ethical concessions that may lead into conflict.

According to IOM (2016), there are over 16.2 million IDPs in Arab countries, which constitute nearly one third of all internally displaced people in the world. Standing out as having one of the highest levels of human mobility, the MENA prolonged history of armed conflict and civil wars generated a more complex trend of forced migration, nevertheless, losses from 'climate changes induced displacement remains unidentified. Findings from the 2017 Global report on internal displacement indicate that 'by the end of 2016, there were 40.3 million people internally displaced by conflict and violence across the world. An unknown number remain displaced as a result of disasters'.(Internal Displacement Monitoring Centre, Norwegian Refugee Council 2017)

With climate change, disasters affecting 'haphazard development, weak institutions, lack of social safety nets and short-termism of our decision making practices are some of the factors that drive natural disaster risk'(Mochizuki et al. 2014). Evidence from the policy review of MENA Disaster Risk Regional strategies, indicates that accurate data on disaster losses and risk models is essential to building resilient cities in the MENA Region.

It is evident from the literature that definitions and concepts of resilience and sustainability are interlinked, on the contrary sustainable development cannot be achieved without defining the time scale of action for disaster risk reduction. 'Sustainable recovery from a natural hazard event ensures that existing risks are reduced and any new risks are managed' (Saunders W. and Becker J. 2014), yet the decision making process for long-term action contradicts with emergency response, and require inclusive data on disaster losses to achieve sustainable development.

This can be achieved by building coherence between the global 2015-2030 targets for DRR and the SDGs, strengthening local investments, building capacities of institutional organisations and civil society groups, with emphasis on the need to integrate sustainable development principles into Arab cities spatial planning strategies, and disaster risk management policies.

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Linking Between Sustainable Development and Facilities Management Strategies: An Integrated Approach for Evaluating the Sustainability of Existing Building in the UAE

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Abstract

Recently, the term Sustainable Facilities Management (SFM) has been introduced to integrate sustainability principles into FM. In the last few years, the UAE's main target has been to champion the implementation of solar energy for greener future. The Dubai Government has announced its major objective to transform Dubai into a smart city. The use of an eco-friendly economy plan, can lead to make it the most sustainable city in the world by 2021. Abu Dhabi is also motivated to construct its own plan to become fully sustainable city. This signifies the need to have a framework to guide firms and FM industry to achieve the (SFM) term. The aim of this study is to incorporate sustainable practices into FM to manage existing buildings. The specific objectives are to develop a sustainable FM framework for a building incorporating the sustainability principles: economic, social and environmental, in order to construct an assessment method to evaluate and to apply the proposed SFM through a case study.

This research focuses on the performance assessment of a building in Dubai. The assessment methods used for the building are reviewed and their strengths and weaknesses are discussed. The variables under the three pillars of sustainability: economic, social and environment were identified through literature review and an exploratory study. The survey design was adopted and data were collected using self-administered questionnaire sent out to participants by email.

Keywords: Sustainability, Climate change, Sustainable facilities management, Building performance.

1. Introduction

"The history of life on earth has been a history of interaction between living things and their surroundings" (Carson, 1962)

Facilities management (FM) is an emerging discipline where it is integrated into an organization's business function and no longer operate as a separate entity (Alexander, 2003). Before 1980's, FM was viewed as non-core services and organizations tend to cut cost in FM to maximize their business profits (Duffy, 2000). At present, FM has been gaining emphasis in organization to deliver values in core business. There is a direct link between business and supporting infrastructure to improve business performance (Grimshaw and Cairns, 2000). Jones (2000) suggested that effective FM will be able to provide long term cost savings and to add a value to any organization.

Nutt (2004) suggested future FM will move forward based on the four basic resources trails available in an organization: financial resource trail (business), human resource trail (people), physical resource trail (property), and knowledge resource trail (information) (Amaratunga, D. and Baldry, 2001). He further suggested that FM should be strategically planned in order to exploit the opportunities available within the four trails (Nutt, 2004).

Sustainable development has become increasingly an important aspect of Architecture, Construction and Operations for the new and existing building as a way to championing "Green Vision of Dubai". The integration of the triple bottom line (economic, social, environment) into FM has placed pressure on FM profession to integrate sustainable measures in building operations and maintenance by taking environmental and social issues into the FM practices. Green regulations have been strictly implemented in newer building under construction. Furthermore, building owners are responsible by law to implement sustainable and effective

procedures to decrease gas emission, improve energy efficiency and minimize energy consumption in buildings. Both facilities management and sustainability subjects are still maturing, unclear and may cause confusion for many people who are not involved in the details. The study aims, however, to increase the level of awareness of both subjects and engage all stakeholders to achieve the right balance to protect the environment for the next generation and improve the economical side without affecting the level of occupancy comfort in buildings.

2. Sustainable Development Concept

The most used definition for Sustainable Development is that by the Brundtland Commission in 1987: "development meets the needs of the present without compromising the ability for future generations to meet their own needs" (WCED, 1987, p.43). This definition is different from the others, in that it shows the significance of intergenerational equity. This idea of saving resources for future generation is one of the main features that distinguished the policy of sustainable development from other international environmental policies.

In the last two decades, FM operators changed their perception towards sustainable development as an effective tool to reduce the climate warming. The global system encompasses ecosystem for people to sustain their life and activities, whereas the social system provides a base to fulfil human existence through politics, economic, technology and human systems that consist of health, safety and security (Komiyama and Takeuchi, 2006).

The UAE can play an important role regionally and internationally in actions positively impacting climate change. The country has a unique chance to shift towards a low-carbon emission while maintaining economic growth, and to lead in providing clean renewable energy and low-carbon emission.

3. Climate change and energy

The geological record shown in Figure 1 incorporates a critical confirmation for the extensive scale of climate changes in Earth's past. A case of this variability appears in the plot of the temperature throughout the previous 420,000 years. This information was obtained from an Antarctic ice center. (National Climate Change Strategy, 2005).

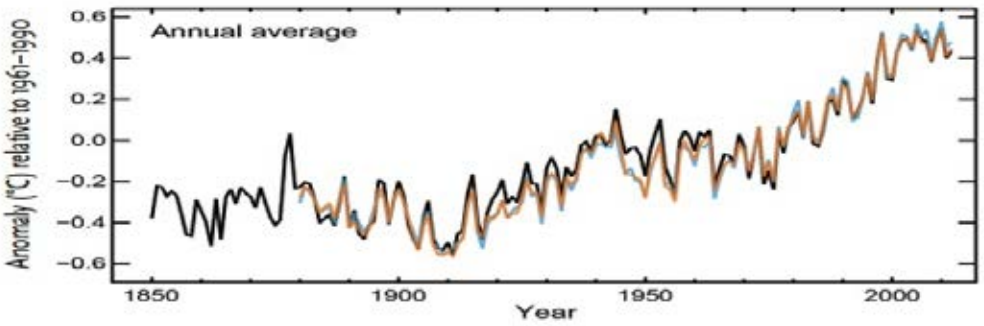

Figure 1 The plot of temperature throughout the previous 420,000 years. Source: (National Climate Change Strategy, 2005)

Earth invites us to combat climate change, by slowly reducing global greenhouse-gas (GHG) emissions in the next five years and beyond, the average temperatures are likely to increase for more than 2°C this century. The probable impacts would be disastrous: declining crop yields, rising sea levels, ocean acidification, droughts, floods, storms and heat waves, and major economic losses. We are also in risk of losing between 15-40% of our species from extinction (Building and Construction Authority, BCA 2009).

Carbon emissions schemes in operation during 2014 secured 3.7 Gt (11 %) of worldwide energy related CO2 emissions and had a total cost estimation of $26 billion (IEA, 2015). The normal cost was around $7 per ton of CO2 as shown in Figure 2.

Figure 2 CO2 Emissions Schemes over the world. Source: (National Climate Change Strategy, 2005)

The UAE government has realized the importance of climate change and decided to achieve a green economy and reduce the use of fossil fuel by using renewable sources of energy (MONE, 2010).

4. The UAE building sector and global warming

Hong (2009), stated that some construction materials and systems if applied can help decrease the amount of CO2 emissions by around 6.9%. In most projects in the UAE, materials are evaluated and selected based on their aesthetics and cost and not on their energy and environmental performance (Radhi, 2010). It is, therefore, not surprising that 70% of the annual electricity consumption is by building systems only. Figure 3 clearly states the consumption of energy per sector in the UAE.

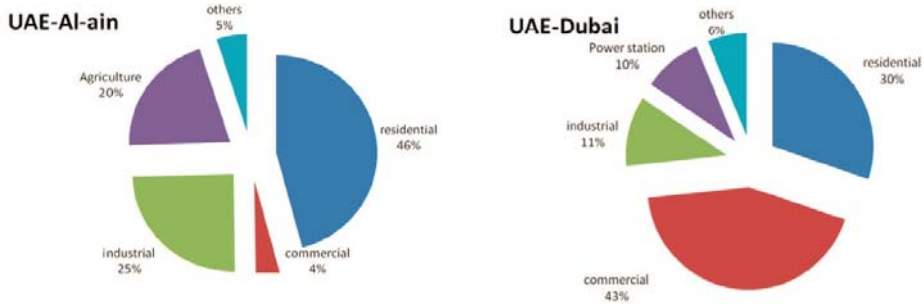

Figure 3 Energy consumption per sector. Source: Radhi (2010)

Figure 4 shows the energy end-uses of a typical residential building in the UAE, where electricity consumed by HVAC systems for cooling is the most significant. The increase in electricity consumption for cooling buildings in the UAE has been ten folds (from 5 to 50 Billion kWh) over the past two decades.

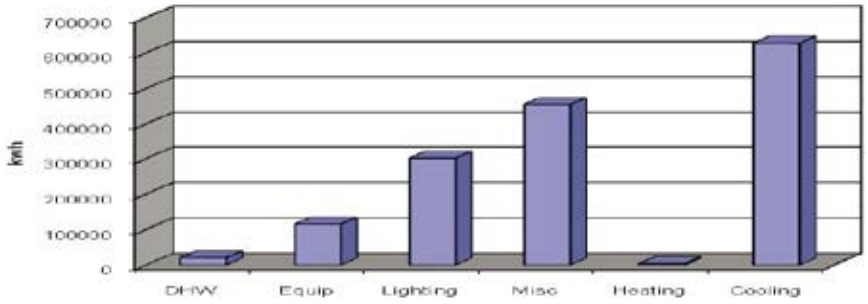

Figure 4 Energy end-uses in the typical building. Source: Radhi (2010)

5. Sustainability Facilities Management and the Drivers for Growth

The increase in awareness of environmental issues, the introduction of building certified schemes for existing buildings, the increase in the number of aging buildings and emerging new building technologies are identified as the drivers for SFM to develop and grow. Introducing sustainable concepts for new building development can also be applied for existing facilities management in areas such as refurbishment, renovation and alteration and addition (A&A). Hodges (2005), Nielsen et al. (2009) and Shah (2007) integrated sustainability principles into FM. SFM is growing rapidly (Elmualim et al., 2010) and can be defined as "a holistic approach which includes consideration of not only core business and support functions, but also relations with the local and global society as well as the climate and the eco-system" (Nielsen and Galamba, 2010). The drivers for the growth for SFM practice are the following:

5.1 Awareness on Environmental Issues

Buildings have significant impacts on the environment, economic and social issues. The United Nations Environment Programme (UNEP, 2006) reported that the building sector consumes 40% of used global total energy and contributes 40% of global total carbon emissions (see Figures 5 & 6). This is due to the fact that buildings consume huge amount of materials, resources and energy; meanwhile they generate air, water and soil pollution over their life cycle time (Tucker et al., 2003). Price et al. (1998) studied the main drivers of increased energy demand in buildings and found that the increase in urbanization, industrialization and in commercial floor space are the major contributors to this large energy consumption in buildings. In addition, pollution from existing buildings causes environmental concerns. In the UAE, the building sector was the second largest consumer of electricity after industrial sector in 2005 and consumes more than 30% of the total end-use electricity (MTI, 2007) (see Figure 7).

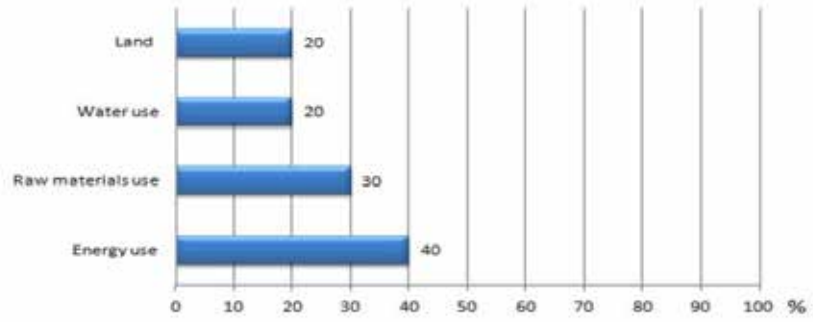

Figure 5 Share of Built Environment in Resource Use. Source: UNEP, 2006

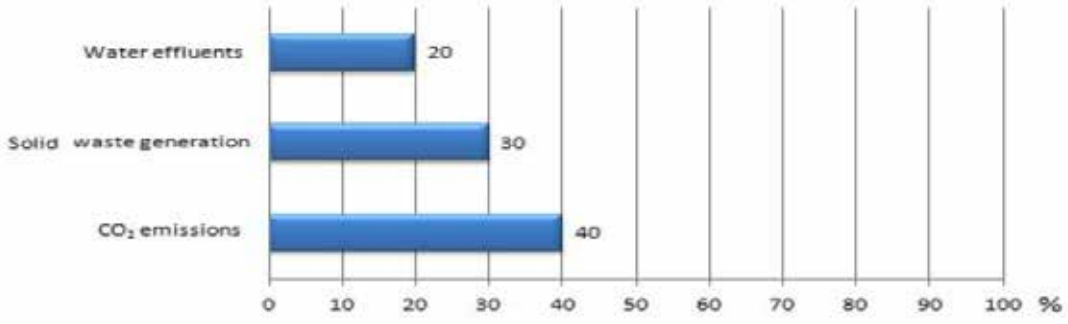

Figure 6 Share of Built Environment in Pollution Emission. Source: UNEP, 2006

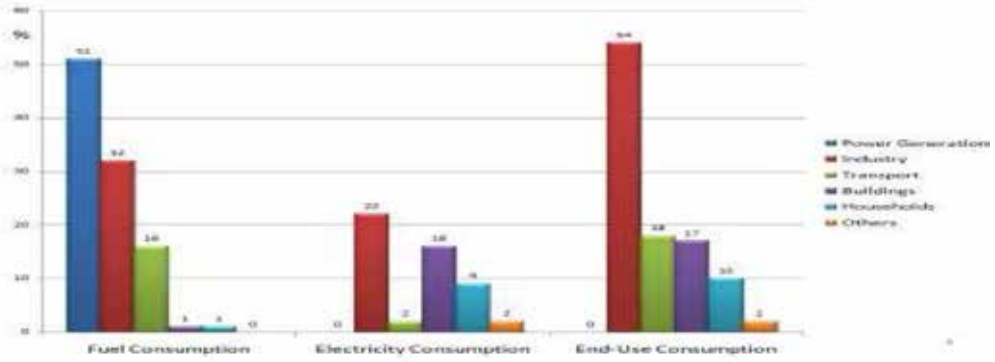

Figure 7 Energy Consumption by Sectors in 2005 (Source: MTI, 2007)

When in operation, the air conditioning consumption constitute about 60% of the total building energy consumption (National Climate Change Strategy, 2005). FM can help in reducing the environmental impact and improving energy efficiency of these buildings through energy retrofitting by using energy efficient technologies. (Mawed and Al-Hajj, 2014)

5.2 Environmental Building Assessment Method for Existing Buildings:

Environmental building assessment methods for new buildings have been introduced since 1990's such as Leadership in Energy and Environmental Design (LEED) in the United States, BRE Environmental Assessment Method (BREEAM) in United Kingdom and ESTIDAMA Ratings System in the UAE. In the United Arab Emirates, Estidama pearl rating system (PBRS) is to demonstrate the sustainable development in Abu Dhabi buildings and develop the life quality of the city. PBRS aim to integrate four pillars of Estidama together. That process known as integrated development process; the process encourages water, energy and waste minimization as well as local material use and aims to provide the supply chain for sustainable and recycled materials and products (PBRS, 2010).

5.3 Increase in Existing Building Stock

The building stock is in the increase consistently (Alexander, 1998; Shah, 2007). Inefficiencies in managing aging buildings will lead to higher energy costs (Holness, 2008). In view of increasing building stock in the UAE, it is envisaged that more and more construction works would involve refurbishment, retrofitting and renovation of existing buildings. Wood (2006) mentioned that existing buildings have the potential to contribute to sustainability through lower 'embodied energy'. There are many opportunities to achieve energy savings in existing building stock through energy retrofitting (Sussman, 2007) and buildings refurbishment (Mickaitytė et al., 2008).

5.4 Advancement in Building Technologies

The advancement in building technologies has changed the way in which FM operates. Building technologies such as Building Automation System (BAS), information technology (IT), Energy Management System (EMS), Communication Management System (CMS) and Building Information System (BIS) are increasingly adopted in buildings (Kua and Lee, 2001; Wong et al., 2005). Alexander (2003) anticipated the emergence of intelligent users' where knowledge is acquired in integrating building technologies into building functions in providing optimum building environment. Thus, there is a need to change the way buildings are managed.

5.5 Gaps in Knowledge to deliver SFM

Most studies have not integrated economic, social and environmental aspects in managing building facilities. In addition, no guide has been developed for assessing existing buildings on the extent to which the FM carried out to be sustainable.

6. Conceptual Framework for Sustainability Facilities Management

Wood (2006) studied the role of existing buildings in the sustainability agenda and found that existing buildings do interact with physical infrastructure, cultural and heritage in the society. He further suggested that existing buildings can be improved to avoid constructing new buildings where more resources will be consumed if more new building are constructed (Wood, 2006). Sunikka (2003) mentioned that sustainability potential lies in management systems of the existing building stock. Hong et al., (2006) and Mickaitytė et al. (2008) suggested that building refurbishment help reduce energy consumption and create a better living.

Several studies linked sustainability principles with FM practices. Shah (2007) proposed a framework of implementation of green FM management through building automation system. Sobotka and Wyatt (1998) proposed strategies in eco renovation for existing buildings. Their study has two limitations where social aspect did not taken into account and did not address the issues of the energy embodiment in renovation. Hakkinen an Nuutinen (2007) linked sustainable construction into life cycle facilities management. However, their study did not take into account the different business goals and trade-offs in organizations. Changing environment should be considered in the life cycle approach (Wyatt et al., 2000). Mickaitytė et al. (2008) proposed green refurbishment to achieve sustainable built environment. Epstein (2009) and Folke et al. (2002) mentioned that the three sustainability bottom lines (economic, social and environment) should be viewed in an integrated ways. The three aspects are inter-linked and impact on each other. Thus, economic, social and environment should be integrated in the sustainability framework (Folke et al., 2002).

Sustainable approach will directly and indirectly create values to the company. Companies nowadays realize that social aspects also need to be taken care of. Some authors determined the relationship between business and sustainability can be linked by physical facilities (Epstein and Roy, 2003; Paumgartten, 2003). FM can be used as a platform to perform sustainable business strategies and enhance business sustainable performance such as reducing operating cost, resource allocation, eco-efficient operation and more productive workers (Willard, 2002).

7. Barriers to sustainable FM practice

Researchers have highlighted the unequivocal role facilities management profession can play in advancing the sustainability agenda and the account of its potential contribution to sustainability goals in organizations (Wood, 2006; Shah, 2007). However, the rapidly evolving nature of FM means that there are likely to be barriers capable of hindering full integration of FM practice into the sustainability agenda among organizations. Additionally, Kato et al. (2009) contend that notwithstanding the proliferation of green buildings, there are impediments to the construction and management of green and sustainable buildings. Elmualim et al. (2010) investigated barriers and commitment of FM profession to sustainability debate using an online survey of facilities managers in UK. The study discovered time constraints, lack of knowledge, and lack of senior management commitment as the three main barriers to sustainable FM practice in UK. Thus, facilities managers who are responsible for championing the cause of sustainability within organizations are not getting enough information regarding sustainability issues, while top level management is slow in their commitment to the cause of sustainability within organizations. It is equally important to emphasize that technical barrier such as lack of adequate professional and scientific training on complexities and operations of intelligent buildings can be an impediment to successful sustainable FM practice (Finch and Clements-Croome, 1997).

In a study in the food industry in Lebanon, Massoud et al. (2010) revealed that lack of government support and incentives, lack of relevant environmental laws and regulations, and uncertainty of outcomes and benefits are the three most common barriers to the successful implementation of environmental management systems in the Lebanese food industry. Other

common barriers to sustainable FM practice in the literature include: lack of awareness, lack of training and tools (Finch and Clements-Croome (1997); financial constraints, cost of certification, lack of in-house knowledge, customer demands and constraints, physical and historical constraints, and organizational engagements (Shah, 2007; Elmualim et al., 2008). There is unanimity among researchers for a continued identification of the challenges capable of frustrating the adoption of sustainable practices within organizations which underscores the need to investigate factors militating against sustainable FM practice.

In summary, evidence from relevant literatures has established FM as a key player in global sustainability agenda. The study contained in this paper contributes to that existing body of knowledge by using data from different countries to empirically explore the level of commitment by corporate organizations to the course of sustainable FM practice (Journal of Facilities Management, 2014).

8. Survey Analysis

76 valid returns were received from a total of 116 questionnaires sent out, making it 65.5% success rate. The majority of the participants are occupiers (36, 47%), followed by in-house FM, outsourced FM and management staff (40, 53%).

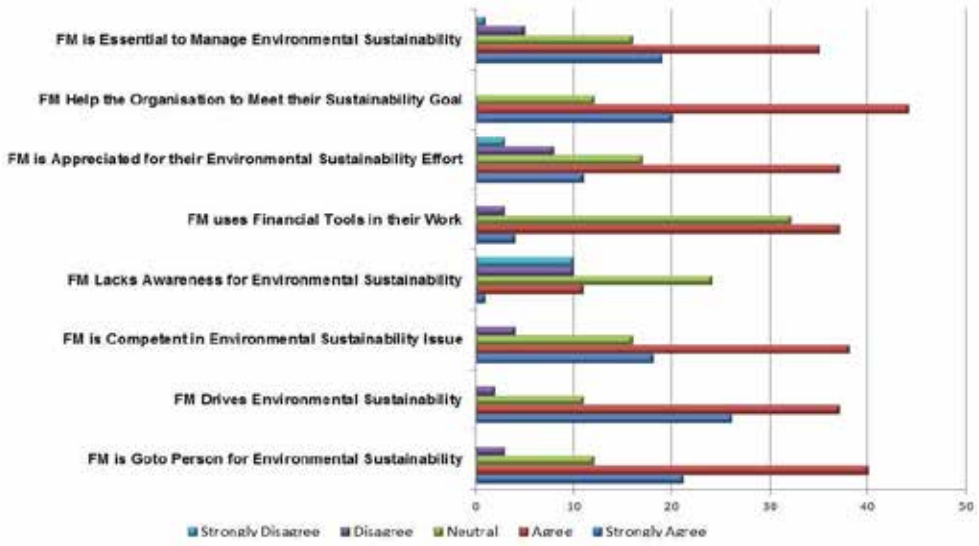

Figure 8 Perception of FM Role in Environmental Sustainability.

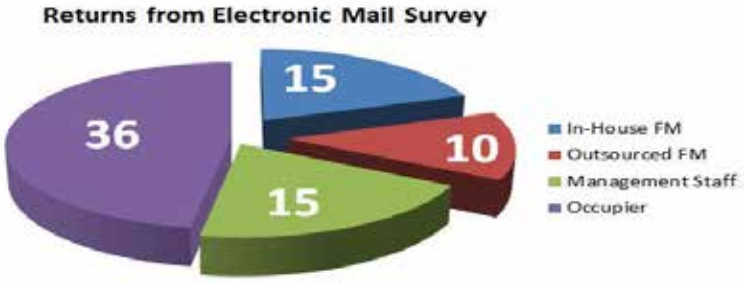

Figure 9 Respondents Profile.

The survey data shows that the findings agree with the original premise of the study that qualified FM equipped with skills and experience, and an enlightened management positively affect sustainability.

9. Case Study

The SFM concept was implemented on a hotel building in the UAE in order to evaluate the building and facilities performance toward sustainability. The building id identified as Building A. It was selected because it fits the required organizational characteristics and the level of FM implementations.

The case study aims to demonstrate the ways of integrating sustainable development and facilities management strategies in order to generate effective tools that can be used to review and evaluate the economic and environmental benefits of implementing SFM in buildings.

10. Building A

The building under consideration for the study is a hotel tower located in Downtown Dubai at the heart of Dubai, close to Burj Khalifa, the world's tallest building. It is an exceptional building with best in class engineering and stands tall comprising of 29 storeys, 290 flats offering occupants facilities such as, swimming pool, sauna, GYM area, and spa. The building includes 5 podium levels as car parking, retails floor, ground floor as the building main reception lobby, and a restaurant. The building has 141 one-bedroom units, 111 two-bedroom units, 26 three-bedroom units, 5 one-room duplex flats, 7 two-room duplex lofts and 16 retail shops. The scope of the study will be limited to the building common area with a total area of 484,612 SQF. DEWA (Dubai Electricity and Water Authority) is the main supplier of electricity to the building. The building's HVAC system chilled water comes from a District Cooling distributer.

The study will provide the optimal effective measures by using SFM that can give the most efficient energy consumption with best payback period and with reduced impact on environment and the building operational cost.

Table 7 Building Information.

Premises Name	LUXURIOUS HOTAL APARTMENTS
Location	Dubai Downtown
Building Type	Hotel apartments
Number of floors	B+G+4P+25
Conditioned space surface	≈ 45,022m^2 estimated
Energy source	DEWA Electricity
Annual Energy Cost	≈ AED 3,480,880 (USD 948,469)
Date of Technical visit	Oct 27th, 2016

11. Characteristics of key contributors

Information provided for the case study came from five personel in the FM team and Two of the building occupants (tenants). Table 2 shows the designation and years of experience within the FM team. Data was collected using an observation checklists, interviews and existing records.

Table 8 Profile of Building Users (Employees) for case study Building A.

Designation	Years of Experience in FM
Building Owner Representative	15
Facility manager	12
Facility officer	2
HSE officer	1
House Keeping Manager	2

12. Methodology

The first stage in the study is to define the building energy base line, followed by a partial implementation of SFM principles and calculation of the economical benefits such as the Return on Investment of each recommendation and the amount of reduction in CO2 emission. The final stage consists of interviews with the FM team, building owner representative and FM experts in order to analyze and get feedback about the SFM concept.

13. Results and Discussions

To examine SFM and its implementation on the building a detailed analysis was carried out. The results show that there is a potential for saving 13% of the cost of cooling, 16% in electricity and 30% in water consumption. This will result in an overall annual saving of about *16%* of the total energy consumption which is about 487,255 AED/year. This will reduce the CO2 emission in the environment by about 461 Tons. This is equal to a total investment of about 499,668.8 AED and about 13 months of payback period.

Table 9 Overall case study energy conversion results by implementing SFM.

S/N	Energy Conservation Measure	Type of Energy	Annual Saving KWh. Lit RTH	Annual Savings (AED)	Saving %	Investment (AED)	P/B (Months)
1	Replacement of 3 way valves to 2 way valve	Cooling	102,758	83,760	4.5%	72,000	10.3
2	Continuous Improvement on Chilled water System	Cooling	130161	106,097	5.7%	55,000	6.22
3	Control Measures on the operation hours of FAHUs in common area	Cooling	4914	4,895	0.7%	0	0
		Electricity	50808	21,847.4			
5	Control the indoor space temperature	Cooling	1405	1,400	0.3%	0	0
		Electricity	24030	10,340			
6	Modification of Motor Pulley for Energy Conservation	Electricity	4384	1,664	0.08%	1,480	10.7
7	Rectification of the VFD system related to Domestic water	Electricity	12045	5,179	0.05%	5,000	11.6
8	Low flow water fixtures	Water	126,150	65,100	30%	27,000	5
9	Improving the FAHU efficiency	Cooling	12,443	12,396	1.1%	51,750	19.9
		Electricity	43,812	18,850			
10	Retrofit the existing lighting fitting measures on the cooling system	Electricity	253,757	109,000	10.7%	300,240	33
11	The reflect of heat losses of lighting measures on the cooling system	Cooling	46,580	46,406	1.42%	0	0
Electricity			388836	167,199	16%		
Cooling			298,261	254,954	13%		
Water			126,150	65,100	30%		
Total				**487,255**	**16%**	**499,668.8**	**13**

The amount of savings from implementing the SFM Guide list for a period of 10 years will be about 5,146,786 AED as shown in Figure 10**.**

Figure 10 The expected cost saving over 10 years.

14. Interviews Discussions

The fieldwork started with a pilot study in the form of a preliminary survey and interviews conducted to determine the causes of difficulties in achieving sustainable FM practices in UAE existing buildings. The survey questions were formulated based on information gathered to address the main objectives of this research and defined the SFM Guide list that can be implemented in any existing building in the country.

The average experience of the respondents is 12 years. They have broad knowledge of FM and thus information obtained can be reliable. In-house FM personnel were interviewed on the potential causes of difficulties in carrying out sustainable FM practices for UAE existing buildings. They were able to provide an integrated overview and insight of their organizations' operations.

15. Analysis of Interview Results

The interviews were carried out in order to understand the interviewees' reasoning behind linking sustainability practices with facilities management and their evaluation of SFM ideas. The interviewees were selected based on their experience in FM, so they can add a value to the research subject by sharing their views and thoughts. The results of the interviews showed that there is an overwhelming agreed that retrofit project in existing buildings is important and should be considered as one of the main elements in the modern FM strategies. They also agreed that there is a link between sustainability and FM. This link will be enhanced further in future. The following additional points have been highlighted in the interviews:

1. Awareness of green practices that must be implemented immediately in all buildings in UAE as a first step toward sustainability.
2. The potential opportunities in the existing buildings to save energy and increase energy efficiency.
3. Building owners have the opportunity to save from 10% to 50% of annual energy consumption by implementing SFM.

16. Findings and Study Limitations

In the UAE, buildings are one of the largest consumers of energy, making them the main producer of the atmospheric CO2 and hence largely effecting climate changes. The existing buildings stock in the UAE stands on about 210 million m2 floor area and this is still increasing (BCA, 2010b). It is, therefore, envisaged that more and more construction works would involve refurbishment, retrofitting and renovation of existing buildings. Wood (2006) mentioned that existing buildings have potential to contribute to sustainability through lower 'embodied energy'. The main finding of this study is that the number of sustainable buildings is very low among the stock existing buildings. The sustainability practices can be easy implemented to the existing buildings as shown in the case study. On the other hand, by linking the concept of

sustainable development and facilities management, the existing buildings can be converted into the green standard ones.

One of the major limitations in this study is that quantifiable data such as embodied energy in buildings were not collected. Another limitation is that the study was carried out on one building only.

17. Conclusions

The stock of existing buildings has risen rapidly as the population continued to increase and human activities have further contributed to the depletion of natural resources. Sustainable development is needed to meet the present needs without compromising the future generations' ability to enjoy their needs. Awareness of delivering a sustainable built environment has increased to meet the needs of economic, social and environment in a balanced way.

There is an increase in the number of designed and built green buildings. There is a need to manage buildings in a sustainable way by considering the three sustainability pillars for FM. This is because a building will not be sustainable even if it is designed to be green if sustainability is not extended into the post construction stage.

SFM can be used to assess more operational buildings in order to generate a pool of database of building performance in the UAE. The top 10% performance assessed under SFM can be adopted as a benchmarking tool. FM personnel may use the indices as an assessment tool to evaluate building performance and to work towards the SFM goal.

Further research can be carried out to look at additional relationships between variables and building performance besides electricity and water consumption such as, economic benefits, social benefits and environmental benefits that are contributed by SFM practices.

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Effects of Green School Environment on Users' Wellbeing and Productivity

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Abstract

Green schools are designed to answer a need for energy efficiency and sustainability. In addition, they contribute to improving the learning process, by enhancing teaching and learning standards and productivity, as well as the health and wellbeing of teachers and learners. This paper assesses the way in which green schools environment impacts on occupants' wellbeing and productivity. This is achieved by comparing between conventional and green schools when assessing users' experience in schools buildings with a special emphasis on Internal Air Quality (IAQ), Thermal Comfort, Lighting (daylight and views), Acoustics Performance, and Maintenance Standards. The study intimates that green schools' Internal Environmental Quality (IEQ) positively impacts students and teachers' wellbeing and productivity, as compared to conventional school buildings environments. This was verified against a case study involving four schools in the Emirates of Abu Dhabi, two of which are categorized as green schools built in accordance with ESTIDAMA Pearl Rating System. The other two schools are conventional old schools. The data used in this study was gathered by means of several methods, namely IEQ readings in audit reports, distributed questionnaires to students and teachers, clinical records, absenteeism records, and finally, interview questions put to green building experts. The results confirmed the study hypothesis, and all the factors taken into consideration pointed to better results by the green school buildings, against the conventional buildings. The study clearly concludes that green schools' environment positively impacts students' and teachers' wellbeing and productivity.

Keywords: IAQ, IEQ, Green schools, ESTIDAMA, Productivity, UAE, GCC

1. Introduction

'Green building' refers to buildings designed, built and operated in order to minimize environmental impact and provide occupants/users with better and healthier spaces to live, work and study (O'mara & Bates 2012, Lumpkin 2013). The top drivers for a green building programme are: energy reduction and water use, operational cost savings, enhancement of health and wellbeing, increase of performance, reduction of absenteeism and retention of staff (CEFPI, 2012, Bernstein, Russo and Carr, 2013, and Bernstein and Mandyck, 2013).

Green schools are characterized by high efficiency and performance and being environmentally friendly, economical, and have effective maintenance process, contributing to better learning outcomes. A Green School Building whether new or a retrofit project is a healthy facility designed and constructed with the use of natural resources, renewable energy technologies, and sustainable materials to reduce ecological footprint, operated to provide safe and comfortable interior spaces, and then maintained to keep its high performance attributes. The design of green schools buildings generally emphasizes on the indoor environment referring to air quality and thermal comfort, lighting (through use of daylight and sustainable artificial light) and noise (through use of good acoustics providing better conditions for listening). Therefore, providing high quality indoor environment ideal for increasing user's productivity, health, and wellbeing.

A dramatic increase in environmental awareness and concerns about quality of buildings especially the IEQ and its effects on occupants' health conditions has been witnessed in the last decades, as a result certain 'green' building standards and criteria adopted worldwide and became mandatory e.g. BREEAM in UK, LEED in USA, Green Star in Australia, and ESTIDAMA in UAE. ESTIDAMA was launched in 2008 in response to the global warming threat and UAE many environmental challenges originated from its rapid development (ADUPC 2013). ESTIDAMA

aligned the green buildings PRS criteria with BREEAM, LEED, and Green Star. Figure 1 depicts the seven core criteria that apply to all construction project types including sustainable schools.

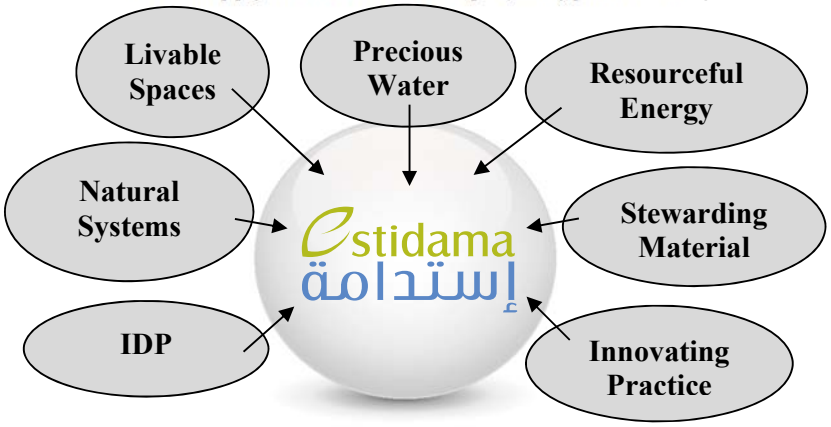

Figure 1 ESTIDAMA Pearl Rating for Green Buildings. Adapted from ADUPC (2011)

The UAE 2030 plan led to increased life expectancy and greater economic opportunity, and thus more environment and public health threats (ADUPC 2011). To safeguard the future generations new measures were adopted to enhance the wellbeing and efficiency of people. In the UAE, and with the understanding that a clean indoor environment improves learning and teaching, ADEC started to design and build new schools facilities in 2011 in compliance with ESTIDAMA PRS providing healthier environment for schools users. The performance of these certified schools has not been thoroughly investigated. In an attempt to explore the IEQ and its impact on users' wellbeing and productivity, this paper reports on research that compares the performance of ESTIDAMA certified sustainable school buildings and the conventional school buildings in terms of IAQ, thermal comfort, lighting, acoustics and maintenance standards together with their effects on users' wellbeing and productivity.

2. Sick Building Syndrome (SBS)

SBS is caused by inadequate ventilation, chemical and biological contaminants from both indoor and outdoor sources (Miller et al. 2009). Negative aspects of sick school buildings include: poor IEQ which have poor ventilation system, lack of natural daylight, inefficient cooling/heating system, and poor acoustics create impairment conditions to students' learning abilities (Acuff et al. 2005, Ghodrati, Samari, and Shafiei 2012, Higgins et al. 2005). Heckman & Masterov (2007), and Barnett et al. (2009) indicated that children could be at social high risk if they stay in an adverse environment. ASHRAE reported that employee productivity is reduced due to poor IEQ causing great economic loss for the American businesses in 1999 (Hepner & Boser 2006). Inadequate air circulation, poor lighting, mold building up, carpeting and furniture materials, variances in temperature, toxic adhesives and paints, pesticides and high concentration of pollutants (USGBC 2012). 50% of all illnesses are caused by polluted indoor air (ACAAI, 2009). The common conditions of SBS affecting users are respiratory problems, headaches, dizziness, eyes-nose-skin irritation, stress, etc. (Fisk 2002 and Ghodrati, Samari, & Shafiei 2012). No teacher or student can experience optimum productivity and wellbeing if he or she is suffering from the said conditions (Ries et al., 2006). Similar findings by US EPA show that students in poor condition schools score 11% in test scores lower than those in well maintained good condition schools (EPA 2012). People suffering from SBS experience a feeling of lethargy and tiredness within a few hours of entering non- sustainable buildings and usually these symptoms vanish once the individual is out (Burge 2012 and Smith & Pitt 2012).

Buildings related illnesses are very costly not just to the individual but to the organization as a whole because such illnesses result in reduced productivity of the occupant via absenteeism (Miller et al. 2009, and Labuhn 2010).

3. Effects of Indoor Pollutants and Volatile Organic Compounds (VOCs)

VOCs include volatile hydrocarbons and other organic molecules emitted in the atmosphere from both biogenic and anthropogenic sources. VOCs and SVOCs are found substantially in building materials, art supplies, paints, markers, lacquers and printers (Adgate et al., 2004). VOCs are of high risk if inhaled. Acetone, Benzyne, Ethylene glycol, Formaldehyde, Methelyne Chloride, Perchloroethylene, Toluene, Xylene, and 1,3 Butadiene. They can be found in carpets, home and personal care matters. Environmentalists argue that air pollution is the major cause of child respiratory problems, allergies and lung cancer. Pollutants derive from plenty of sources located both internally and externally. Mendell & Heath 2004, and NRC (2006) proved that there is a link between exposure to high concentrations of ozone, nitrogen oxides and carbon dioxide and the degree of absenteeism among students.

Other pollution sources come from cleaning products, air fresheners, fuel for heating, educational materials, building materials, equipment and furniture, as well as micro- organisms (such as fungi) that produce allergies and asthma (Bauer, Mosle, & Schwarz 2010 and Ghodrati, Samari, & Shafiei 2012, Acuff et al. 2005, NRC 2006). IAQ can be affected also by extreme weather circumstances that cause extreme temperatures, and humidity problems. These factors contribute not only to students' absenteeism, but also to teachers' health problems and diseases. Dealing with an increased quantity of air pollution in schools implies deficient conditions for teachers and unfriendly-unhealthy learning environment for students.

4. Effects of Poor Ventilation, Inadequate Temperature, Humidity

Inadequate ventilation results in student inability to concentrate thus decrease performance (Higgins et al. 2005, Kats, Perlman & Jamadagni 2005). This is because of the main source of carbon dioxide in buildings is exhaled breath. Even though carbon dioxide is not a threat to health at levels typically found indoors, however due to the poor ventilation conditions the carbon dioxide levels are not diluted (Alevantis & Levin 2011 and Smith & Pitt 2012).

The key variables of thermal comfort are temperature and humidity. If temperature is maintained at the far end of the comfort zone, then adverse health symptoms are expected to increase and productivity may decrease as a result (Ghodrati, Samari, and Shafiei 2012). It is observed that warmer temperatures are likely to reduce performance whereas colder temperatures are related to reduction of manual skills and speed (Smith & Pitt 2012). Seppanen, Fisk, and Lei (2006) found that performance can decrease by 2% for every degree Celsius above 25°C, whereas, between 21°C and 25°C performance remains unchanged. The study, therefore, strongly advises that temperatures in school should not exceed this threshold.

Occupants of non-sustainable buildings with inadequate temperature, humidity, and poor ventilation might suffer from irritation and fatigue. Advanced ventilating increases airflow and helps reducing occupant's contact with air borne microbial agents. Just as fatigue signifies lowered productivity, irritation signifies lack of the sense of wellbeing.

5. Effect of Non-sustainable Building Material

Various rating systems and standards of green buildings have also focused on the selection of constructing materials to improve IAQ (Alevantis & Levin 2011 and Smith & Pitt 2012). Unlike green materials, non-sustainable materials pollute the habitat on which the building is constructed (GGGC 2011). This lowers the environmental cleanliness of both the building and the surroundings. Non-sustainable building material that is used during construction or throughout the building life cycle produce toxic fumes i.e. CO_2 that affects the overall IEQ and cause discomfort. WBDG Sustainable Committee (2013) stated that the use of non-sustainable materials in buildings adversely impact on users' health. Table 1 provides the Red List of non-sustainable material that should be avoided in building construction.

Table 1 List of Non-Sustainable Materials Used in Building Construction

SN	Non-Sustainable Material	SN	Non-Sustainable Material
1	Halogenated Flame Retardants	8	Hydro chlorofluorocarbons (HCFCs)
2	Asbestos	9	Formaldehyde
3	Polyvinyl Chloride (PVC)	10	Chloroprene (neoprene)
4	Mercury	11	Wood treatments containing creosote, arsenic or pentachlorophenol
5	Lead	12	Petrochemical fertilizers and pesticides—for the duration of the certification period or needed for subsequent operations and
6	Chlorosulfonated Polyethylene	13	Cadmium
7	Chlorofluorocarbons (CFCs)		

The new BREEAM Technical Manual contains a section on IAQ in a chapter on health and wellbeing, which includes challenges such as visual comfort, water quality, thermal comfort, acoustic performance and overall safety and security. Palanivelraja and Manirathinem (2010) state that sustainable structures use natural resources such as water, energy, materials and land in a more efficient manner, and using most of the natural light and improved air quality so that these buildings make contributions to enhanced comfort, health, and productivity levels. Figure 2 shows the factors taken into consideration when designing green buildings using ESTIDAMA, BREEAM, LEED, Green Star, and other systems to enhance the productivity and wellbeing levels of the people using these buildings.

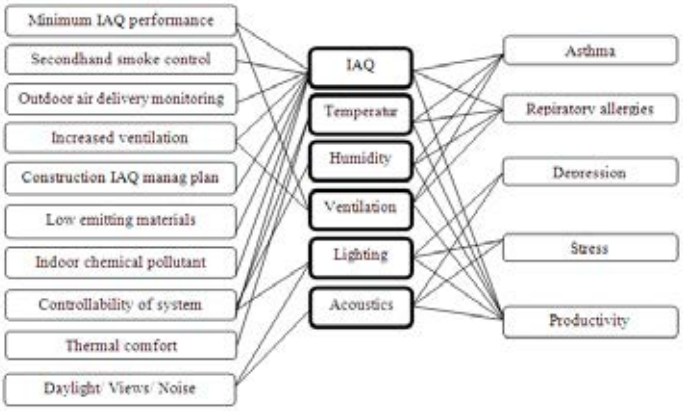

Figure 2 IEQ Occupant Wellbeing and Productivity Structure. Source: Ghodrati, Samari, & Shafieri (2012)

6. Effects of Green Schools Environment on Users' Wellbeing and Productivity

Bernstein and Mandyck (2013), and Cole (2013) found that 87% of higher education institutions and 91% of K-12 schools respondents reported that health and wellbeing are better in green buildings. Furthermore, 63% of higher education institutions and 74% of K-12 schools agreed that green buildings directly and positively impact productivity and improves standards of facilities.

As specialized literature posits the advantages and positive effects of building green schools are manifold (Barr 2011). There are a variety of factors to take into account when constructing green buildings, these factors include the effective use of land, the location of the site, the materials used, water and energy efficiency, as well as aspects related to pollution and the inhabitants' wellbeing and health (Yu and Kim 2011). While all these factors are likely to have a significant impact on students and teachers' health, wellbeing and academic performance, the indoor environment is even more important. Cole (2013), and Taylor (2009) argues that there is a direct relation between educational space and learning where architects must understand the learners' developmental needs and integrate their design accordingly.

The Brundtland Report in 1987, defined green/sustainable development as that that meets the needs of the present without compromising the ability of the future generations to meet their own needs (Smith & Pitt 2012). A green building is believed to address the problem of students and employees disengagement (Pech & Slade 2006). Various researches show that teachers experience increased job satisfaction and productivity level by working in green buildings. Previous studies suggest that it is essential to offer environment that favorably impact students' and teachers' wellbeing and productivity. The potential links are students and teachers' engagement during teaching- learning hours resulting in enthusiastic and efficient relationship with their work and looking up to challenges without being stressed over the situation (Bakker et al. 2008). Pech & Slade (2006) cite that working in a more calmer and reduced-stress environment if not stress-free, benefits in the form of high interest level, adequate decision-making power and low absenteeism, along with participants' focus on the root-causes (poor school environment) such as IAQ to address future problems.

Green schools provide healthy environment conducive to learning while saving energy, resources, and money (Newsham, et al, 2012, Barr, Brian & Cross 2013). Singh et al. (2010) concluded that those working in green buildings would have experienced increased productivity that can result in an additional 38.98 work hours per year for each occupant.

7. Research Methodology

The study used quantitative and qualitative methods in collecting the data: IEQ readings, students-teachers perceptions through postal questionnaires, experts' views through online interview questions, and finally, absenteeism and clinical records through schools clinic records. In the case study, two tools were used to collect information: physical audit through taking readings of IEQ at various locations inside the schools buildings, and postal questionnaires handed over manually to schools principals for collecting users' perceptions. An online tool is used for structured and semi structured interview questions to get the green building experts' views on green buildings and their effects. The real names of the participating schools were concealed for confidentiality purposes.

For quantitative information, an audit was conducted for each of the participating schools. The audit comprised readings for IAQ, acoustic performance, lighting and thermal comfort. All instruments employed in the research were supplied by ADEC and the readings were taken with the support from ADEC's EHS Engineer.

Fieldwork at both Green and Conventional Schools: Issues referring to the IEQ readings, students and teachers questionnaires, clinic and absenteeism records, and experts' interviews were carefully considered and all formed the different fieldwork sources.

Physical Environment: Data on the physical environment was collected, considering its significant influence on occupants' wellbeing and productivity. A relationship was identified between the learning space and the students and teachers performance.

Audit Report-Readings for IEQ at Schools: Readings on the quality of the indoor environment were provided. The readings undertaken were about the levels of IAQ, thermal comfort, lighting and acoustics performance, and audit reports. All readings undertaken had to comply with ADEC EHSMS, as well as with the standards and guidelines required by ESTIDAMA.

Students and Teachers Perceptions on IAQ, Thermal Comfort, Lighting, Acoustics and Maintenance Standards: The participating schools, were given two sets of questionnaires distributed to both students and teachers through Schools' Services Division. In addition, absenteeism and clinical records were provided and analyzed to study effects on the wellbeing and productivity of schools users.

Students and Teachers Questionnaires: The questionnaire comprised of six sections covering: IAQ, Thermal Comfort, Lighting, Acoustics, Maintenance Standards, and Effectiveness of Overall School Building Quality. The respondents of this questionnaire were children and teenagers of mixed gender. The questionnaires were prepared in English and Arabic.

Clinic and Absenteeism Records: Evidence collected by means of questionnaires, interviews and audit reports of the four schools were corroborated with clinic records of each school's physician, particularly records of students visited the physician complaining of dizziness, headaches respiratory problems, various irritations of eyes, nose and skin, or even stress. The analysis also included the frequency at which students asked for medical help. The focus was on occurrences of absenteeism caused by poor medical conditions, or even psychological disorders.

8. Data Analysis and Results

8.1 IEQ at Schools

Table 2 shows the IEQ parameters and scales considered for the study. Readings taken at the four schools have been assessed towards determining whether green schools offer superior health and learning conditions. IEQ readings were compared with the standards for healthy schools such as ISO, ASHRAE, and NHMRC. The readings were taken with consistent timings at each school between 10:00 AM & 1:00 PM and with similar weather conditions in all locations. Readings were taken in various classrooms, and offices in each school. An average reading was calculated and recorded in the audit report for each area.

Table 2 Scale of IEQ Parameters' Measurements.

Parameters	Scale
CO_2	100:1
CO	1:1
VOC	10:1
Formaldehyde	0.01:1
Airborne Particles	0.0001:1
Temperature	10:1
Relative Humidity	10:1
Lux	100:1
Sound Level	10:1

The readings revealed that School-D (conventional school) was the least compliant with the standards of healthy schools. Records from School-C show better IEQ readings due to the fact that it was refurbished in 2011. However, there are still many areas of non-compliance with the standards because the refurbishment was not a green retrofit.

Readings recorded for the green schools are much better than those recorded in the conventional schools. School-A shows full compliance with the set standards. It should be noted that the school was awarded the ESTIDAMA three PRS certificate. School-B School parameters were not at the same level of compliance despite the fact that it was also designed and built in accordance with ESTIDAMA PRS but never been certified as green school by ESTIDAMA.
IEQ for classrooms are shown in table 3 below and demonstrated in Figure 3.

Table 3 IEQ Classrooms Readings.

School / Parameter	School-A	School-B	School-C	School-D
CO2	310	720	1040	3540
CO	6.9	7	10	17.2
VOC	65	80	111	156
Formaldehyde	0.055	0.11	0.14	0.2
Airborne Particles	0.009	0.21	0.27	0.055
Temperature	23	23	25	17
Relative Humidity	46	46	56	70
Lux	300	290	247	198
Sound Level	35	38	41	61

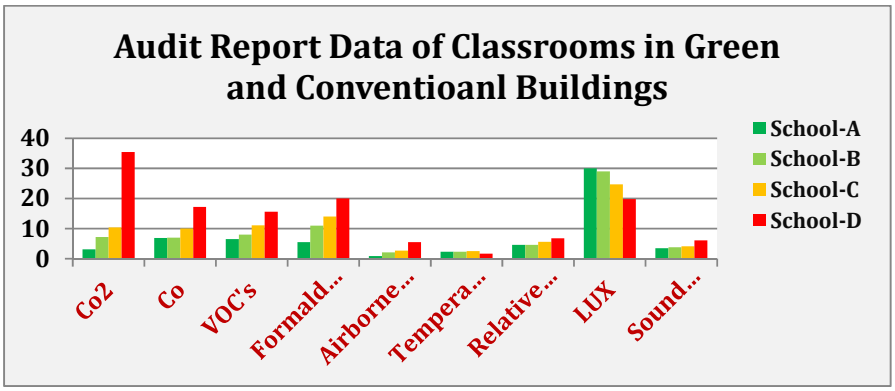

Figure 3 Comparison in IEQ in Classrooms at Green and Conventional Schools.

8.1 Schools IEQ

On average 99% of the 125 teachers and 90% of the 1573 students at the Green Schools (School-A and School-B) participated in the study, compared to 93% of the 113 teachers and 87% of the 1192 students from the conventional schools participated. The analysis of information collected reveals that students complained more about their learning environment in terms of sound quality, lighting, and other directly perceivable factors. Teachers, however, accepted the work environment conditions. Students were having difficulties concentrating in the classroom and complained about the standard of maintenance carried out in the conventional schools, and rated them inefficient. The analysis of responses by students and teachers are shown in Figures 4–9.

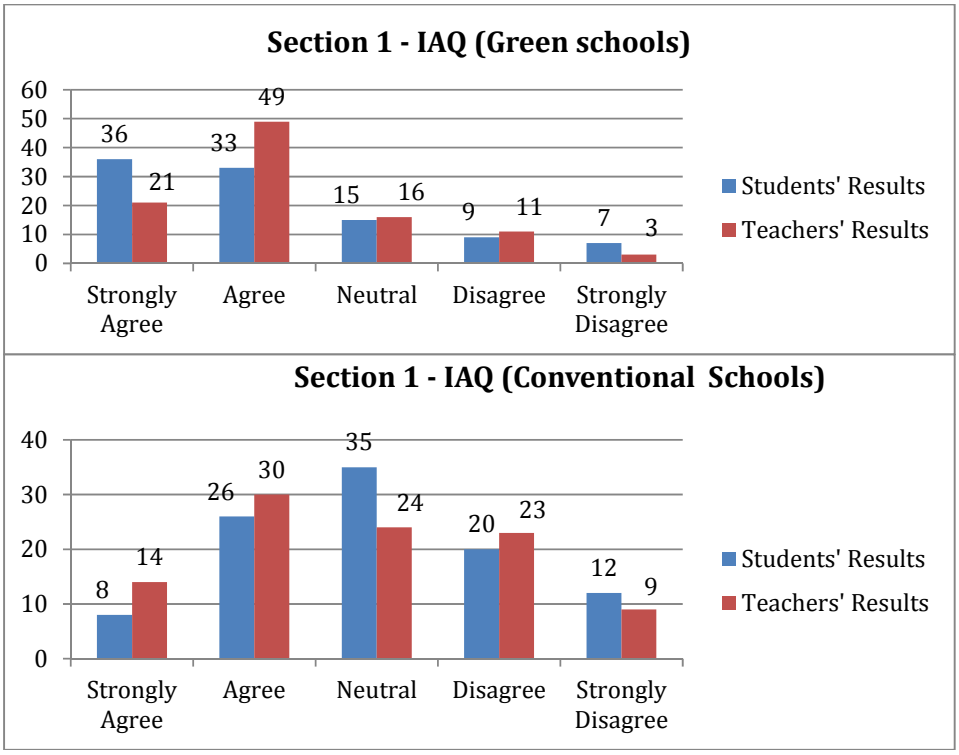

Figure 4 Students – Teachers Perceptions of IAQ at Green Schools Versus Conventional Schools.

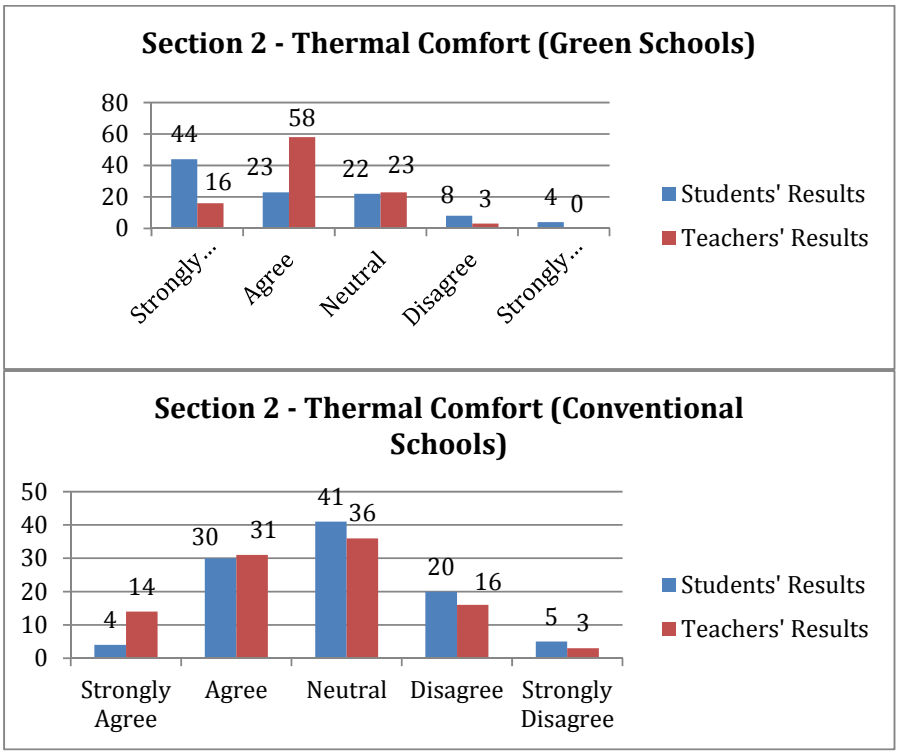

Figure 5 Students – Teachers Perceptions of Thermal Comfort at Green Schools Versus Conventional Schools.

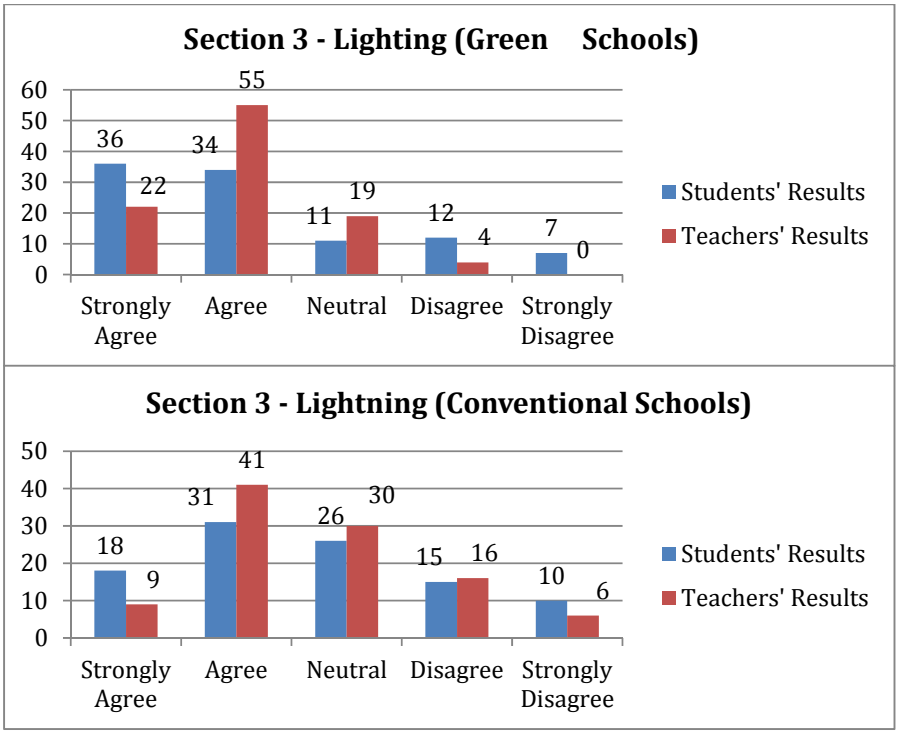

Figure 6 Students – Teachers Perceptions of Lighting at Green Schools Versus Conventional Schools.

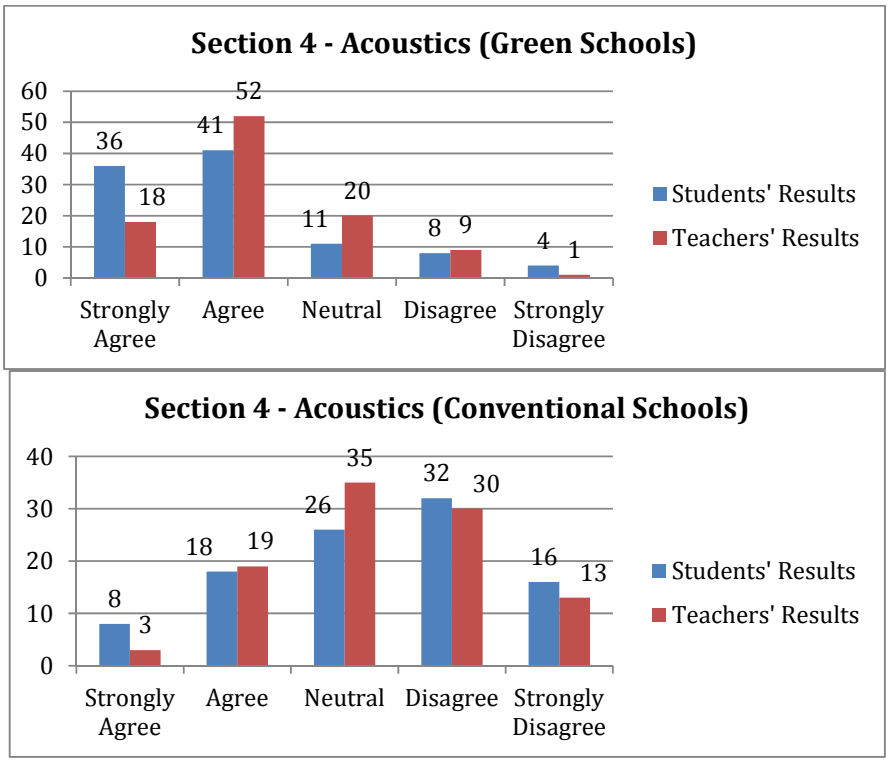

Figure 7 Students – Teachers Perceptions of Acoustics at Green Schools Versus Conventional Schools.

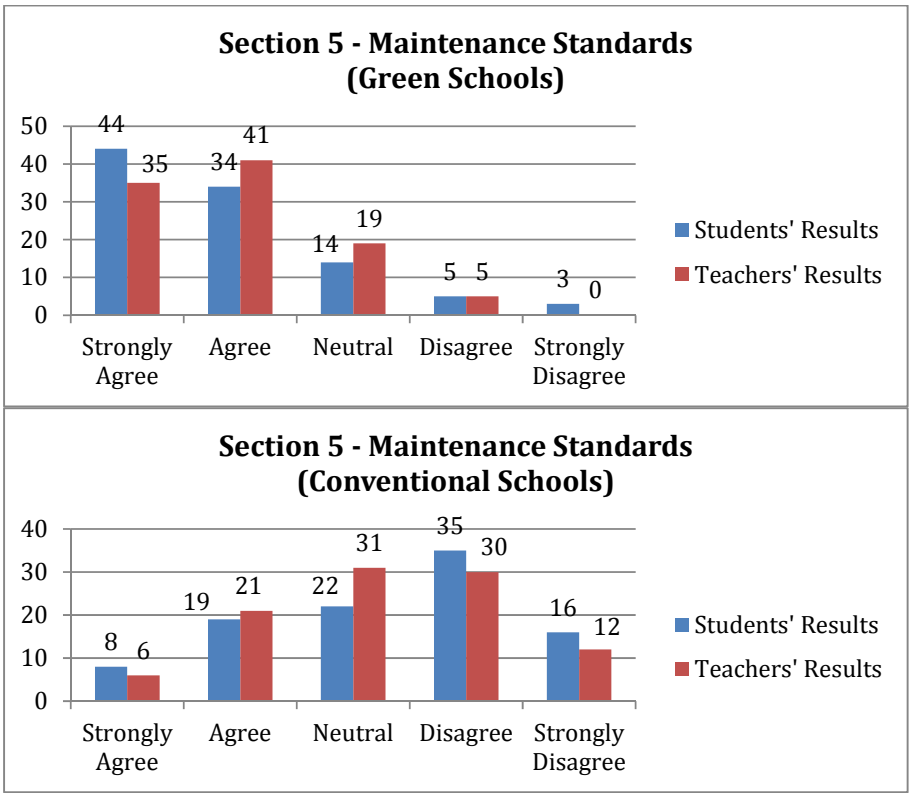

Figure 8 Students – Teachers Perceptions of Maintenance Standards at Green Schools Versus Conventional Schools.

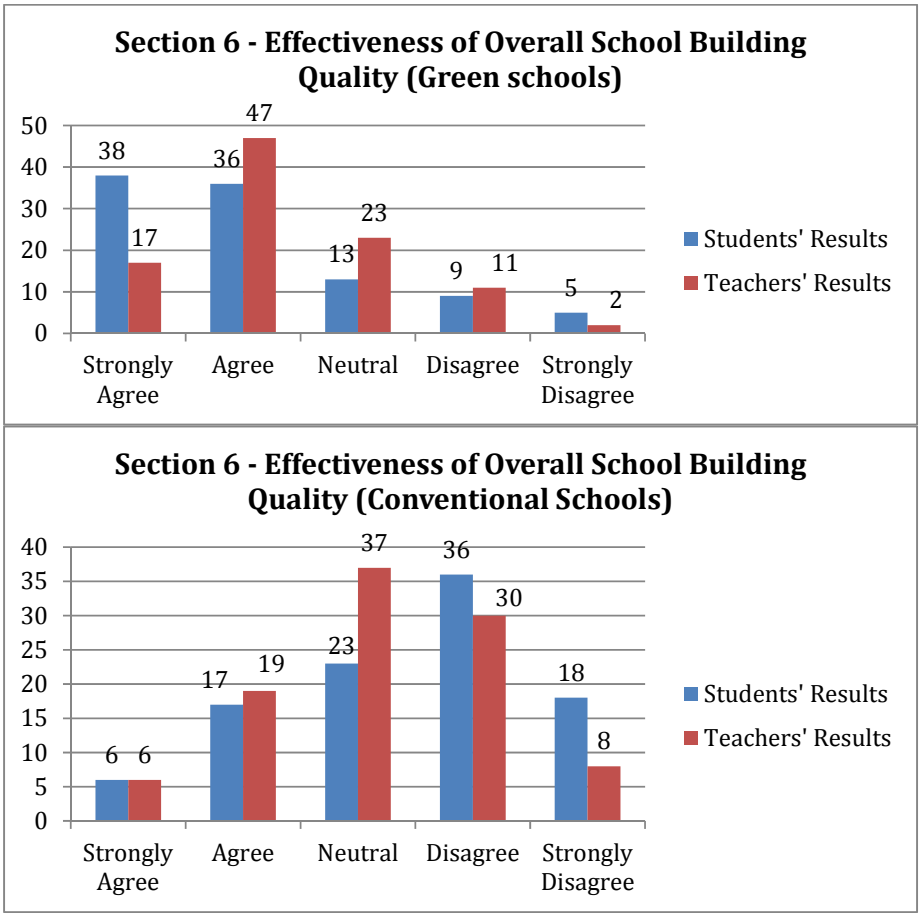

Figure 9 Students–Teachers Perceptions of Overall Effectiveness of Green Schools Versus Conventional Schools.

9. Analysis of Data of Clinic and Absenteeism Records

Absenteeism records were collected from the four schools for a period of six months. Table 4 shows the data collected from school clinics stating reasons of students' visits. It is evident from the records that students in the conventional schools suffered from various symptoms that may relate to the school's IEQ. Symptoms may be acquired from other sources.

Figure 10 displays the total number of clinic visits at each school. School-A ESTIDAMA has the lowest number of clinic visits demonstrating an excellent IEQ compared to School-D with a much higher absenteeism records. These results clearly show green school may positively affect the physical health and safety of schools' users. There is a 39.5% difference between the mentioned schools of the percentage of people that attended the school clinic over the set period (6 months). Similar results were achieved in another case study conducted by Al-Shemery and Al-Hajj (2014), where staff productivity increased by 37% after improved HVAC system is installed in premises.

Table 4 Reasons and Number of Students Clinical Visits.

	School-A	School-B	School-C	School-D
Asthma	2	7	10	25
Allergy	4	6	14	20
Nasal Congestion/Sinus	7	5	11	15
Shortness of Breath	0	4	6	25
Headache	20	35	51	92
Fatigue/Dizziness	8	20	39	110
Eye/Nose/Throat/ Skin Irritation	5	22	25	39
Total Clinic Visits	46	99	156	326
Total no. of Students in the School	998	575	452	740
Percentage	4.6 %	17.2 %	34.5 %	44.1 %

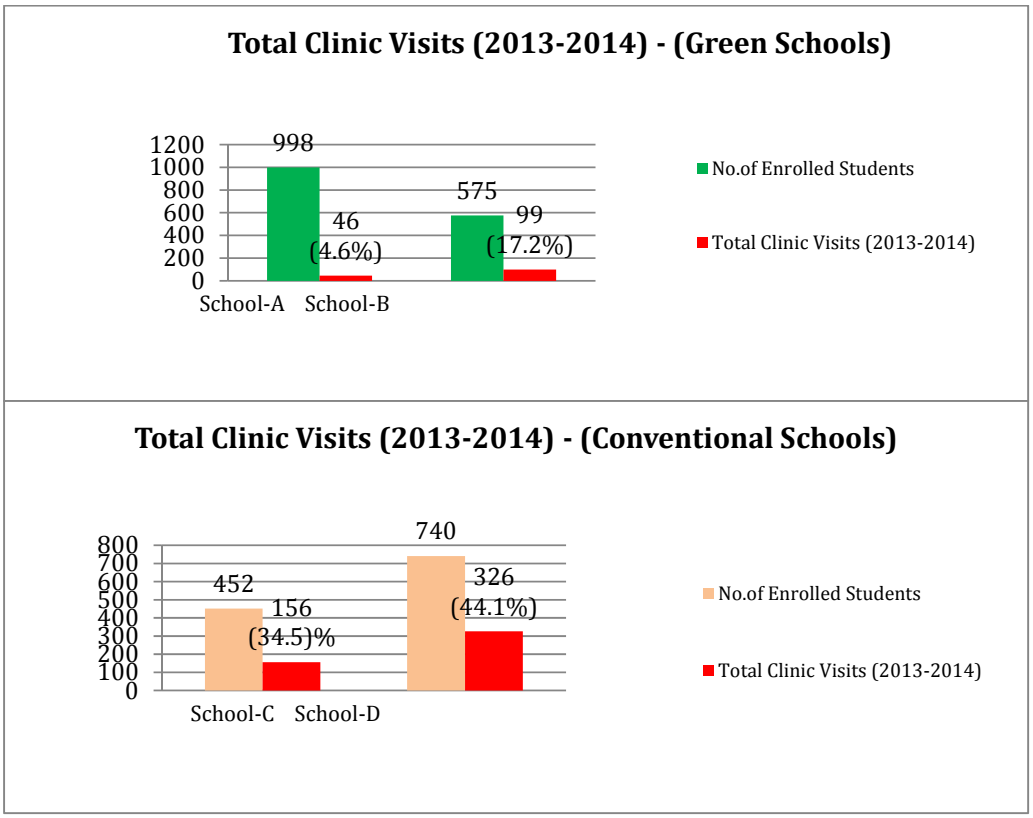

Figure 10 Number and Percentage of Clinic Visits of Green and Conventional Schools.

Clinic records were further analyzed and it was apparent that the high rate of visits was due to headache and dizziness. These symptoms could be caused by poor IAQ highlighting the possibility that School-D could be having SBS issues. The symptoms of sickness at each School-Are demonstrated in Figures 11 and 12.

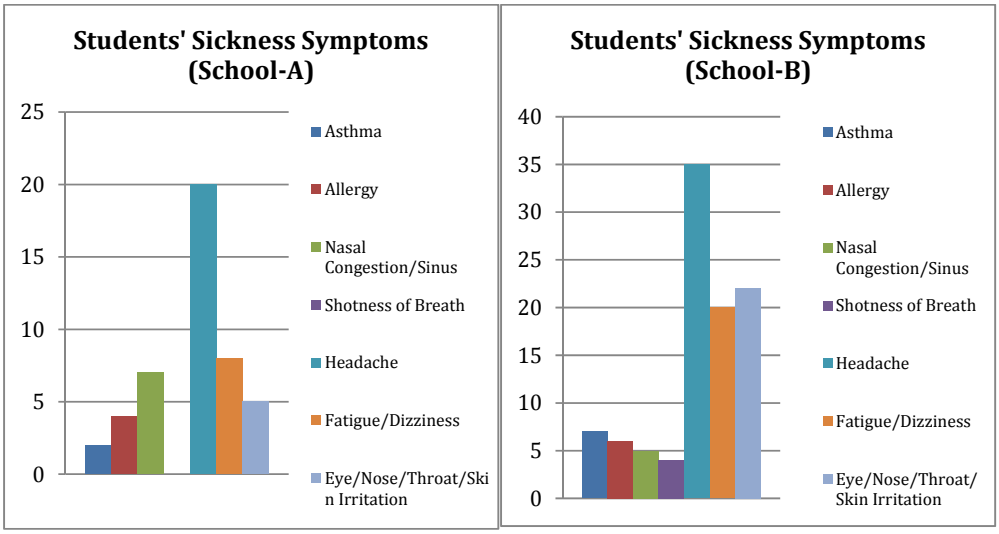

Figure 11 Students' Sickness Symptoms at Green Schools.

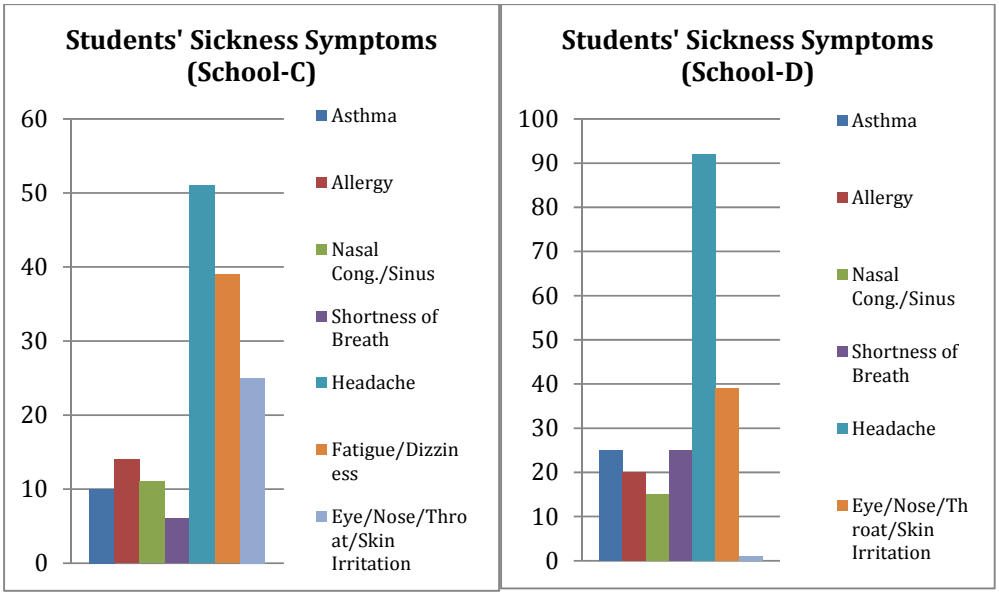

Figure 12 Students' Sickness Symptoms at Conventional Schools.

Students' absenteeism records due to sickness from 15th September 2013 until 6th March 2014 were also analyzed revealing that conventional schools have a high number of absenteeism compared to the ones in green schools especially at School-D as shown in Table 5 and Figure 13.

Table 5 Absenteeism due to Sickness at Green and Conventional Schools 2013-2014.

	School-A	School-B	School-C	School-D
No. of Absenteeism due to Sickness	29	37	52	150
Total no. of Students enrolled in the School	998	575	452	740
Absenteeism Percentage	2.9 %	6.4 %	11.5 %	20.3 %

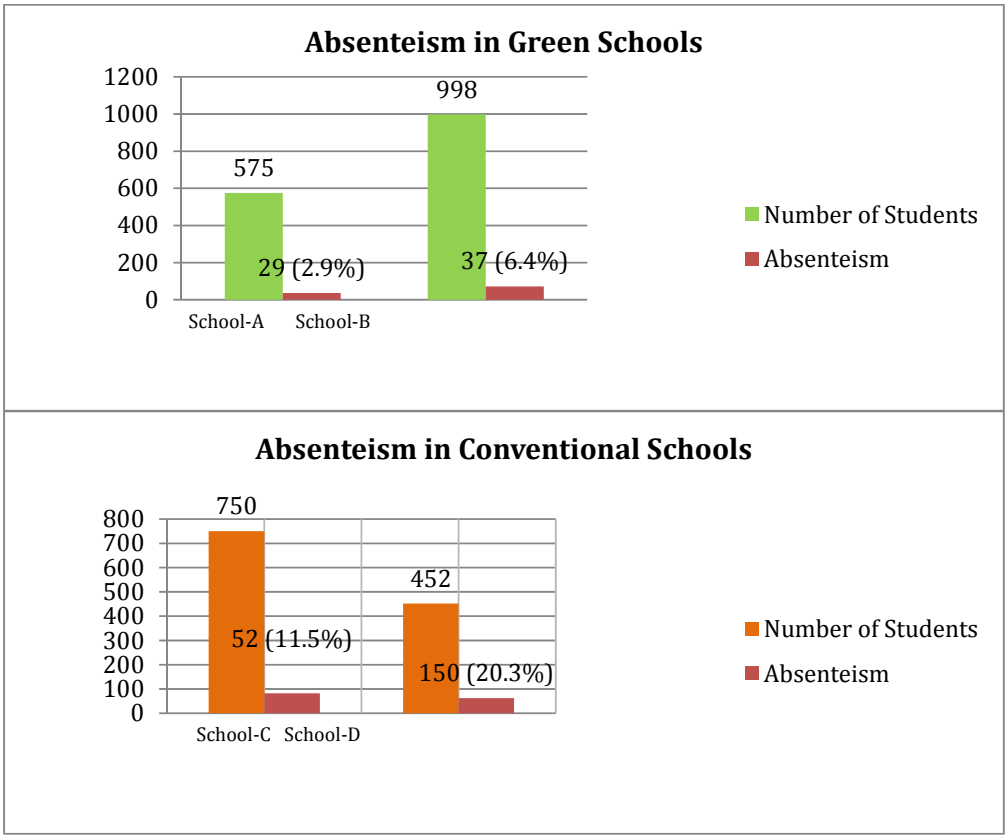

Figure 14 Absenteeism due to Sickness at Green and Conventional Schools.

The figures provided by the measurements of IAQ, thermal comfort, lighting and acoustic conditions indicate that the overall conditions provided by green schools for teachers and learners are superior to those offered by the conventional schools. CO_2 levels in School-A and School-B schools were below the critical level of 1000 ppm, whereas both conventional schools, School-D and School-C, had much higher risky levels. CO levels were significantly lower in the green schools than in conventional schools, whereas the values for VOCs measurements in the two green schools were roughly half of those in the two conventional ones. Visible lower values were recorded in Formaldehyde and airborne particle levels mainly in School-A, revealing that overall IAQ is superior. With regard to the thermal comfort, temperature values were at the median range of the standard reading for green schools ($23\ ^0C$), while being at the lower edge in conventional schools. Humidity levels were more diverse, as the two conventional schools, had more humid environments than the two green schools.

Conventional schools demonstrated poor quality of lighting due to deficiency of natural light and use of ordinary artificial lights. Green schools, however, provided good acoustic performance.

In comparison with the remaining three schools, School-A certified by ESTIDAMA provided a strong evidence of enhanced IEQ, thus enhanced environment conditions to users.

10. Students and Teachers Overall Satisfaction

Students and teachers at green schools expressed more satisfaction with the schools' IEQ, compared to those in conventional schools demonstrating that green solutions improve the learning environment in schools, encouraging developers to adopt more measures for making schools greener. This is further supported by the results of the survey.

11. Students' and Teachers' Wellbeing and Productivity

School-D students shared similar opinions of the negative aspects of their school. However, the results reflected that green schools are palpably healthier places that have positive impacts on wellbeing, productivity and health. The high ratio of the absenteeism due to sickness along with frequent visits to the clinic due to various symptoms indicate that students health, wellbeing and productivity are at risk while studying in conventional schools. These results vividly portray that since students experience a rich sense of wellbeing in green schools; the absenteeism in green schools are lower than conventional schools.

Teachers were highly supportive of the study as 100% of teachers participated at School-A and more than 90% from the other schools demonstrating high commitment towards improving the learning environment by promoting the green agenda. Teachers confirmed that they benefited from green buildings through their own increased enthusiasm and experiencing better performance by their students. Teachers who worked in conventional schools before were able to directly compare both environments and constructively evaluate the impact on users' wellbeing and productivity.

12. Conclusions and Recommendations

The newly ESTIDAMA PRS designed-built schools provide users with healthier environment, while responding to the ever-increasing need for economic potential, energy saving and increased life expectancy.

There is a strong correlation between the results obtained in the literature and the results obtained from the analysis. The study confirms that student and teacher health, wellbeing and academic performance is enhanced due to the high quality of indoor air, thermal comfort, lighting, and acoustics performance.

The study recommends that green retrofit should be considered for all schools future refurbishment in accordance with ESTIDAMA PRS. Also, involve Facilities Managers in school construction projects from the design stage to ensure incorporation of operation and maintenance issues effectively. In addition, ensure collaboration between designers and educators to evaluate needs for better educational environment. Furthermore, conduct appropriate due diligence and develop a list of items that directly impact learning environment for early evaluation in the design process. Finally, focus on educational needs rather than budget to provide environments conducive to achieving better academic performance.

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Heritage, Markets & Sustainability - Architectural Identity in a Changing World: Case Studies From Bahrain & Bosnia

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Abstract

Sustainability has gained an increased international recognition and become central to development strategies and human settlement policies. It is essentially a multi-sectors pursuit of socio-cultural, economic and environmental objectives that recognise the complexities, dynamics and interrelations of the built environment. Hence, this will necessitate comprehensive approaches to the ways heritage buildings are considered, evaluated, managed and used for co-ordinating among different actors and activities in order to meet present and future needs. Unfortunately, the full potential of heritage sustainability has not been sufficiently realised because the notion itself has been either casually used or misunderstood. Therefore, the basic principles and relationships between heritage and sustainability have to be clarified and then holistic innovative frameworks, demonstrating economic and environmental potentials, have to be formulated if the maximum benefit is to be achieved. However, these tasks should be seen in the light of the enormous challenges of urbanisation, globalisation and information revolution, which are confronting our cities and villages today changing and diminishing their cultural identify at a rapid speed.

The paper focuses on sustaining heritage places that go beyond the mere stylistic fashion of recycling tradition. This is extremely important in a global modern world, where culture has been cloned, marketed and consumed. In this regard, traditional Markets / Souqs in Bahrain & Bosnia provide excellent case studies despite the difference in their physical, social and economic indexes. The paper examined how heritage places have been revived, protected and reused with the view to demonstrate their importance on economic, social and environmental levels; the basic dimensions of Sustainability.

Key words: Bahrain, Bosnia, Heritage, Sustainability, Market / Souq & Architectural Identify.

1. Heritage Under threats

From the Industrial Revolution, to Modernisation to Globalisation, cities have been undergoing profound transformations and facing serious challenges and problems. Real estate developments, high-rise buildings, shopping centres and recreational touristic facilities - aim to attract the international investors - visibly manifest the invisible linkages and interactions that congregate cities / societies through global economy and communication technologies. Indeed, communities across the world have been homogenized through different networks and flows of information, goods, ideas and finances. The sensational titles of "The Death and Life of Great American Cities" (Jacob, 1961), "When We Built Again" (Ward, 1985), "Crisis in the Built Environment: the Case of the Muslim City" (Akbar 1997), "Home from Nowhere" (Kunstler, 1998) and "City: Rediscovering the Center" (Whyte, 2009) offer a bleak image of the sterility of our modern cities physical approaches to planning, with its professional domination; revealing their failures in creating liveable, healthy, efficient and cohesive urban areas. Hence, the importance of heritage as a mean maintaining identity and uniqueness of place cannot be over emphasized.

In such a situation where money, power and images are the driving forces; an important question could be asked of how local/indigenous places can be sustained and their roles redefined in order to reclaim their positions in a global era? Or instead of “rendering of the world as a single place” it is important to examine heritage within the framework of sustainability; where heritage is not seen from nostalgic point of view but considered as a vehicle for social, economic and environmental improvements. This has been clearly explained by Martin K. Meade (1998?) in his article "*Architectural and urban heritage: dead weight or*

dynamic asset for future? When saying:

> In an era of ever-increasing mobility, mass communications, sound bytes and virtual reality, the vital cultural role of the architectural and urban heritage is more crucial than ever, for it offers authentic points of reference linking the past with the present and the future. Rather than considering this legacy as an encumbrance, strategies that see the built heritage as a positive asset forming an integral part of a productive urban dynamic promise to ensure its continued vitality.

The paper explores the above questions through two Market / Souq case studies from Bahrain and Bosnia providing a detailed account of the problems and challenges facing heritage places as well as the potentials and benefits should social, economic and environmental aspects considered. This holistic integrated approach will prove that 'local' modest places can be revitalised to survive the competition of the 'global' hyper forces by offering a taste of tradition and locality while maintaining economic feasibilities, social benefits and environmental integrities. Heritage within the framework of sustainability is difficult endeavour because both heritage and sustainability are exceptionally complex concepts and cannot be narrowed to a single definition. Each has different interpretations and emphasises reflecting various agendas, interests and research inclinations.

2. Heritage in Brief

Heritage refers to the past; both to material and non-material productions of a society passed down from one generation to another but do not necessarily belong to the ancient times. According to Lowenthal (1975), heritage symbolises and embodies a society's shared recollections and is considered 'created' by the contemporary society from the past resources and managed for its present purposes (Graham et.al, 2000). It constitutes both tangible and intangible aspects of social production, the former comprised of buildings, built structures, natural environments and artefacts while the latter is comprised of values, customs ceremonies and lifestyles. Various definitions highlighted different aspects of heritage.

> ...not only something we want to hand down to future generations, it is also something we want to appreciate and experience to the fullest extent (Masser et al. 1994: 31)
>
> ...about a special sense of belonging and of continuity that is different for each one (Millar,1995: 120)
>
> ...exists in the physical attributes of buildings, public spaces and urban morphology; it is experienced by users (inheritors) in the present and it is concurrently in the making of the next generation of heritage (Orbaşli, 2000: 13)
>
> ...an expression of the ways of living developed by a community and passed on from generation to generation, including customs, practices, places, objects, artistic expressions and value (ICOMOS 2002: 21)

These varieties of definition inadvertently gave rise to an array of reasons for heritage protection (Figure 1).

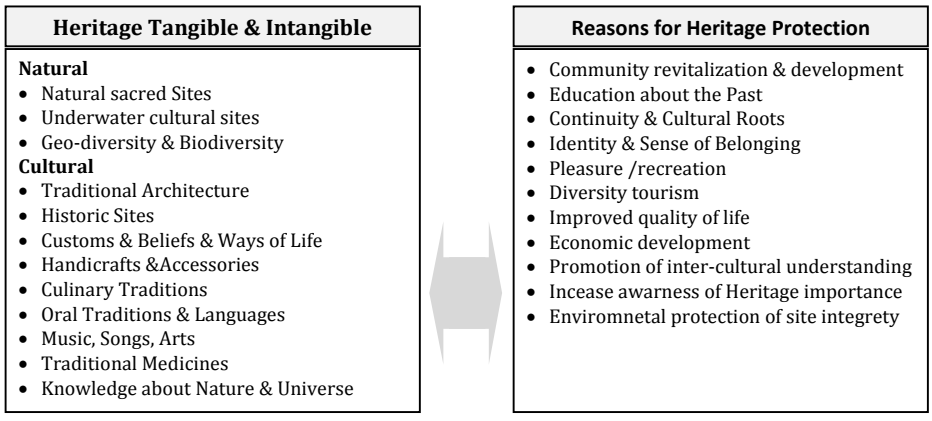

Figure 1 Heritage Types & Reasons for Protection

These reasons for Heritage Protection reflect mix of socio-cultural, economic and environmental aspects which are the basis of Sustainability. Important to note that architectural heritage is not limited to monuments but also covers modest old areas and buildings that are still in use and subject, most of the time, to disfigurements and abuses' by modern developments and insensitive planning policies. In fact, old areas and buildings are living museums where people are not only spectators, but also participants through experiencing architecture – seeing, hearing, smelling, moving and living in. Traditional architecture has also an ecological dimension by responding effectively to the climatic conditions, depending on passive design principles and being compatible with the natural environment.

3. Sustainability in Brief

In the case of Sustainability, the concept has gained a wide publicity and recognition with the famous Brundtland phrase: "*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED, 1987: ?). It aims to finding strategies to promote economic and social developments in ways that avoid environmental degradation. The concept is not new and its roots could be found in many religious doctrines, in the origin of most traditional settlements and societies and in the environmentalists' movements and debates of the 60's and 70's. However, despite the growing literature on the subject, the concept has been described as elusive, vague and subject to wide interpretations resulting sometimes in contradictory meanings (Haughton & Hunter, 1994: 16; Barrow, 1995: 370-71; Greed, 1996: 123; Moffatt, 2001: 4). It is often pointed out that sustainability has become a cliché and a slogan used even to justify unsustainable actions.

> Politicians claim to aspire to it. Development plans claim to 'deliver it'. Developers argue at appeals that they will achieve it. The principle of sustainable development is undoubtedly in fashion. But through overexposure and inaccurate use it is in danger of losing whatever resonance and motivating power it at first … possessed. It is easy to become cynical about it, dismissing it as the latest planning craze (Barton, 1996: 115)

Whilst there are many definitions, sustainability and its application on human settlements have passed from Stockholm (1972) to Rio de Janeiro (1992) to Johannesburg (2002) to Rio +20 in a process of evolution, which is expected to continue in the future. The culmination of the idea was in Rio (1992) when declaring Agenda 21 which directly relates the concept of sustainability to cities. In principle, sustainability is a call for all human actions and interaction with Nature to be balanced and harmonious. It is a call of equality of opportunity (rich/poor, inter- and intra-generational and right of other species); protection of ecological systems and bio-diversity; improvements in human health and welfare; and the restructuring of economic systems and emphasizing on long term benefits (Hall & Pfeiffer 2000; Smith et al. 1998; Barrow 1995). This implies that the social, economic and environmental facets of human settlements should be mutually supportive and integrative. However, the available intersectional model between social, economic and environmental circles is of limited value because it does not allow for different scenarios of interaction (Figure 1). Therefore a new concentric sectoral model is proposed which would better illustrate the different types of interactions between any two sectors and between all the three sectors (Figure 2). Hence it represents the different levels of sustainability usually referred to as different shades or hues of green from pale to dark green or different approaches or levels of sustainability from weak to ideal sustainability (Moffatt et al. 2001: 272-76; Evans, 1997: 6; Greed 1996: 117).

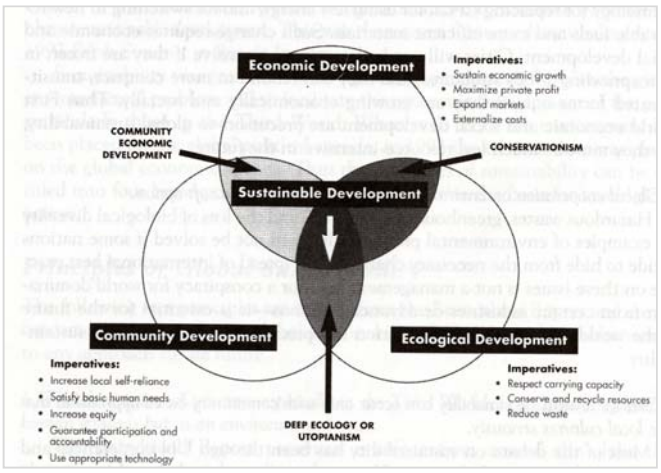

Figure 2 Existing Model of Sustainable Development. Source: Newman & Kenworthy, 1999: 4

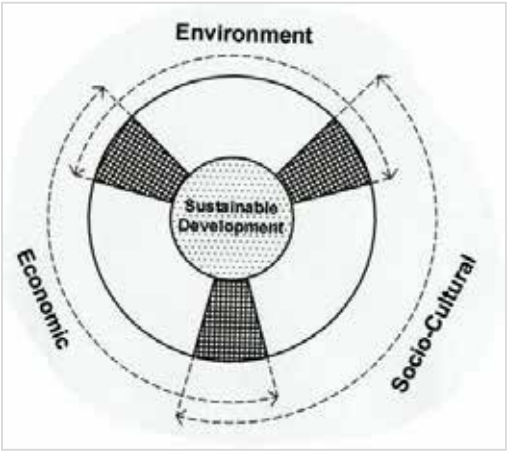

Figure 3 Proposed Model of Sustainable Development. Source: El Masri, 2005: 4

It is clear that achieving sustainability is not a simple undertaking because it requires careful consideration of many important issues that could be summarised in Table 1:

Table 1 Issues regarding sustainability.

Sustainability	Details
Is a dynamic concept	that supports together healthy environment, social cohesion and economic efficiency within a process where fairness, equity, self-reliance and participation are important pillars.
Requires a set principles	of ethical and socio-cultural in addition to economic and environmental ones. Tipple (1994: 121-122) elaborates more on the principles of sustainable development by listing the following principles: Subsidiarity/decentralisation, participation, empowerment, responsiveness, transparency, inclusiveness, realism, multi-sectoral teams and local agenda 21s.
Is a process rather than an end product	it is a journey rather than a destination. Sustainability involves creativity and innovation requiring a set of changes in visions, habits, policies, priorities, ways of life, global impulses, etc.
Is a vision	to be translated locally, regionally and globally with long-term objectives; it *is an investment into the future*. However a special emphasis should be given to the local level and considerations with emphasis on self-determination.

Recognises reality	there is no magic remedy but a variety of integrative approaches in the social, economic and environmental sectors recognising the complexities of the issues involved.
Operates within a corporate global atmosphere	with its inequality and injustice, exploitation and short-term benefits, competition and 'commodification' of the Commons (privatisation) and emphasis on capitalism and market values.
Acknowledges IT Importance	for modelling and measuring and evaluating the progress of sustainable development.

Sustainability paradigm represents a shift from spatial planning or lack of planning with their adverse negative impacts, to ***a-spatial*** type integrating and synchronizing social, economic and environmental dimensions into one coherent view of the world (Greed, 1996: 2). Given the present global system of market driven economies based on circuits, exploitation and short term benefit, urban sustainability represents a shift from mobilisation to reinventing civilisation; city of diversity, conviviality and humanness. (Mega 2000: 230-31; Girardet, 1999: 11-13; Peattie, 1998: 247- 253)

4. Heritage, Sustainability & Traditional Markets

Since its inception, Sustainability concept has been evolved and applied to all aspects of life: Urban developments, Education, Business, Finance, Industry, Wildlife and especially in the field of human settlements. However in the case of heritage, it was recognised that:

> Heritage was long absent from the mainstream sustainable development debate despite its crucial importance to societies and the wide acknowledgment of its great potential to contribute to social, economic and environmental goals (http://whc.unesco.org/en/sustainabledevelopment/)

This was changed in 2030 Agenda adopted by the UN General Assembly (August 2015) when the role of culture diversity was recognized as enablers of sustainable development across its various goals. On 19 November 2015, the World Heritage Convention adopted a *Policy on the integration of a sustainable development perspective into the processes of the World Heritage Convention* representing an important milestone in its history.

> The overall goal of the policy is to assist States Parties, practitioners, institutions, communities and networks, through appropriate guidance, to harness the potential of World Heritage properties and heritage in general, to contribute to sustainable development and therefore increase the effectiveness and relevance of the Convention whilst respecting its primary purpose and mandate of protecting the Outstanding Universal value of World Heritage properties (http://whc.unesco.org/en/sustainabledevelopment/)

Hence the importance of protecting and promoting cultural diversity is equally recognised in addition to environmental bio-diversity. Architectural heritage is a testimony of human history and human creativity in responding harmoniously to environmental, socio-cultural and economic conditions. This could be better illustrated in the case of local markets because of their importance within the urban fabric and their socio-cultural role. They represent a dynamic urban experience where all the senses are engaged; an aim that architecture and urban design relentlessly strive to. Traditional markets, that echo many economic and socio-cultural values, have been facing serious challenges such as: rapid urban growth, increase of land prices, modern planning approaches and drastic changes in retail activity. These modest places, embodiment of cultural identity, have to face the rapid mushrooming of shopping malls and hypermarkets with their variety of facilities, promotions and conveniences. So how these places respond to these challenges in the case of Bahrain- Manama and Bosnia - Sarajevo?

5. Manama Souq

The Souq's growth has been concurrent with the expansion of Manama that was established in 1320 AD and the oldest record of Manama Souq is dated to 1819. The Souq exhibited similar characteristics of local markets flourished in the Arab World and consisted of 22 sub-Souqs that were named either after products or crafts. It was located on the Northern strip adjacent to the sea before establishing the famous Bab Al Bahrain. It was gradually absorbed within the urban

fabric of Manama with increase land reclamation and urbanisation. Thus, the living conditions in the Souq increasingly become hazardous with buildings prone to collapse, dense, unhygienic and the risk of fire. With time, the Souq suffered from a combination of problems that led to diminish its urban importance and economic status; these problems could be summarised as follow:

- Urban growth of Manama and local inhabitants' relocation to modern convenient areas leaving old area to become low-income enclaves for foreign workers
- Modern Urban Planning approach that lack sensitivities in dealing with heritage places, especially car access, parking and integration with new urban areas
- Lack or inexistence of Heritage conservation policies to guide protection and developments within the Souq. Unique historical buildings in Bahrain are under threat of disappearing due to the lack of laws protecting them from economic and urban expansion, according to a top government official. Laws urged to protect heritage.
- We as a nation in the absence of implementation of declaration such as Su Z Hou 1998, the World Heritage convention 1972, Earth Summit 1992 and others destroyed a large part of our tangible cultural heritage. (SAMI, 2007 GDN on Line)
- Invasion of modem buildings into the Souq that do not blend with the architectural style and the organic urban structure
- Lack of regulations to control growth and to enforce maintenance that led to continuous deteriorations and disfigurements of the cohesive market layout and the charming urban characters.
- Competition from the shopping centre phenomena that offer all convenience: air conditioned environment, covered parking, suitable hygiene, and variety of facilities; but lack the interesting experience of the Souq

Several modest attempts to revive the Souq Area have been initiated with the latest dated to the year 2000. It is a wide raging study with phasing strategy of which only phase 1 was completed and could prove to be successful if other phases are updated and implemented. The first phase design was commissioned in 2004 to be occupied in 2010. This was a response to the traders' complains regarding diminishing of commercial activities and dilapidation of old buildings. The project aims to protect the organic fabric of the Souq, whose haphazard development has led to a fragmentation and lack of unity, congestion, lack of safety and many environmental and visual problems. It hopes to reinstate pedestrian movements by improving circulation and ensuring proper parking provision. However, the implementation of the project had to deal with several complications:

- Shifting project ownership from Ministry of Industry & Commerce to Ministry of Works to end up finally with Ministry of Municipalities & Agriculture;
- Coordinating with large number of stakeholders: Various Ministries, Police, Traffic, Civil Defence, Utility Providers, Tenants & Owners, and Chamber of Commerce;
- Dealing with logistic matters such as; Relocating existing tenants and Delay in obtaining demolishing Permits; and
- Minimizing disruption of commercial activities and inconveniences for residents, traders, and shoppers.

Phase 1, named Development of Bab Al Bahrain Souq includes an number of integrated interventions that varied from Restoration of heritage valuable part, to Demolition of deteriorated part and replacing it (infill), to facade rehabilitation (face lifting) to reduce visual pollution, to pedestrian-ization and improvement of circulations, and to improve the hygienic conditions and to promote the Souq as an attractive destination. It aims to reinstate the Souq local character, to improve conditions and most important to be seeds for further improvements. Today, the project becomes an active public space from which journey into the wider Manama Souq starts and ends. Besides it is commercial aspect, Souq Bab Al Bahrain becomes a focal place for entertainments, tourist activities, and festivals especially during the holy month of Ramadan. However the initiative is still incomplete and Manama Souq is still struggling to survive as been recently published (GDN, 28 July 2017: 3 & 30 July 2017 2&3). As been demonstrated physical improvements are not conditional to a full success as the initiate needs to be economically viable and environmental sound. Therefore the Souq conservation strategy needs to be reviewed in light of the various developments that have been taken place since the turn of the century. This could be better resolved if the Souq revival is discussed within the framework of Sustainability that is multi-dimensional and been the centre of Bahrain 2030 strategy.

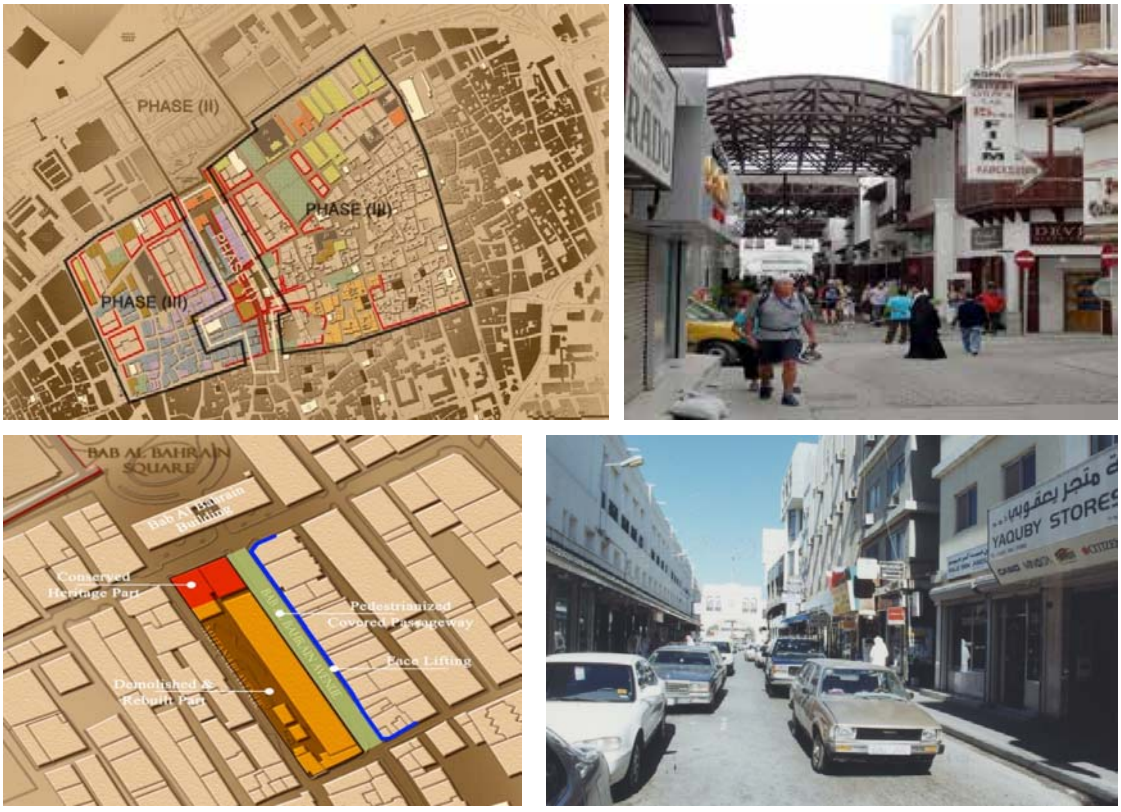

Figure 4 Manama Souq – Rehabilitation Phasing. Source: Gulf House Eng. Archive

6. Sarajevo Souq / Bascarsija

History manifests itself clearly in Sarajevo's urban developments. Since the 15th century, Sarajevo has been expanding linearly with different architectural and planning principles shouldering each other. From the Turkish Oriental to the Austro-Hungarian to the Independence Socialism era, the city grew from East to West allowing these different historical stages to be manifested in its buildings and districts. During the war 1992-95, Sarajevo's architectural heritage suffered badly from destruction and "*urbicide*" phenomenon. In the aftermath of the upheaval, the city has been experiencing another stage of its history and architecture because of increase real estate developments and tourism activities.

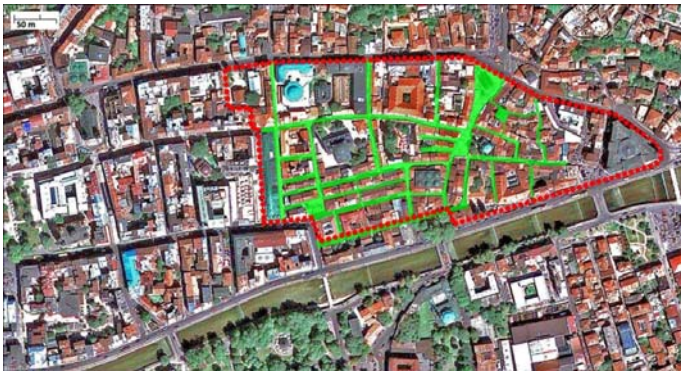

Figure 5 Bascarsija Limit & Pedestrian Network. Source: Author from Goolge Erath Image

Figure 6 Bascarsija Images. Source: Author, Summer 2017

The origin of Bascarsija is dated back to the Ottoman era. It stands today against all odds and misfortunes to remain a unique place and an authentic historical urban centre. Populated entirely by small-scale private business enterprises; the *Baščaršija* reached its peak of development during the 16th century (Figure 4). There were 80 different strictly regulated crafts guilds. They were organized by the type of the craft or *esnaf*, so that the given street would be composed of the shops and workshops of a single or closely related crafts. There were in all 45 such streets forming the Sarajevo Baščaršija (Museum of Sarajevo, 2001: 17). Large numbers of trading centres were constructed too; the most important were the *bezistans*, resembling the souqs of the Arab World. They were followed by khans, numerous shops, storehouses and *dairas* or places were the clerical work was carried out. The most important role in the urban development of Sarajevo was played by the *vakufs* (Arabic: waqf). The establishment of *vakufs* enabled the construction of various buildings such as *madrasas*, mosques, imarets (public kitchens) and *musafirhanas* (hostelry).

Bascarsija is a completely pedestrian zone and has its clear and distinct urban character as well as very well defined boundaries. The fact that thousands of tourists; both foreign and domestic flock to the city each year to experience Bascarsija demonstrates an attraction that is inherent in place. Identity and characters clearly play an important role here. Throughout history, Bascarsija survives and adjusts its role to prove that local modest places could play an important role in economic and social developments. Indeed, it defines Sarajevo as a city and as a part of the national identity. It will be interesting to shed the light on the factors that allow Bascarsija to survive and to conserve its urban identity despites the many misfortunes and disasters (fires, wars).

- Bascarsija Protection is dated back to the early 20th century to be formalised at the end of 1960's when an agreement was finally reached that Bascarsija should be treated as single monument. The regulatory plans for the rebuilding, conservation, restoration and renovation of Bascarsija, adopted in 1975, set out precise measures for the conservation and continued survival of the innermost historic heart of Sarajevo, considering the complex in its entire architectural, urbanistic setting and historic background.
- Sarajevo urban growth where various periods shoulder each other clearly in defined zone: Turkish to Austro Hungarian, to Independence Socialism era to the aftermath of the war and the present modern movement; each occupy a clear defined area with no much intermix.
- Urbanisation is characterised by expansion and population growth and not by displacement of local population or influx of foreign labour force. This could be attributed to the political and administrative system that regulate urban development and determine its objectives.
- Bascarsija's character as a main urban centre and breezing place; this is reinforced by pedestrianazation and controlling car accesses that inflict usually destruction to the integrity of the urban fabric. It is a place to see and to be seen, and a place for gathering and walking. Moving through Modern to Austro-Hungarian to Turkish parts, or vice versa, is a walk through history where multi religion groups can identify themselves and interact. It is a melting pot tailored for human scale with many interesting places to identify
- Adaptation to changes and developments by responding to modern requirements but in a ways that are sensitive to the delicate structure and fine buildings characters. In fact this

ability to adjust, develop with time without affecting urban structure and place identity could be attributed to the strict regulations that control changes, expansions and functional rehabilitation

- Survival of many heritage buildings of different use: religious, khans which add to the use pattern and its continuous operation throughout the day, not morning only. In addition that local population are the ones who operate the shops and many are either inhered the shop or been established for a long time.

These varieties of factors have contributed positively to conserve, to a good level, the Bascarsija's characters and urban structure despite the different unfortunate man-made and natural catastrophes. Indeed, these urban qualities coupled with good environmental conditions free from car pollution are attracting not only local, but influx of tourists in recent years and generating many economic benefits. All these contribute to the survival of this local place and its authenticity in an era of mushrooming Shopping centres and increase global influences. A historic place continue to survive and adapt because of suitable socio-cultural, economic and environmental conditions; the pillars of sustainability.

7. Conclusion

As explained in the two cases of Bahrain and Bosnia, it is clear that there are several important factors that contribute to retain the integrity and characters of local markets. In fact many of the negative factors that inflicted damages in the case of Bahrain are validated in the case of Bosnia despite that there are still a great deal to be accomplished. These factors could be summarised:

- Urbanisation and its impact on local markets and land value, also important to determine the importance of local markets with the urban structure
- Shop management and operation if runs by local or by influx of foreign labours
- Conservation regulations and its history of evolution and implementation; this will determine when preservation actions are been taken because the more delay in imposing control within historic centres the more disfigurements and damages occurred.
- Ability of local place to resist insensitive changes and disfigurements (regulations, administrative system, type of ownerships, people opinion and attachment)
- Ability to adapt and adjust to changes and developments not only to conserve urban characters but also to be able to generate economic benefits and adapt to new modern requirements and technologies
- Use pattern during the day only or extended into the night, the longer time the more economic and social activities are happening.

It is evident that protecting heritage places will not be sufficient as clearly demonstrated in the case of Bahrain and Bosnia. Conservation or revival of local markets should be accompanied and supported with environmental and economic measures to ensure their survival in global world. Physical conservation should be coordinated with socio-cultural, environmental and economic aspects to ensure integration within the framework of sustainability. Surely this not a simple undertaking because it requires to assess opportunities and challenges, to tailor short and long term strategies, to balance between tradition and modern requirements and to understand local and global impulses. This could be done when policies are supported with appropriate regulatory frames and translated into actions plans that set up priorities and solutions. Important to note that conserving local modest places, essence of culture, should also be considered within the processes and policies that shape, manage and finance the cities. They should be connected with urban areas and not stand as isolated island surrounded by roads; to be an integral part of the city and its identity. This requires ingenuity and innovative solution based on participation, collaboration and evaluation, because readymade solutions cannot ensure the desire solution. The more Pillars of Sustainability are maximised the more successes is guaranteed. Conservation should not be treated as a luxury but as a necessity, because history has proven that city without heritage places are cities without identity and soul.

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Sustainability in Architectural Design: A Proposed Framework in Conceptual Designing

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Abstract

How to achieve sustainability in the conceptual phases of architectural design? The paper investigates this research question and attempts to shed more light in this vital area. Architectural design is a complicated activity; it is wicked problem solving in a creative way. The design objective is to satisfy many variables and needs, and in many cases the implementation of these variables and needs contradicts with each other. There is no ideal design solution; the designer selects a solution of more advantages than disadvantages.

The paper presents a framework to reflect of sustainability through its main components in the conceptual design phases. Moreover, the paper utilises examples of students' designs from different design studios and an advanced computer course, each of which has one of the sustainability's components/factors as a theme. The framework implements a proposed rule 'design follows sustainable factors', by focusing on the environmental factors such as thermal, solar, ventilation, daylighting and illumination, and orientation as they have vital impact on building performance. The paper's framework presents certain design methods to be applied in the design studios within conceptual designing.

Keywords: Architectural design, Sustainable factors, Design framekwork.

1. Introduction

The main components of sustainability are social, economic, and ecological environment. The term sustainability in architectural design refers to environmentally conscious design in which the architect attempts at implementing the principles of social, economic and ecological sustainability. In more details, sustainable design should achieve better building environmental performance in the regard of the reciprocal relationship between society and economy. The sustainability also can be comprehended as the methods to minimize environmental impact in buildings and to reduce energy demands of buildings.

Postponing the integration of those sustainable factors to the later design stages would negatively affect the design output (Burger 2008, Fasoulaki, 2008). In many design cases, the passive energy solution is a better and more economic design than the active energy solution. For example in architectural space's dimensions and proportions, the passive solution can achieve the sustainability's targets/calculations without having any active solution in a form of additional treatment/material, or at least can reduce the cost of the active solution.

In Theory of Architectures, many rules, styles and trends appeared after the industry revolution stating from 'form follows function', going through many theories such as 'form forms concepts', and certain trends such as constructivism and minimalism, and ending with design methods of using manual and digital media such as Frank Gehry designs or the sole use of the digital media such as the Animated Form of Greg Lynn. In the current days and the future, sustainability has the most important factors to be satisfied by/into the design. The researcher claims that the new emerging rule/trend will be 'design follows sustainable factors', particularly the environmental factors that are the focus of the proposed framework.

There are evidences that strengthen this predication, such as the global lack of energy resources, the need to reduce the economic cost of designs, the urgent mitigation and adaptation to climate change, and the insufficient resources of our Earth in general. The designers are expected to have high awareness, and consequentially proceed to consciously reflect these vital needs and requirements in their architectural designs.

Computer programs of environmental factor analysis and simulation offer an effective assist for architects and designers to implement the rules of sustainability. The digital use in designing should not be exclusively for form giving, form exploration and design representation. In order

for the digital use to be more beneficial and effective, this use should assist and evaluate design generation by employing different computer programs for simulation and analytical capabilities in the early stages of designing (Abdelhameed 2016).

2. Literature Review

The paper's literature review covers certain models of building assessments regarding environmental factors and sustainability (Ratti et.al. 2003, Zhang et.al. 2006, Haapio and Viitaniemi 2008, Schlueter and Thesseling 2009). On the other hand, some researchers (Cooper 1999, Soebarto and Williamson 2001, Todd et.al. 2001) highlight the contradiction that may appear in implementation of the sustainability components in designing. The differences and contradiction may appear in applying sustainability's factors are not covered by this study's focus. No academia cases in the undergraduate level similar to the proposed framework were found.

Cooper (1999) proposes a solution to improving the built environment in industrialized countries and to reduce the environmental impact, by adopting a Service Economy approach. The differentiation between developing countries and industrial economies in terms of the environmental impact was highlighted (Cooper 1999). Cooper (1999), moreover, proposes to assess building performance in a wider range method to cover the sustainability of the built environment.

Soebarto and Williamson (2001) introduce a methodology based on a multi-criteria decision-making approach where the performance of the building is always compared to a reference building. The assessment tool includes a module for automatically generating the reference building, changeable databases, validated calculation engine, and a user-accessible assessment-criteria module (Soebarto and Williamson 2001).

Todd et.al. (2001) assess building performance through comparing similarities and differences with a selection of available assessment tools. Unlike national or proprietary assessment systems, their proposed system of Green Building Challenge attempts at targeting global users. However, the national conditions and circumstances of assessment negatively affect the system's global spread, where its users tend to utilise the national assessment (Todd et.al. 2001). Ratti et.al. (2003) review the results of a number of papers at Cambridge University investigating what building forms make the best use of land, and presenting the environmental terms using innovative computer analysis techniques. Kolarevis and Malkawi (2005) specify certain benefits resulted from employing computational tools in environmental building performance, namely the exploration of comprehensive fabrication and manufacturing processes, and the optimization of the building components and systems. Zhang et.al. (2006) introduce a building environmental performance analysis system that covers three main aspects related to environmental performance: building facilities, building materials and location. Haapio and Viitaniemi (2008) point out the difficulties to make the comparison between the tools and systems for environmental factor analysis, some of which are assessing different types of buildings, emphasising different phases of the building life cycle, and including some economic and social aspects. Schlueter and Thesseling (2009) state that building performance assessment has to be seamlessly integrated into the design process, in order to evaluate the dependencies of performance criteria on form, material and technical systems. Their proposed approach focuses on utilising the capability of building information models not only to store multi-disciplinary information but also to access parameters necessary for performance calculations (Schlueter and Thesseling 2009). Zuo and MaloneBeach (2010) present a performance-based design approach to enhance understanding of the reciprocal relationship between the built and natural environment. They point out that an early awareness of sustainable energy would result from their proposed approach.

Ceschin and Gaziulusoy (2016) present a review for the past decades covering the evolution of 'design for sustainability' approaches, which can be categorized under four innovation levels: Product, Product-Service System, Spatio-Social and Socio-Technical System (Ceschin and Gaziulusoy 2016). Design systematic engagement has started in early 1980s with the beginning of active interest from industry in environmental and social issues (Ceschin and Gaziulusoy 2016). Buckminster Fuller and Victor Papanek were the pioneers to engage design with different aspects of sustainability discourse and practice sporadically since mid-twentieth century (Ceschin and Gaziulusoy 2016). Ceschin and Gaziulusoy (2016) propose a framework to synthesize the evolution of the 'design for sustainability' field, showing how it has

progressively expanded from a technical and product-centric focus towards large scale system level changes (Ceschin and Gaziulusoy 2016).

The foregoing review of different environmental/sustainable assessment tools and systems furnishes a base for the researcher to propose the implementation details of the 'Design Follows Sustainable Factors' rule, in the conceptual phases of architectural designing.

3. Paper Logic and Rationale

The first design stages have huge impact on the final design. From the literature, many researchers highlighted that the first arrangement of a design problem is vital as it is long lasting and hardly would be fully changed by the designer (Rowe 1991, Schon and Wiggins 1992). Architectural design is a complicated activity; it is wicked problem solving in a creative way. The design objective is to satisfy many variables and needs, and in many cases the implementation of these variables and needs contradicts with each other. A designer may move back and forth towards the solution direction, yet in most cases not to the start point of own design thinking. There is no ideal design solution; the designer selects a solution of a more advantages than disadvantages.

The foregoing evidences of the designing process reveal the impact of initial design phases and conceptual designing on the design output. In order to reflect the sustainability's factors or even only a few of factors in the design output, the architect should respect the sustainable factors starting from the design stages of constructing the initial design ideas.

Although the proposed framework generally includes the sustainable components and factors, the research paper highlights only environmental factors which are more related to conceptual designing, design studios and architectural design curriculum. Economy factor, one component of the sustainability that can be represented in cost of the architectural design may vary according to the practical situations, stakeholders and decision makers. The framework focuses on the importance of environmental factors analysis in conceptual design phases. The environmental factors such as thermal, solar, ventilation, daylighting and illumination, and orientation have vital impact on building performance. The environmentally conscious application of the environmental theme, even if it is only one component, has significant positive impact on the design output as the paper will present in the case studies.

There are many obstacles faced by the architects in professional level and by the architectural students in academia level; those obstacles and difficulties do not facilitate implementing the sustainability's factors starting from the initial design phases. They preclude addressing the sustainable components in the design process, for example the use of different analysis computer programs, various knowledge and expertise required to be performed, and terms and calculations associated to these types of analysis.

The research paper with its proposed framework attempts to solve a main obstacle that is the insufficient knowledge the designers generally have in regard to the basic calculations and standards of different environmental factors. The digital use offers an effective assistance for designers in this regard. Only general background of each environmental area's calculations is required in order to have approximate numbers of the environmental impact. These initial calculations will help the architecture students and architects to make certain decisions or to choose between design alternatives.

The research paper utilises examples of students' designs from different design studios, which have been environmentally analysed in an advanced CAD course. Each design case has one of the sustainability's component as a theme, according to which simulation was made. This research paper does not cover the advanced CAD course details, yet presents examples of students' case studies, in which the environmental improvement was recorded. In most students' case studies, their designs were environmentally improved according to building factor performance by enhancing passive energy solutions such as design forms and architectural spaces, or adding active energy solutions such as enhancing insulation materials and reducing glazed materials, areas and ratio. A few examples are presented in the section below.

4. Proposed Framework and Design Follows Sustainable Factors

The proposed framework implements the principle of 'design follows sustainable factors' through levels and aspects: teaching content, curriculum, and designing tools. The researcher

proposes these three areas to cover and link teaching design methods and course/design studio contents in the whole architecture curriculum in order to complementary introduce the framework to the students.

Teaching content: The sustainable design principles and their analysis and calculations should be integrated into the teaching content of the related academic courses in a very conscious way that equips students not only with theoretical knowledge, calculation methods and practical applications but also with methods of applying the sustainable design principles in the initial phases of design generation. These methods of applying are not introduced clearly in the current teaching contents of Architecture. To initiate the design and its details according to the sustainable factors is a vital step that students have to comprehend and practice, whether in courses or design studios.

The researcher for 4 semesters at the Department of Architecture and Interior Design, University of Bahrain has taught an advanced CAD course in which the theme of environmental design factors' analysis was adapted. The course's main goal was to environmentally improve a previous design of each student by analysing building performance and simulating the results in BIM programs, Figure 1.

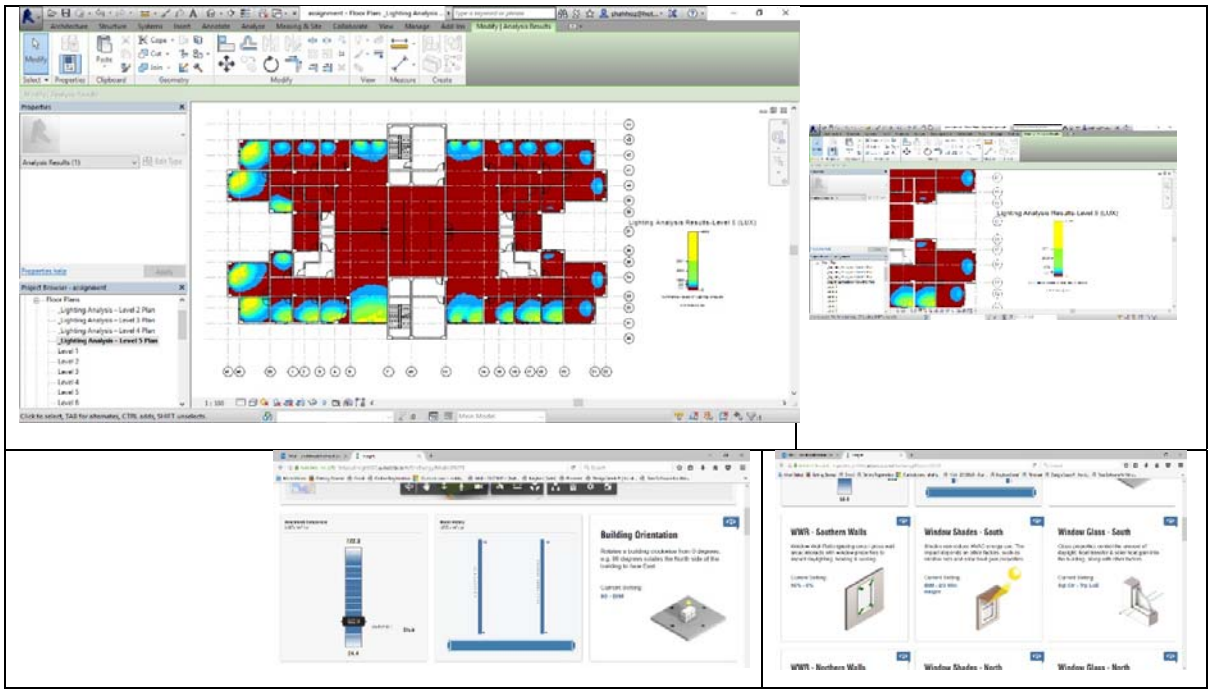
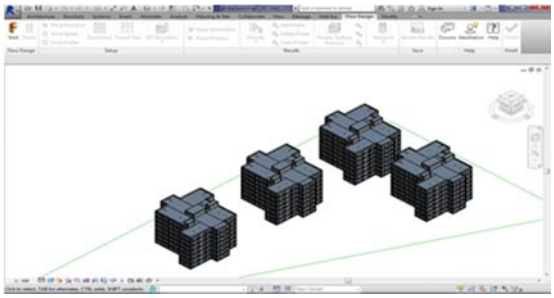


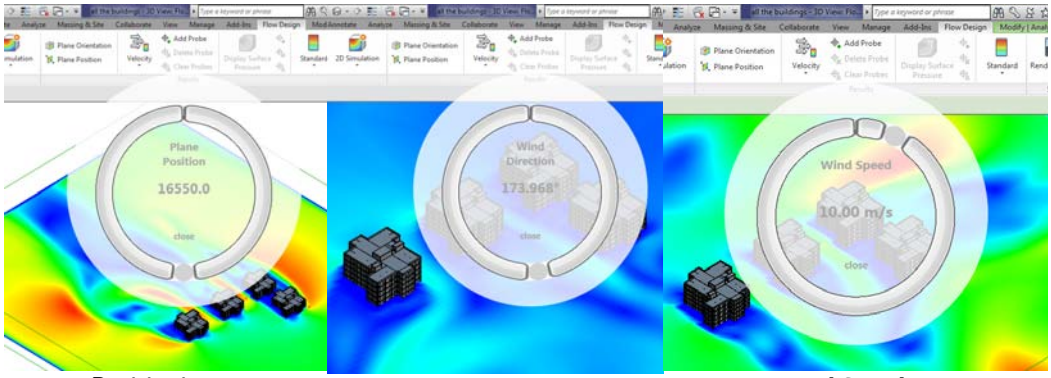
Figure 1 A case study of illumination analysis using Revit and Insight (Above) to achieve the target standards of one level's spaces by changing factors such as building information, window size, window-wall-ratio, etc. (Below Left) and/or treatments such as glass type, shades, etc. (Below Right)

4.1 Curriculum

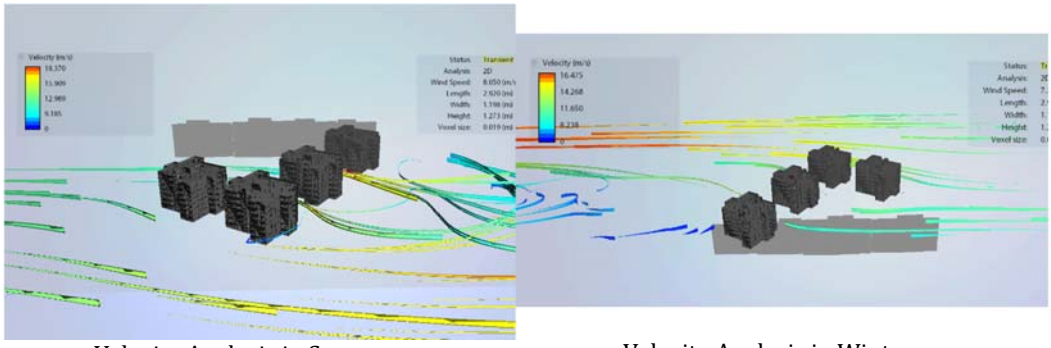
From the researcher point of view, the more effective method to apply the proposed framework is to introduce this theme to the students jointly in a design studio, an advanced CAD course, and the projects of specialised/professional courses such as course projects of Environmental Design or Acoustic and Illumination. Figure 2 presents a case study of the analysis of orientation and wind direction and speed in designing building locations inside the site. Figure 3 displays a case study of solar analysis and its factors related to the design.



Orientation of Apartment Buildings in the Site



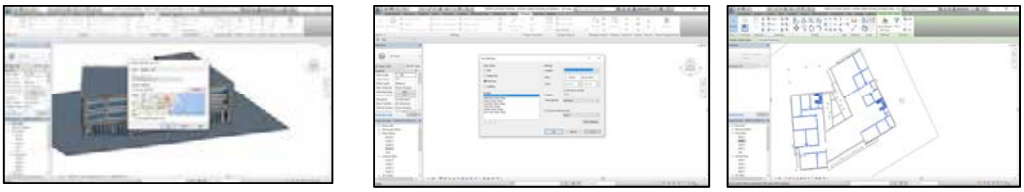
Positioning Wind Direction Wind Speed



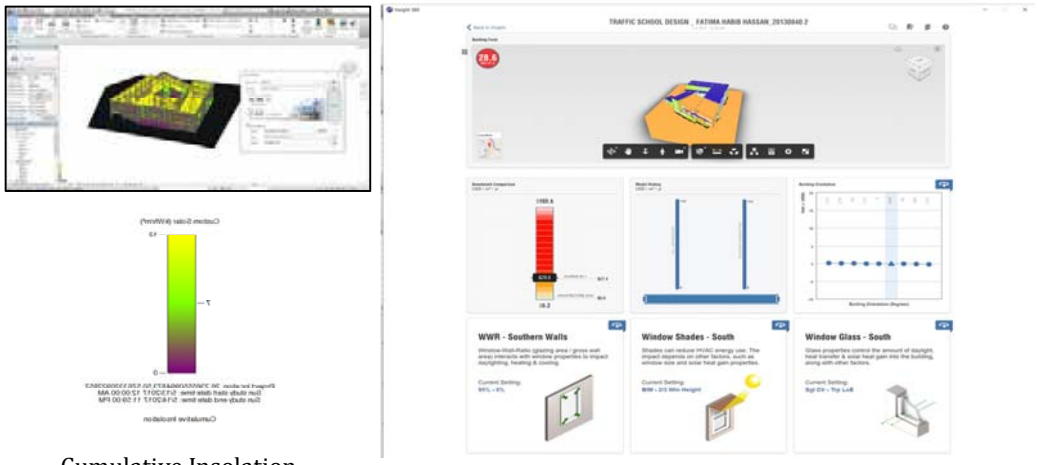
Velocity Analysis in Summer Velocity Analysis in Winter

Figure 2 A case study of using Revit and Flow Design in decision making of conceptual designing phases to finalise buildings' location and distance. Above: building orientation, Middle: factors of wind direction and speed, and Below: velocity analysis in different times.

The well-studied complementary among those courses and inside the curriculum has such importance for students to keep the persistency to apply their theoretical and practical knowledge concurrently inside the curriculum. Therefore, the student would learn the theoretical knowledge, then start applying it from design-ideas germination in the design studio, and end by making design details in the course/s of Working Drawings;



Site location Solar study details Envelope selection



Cumulative Insolation

Insight website

Figure 3 A case study of solar analysis of building through Revit and Insight 360 program. Above: variables and factors details, Below: analysis results.

4.2 Designing tools

The digital use that are introduced to the students in the advanced CAD course for calculations, sustainable factor analysis and simulations, will be utilised inside the design studio in conceptual designing stages in order to generate design-ideas and direct design-solutions to improve building performance analysis. The digital use will be directed to be as a design tool not a mere depiction or design exploration tool.

To summarise the framework into a few steps: students as a first step would learn the required knowledge associated with the calculations and applications, in the specialised courses and their course projects of environmental factors in buildings, in order to achieve the sustainability building-standards such as illumination level, ventilation value, or U value according to the building function and the building code. As the second step, the two courses of design studio and advanced CAD course would introduce the same design project and design details to the students. In the advanced CAD course, the students would practice BIM computer analysis programs for calculations and simulations, and concurrently in the design studio they would employ those programs as design tools of form composition, evaluation and decision making to create their designs. The final step is to create and make design details in courses of working drawings.

5. Conclusion and Further Discussion

The research paper introduced the 'Design Follows Sustainable Factors' rule. The method to apply this new emerging rule in conceptual designing phases is presented. Examples of environmental factor analysis and their role in improving the designs are discussed. The proposition and composition of architectural spaces and forms based on environmental design principles, presented in the paper's framework, would economically help achieve the sustainability standards.

In professional level, in the small-scale designs that are conducted by one architect not a design team of different environmental specialisations, the architect should perform by his/her own the environmental factors' analysis while constructing the concepts and forming the architectural spaces. The priority and the comparison between design alternatives would be based on the analysis of environmental factors.

The sustainability's factors should have the priority to construct and form architectural space planning and to furnish the design according to acoustic and its insulation materials, HVAC system and its mechanical details, and other building factors' performance and their required components. Other building treatments that are relative to energy efficiency and passive solar energy and other sustainable approaches, have to be analysed for improving and enhancing in conceptual designing phases.

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Sustainable-Eco-Neighbourhood Assessment Method in Residential Neighbourhood in Greater Khartoum

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Abstract

This paper investigates the present situation of low to medium rise buildings for medium class professors, teachers and doctors in residential areas in Greater Khartoum such as the Ecological Neighbourhood, addressing questions like whether they are ecologically designed, how they can be evaluated and to what extent, the problems and issues in such evaluation and the solutions therefor.

To evaluate these Neighbourhoods, the researcher has to adopt a rating system; for this purpose, a comparison was made with LEED v3 for Neighbourhood development, which has been in vogue since 2009 and evaluates subjects using sustainable environmental parameters. This research studies three neighbourhoods in Greater Khartoum, which are Residential Villas, Arrak City and El Naser Apartments. This study devises a system known as SENAM, for evaluating the Eco Neighbourhood efficiency in a hot dry climate such as Greater Khartoum. SENAM evaluates nine main categories which are: Sustainable Site, Neighbourhood Design, Pattern and Construction, Waste Management system, Materials and Resources, Water Supply, Power Supply system, Environmental Plan process, Health and Safety and Emissions and Community Participation . The total points for the various categories is 113 and the system offers four main certifications: (35 - 44 pts) Pass, (45 – 59 pts.) Good, (60 - 75 pts) Very Good, (76-132) pts or more) Excellent.

The results would also be evaluated, analysed and discussed as per global parameters for sustained evaluation, such as LEED for Neighbourhood development. The research finds that: Residential Villas score 38% (certified), Arrak City 29% (not certified) and El Naser Apartments 51% (silver). *The analysis shows efficiency in Neighbourhood Design, Pattern and Construction (40%), and Waste Management System (40%). The analysis shows inefficiency in designing, sustainable site (30%), Materials and Resources (20%), and services, such as Water Supply System (27%), Power Supply (20%), Emissions (33%) and Community Participation (27%). The Researcher has applied the Suggested Sudanese Sustainable Rating Systems (SSRS) in the eco neighbourhoods in Greater Khartoum.

Keywords: The definition of ecological neighbourhood, Principle of Designing Ecological Neighbourhood, Sustainable Eco Neighbourhood Assessment Method, (SENAM) to evaluate the Ecological Neighbourhood.

1. Introduction

The importance of Sustainability has been recognized in 1992 at the United Nation Conference on Environment and Development, the "Earth Summit", held at in Rio de Janeiro, Brazil. The central aim was to identify the principles of action towards "sustainable development". Agenda 21 on" Promoting Sustainable Human Settlement Development" lays down that people should enjoy healthy sustainable neighborhoods to live in to meet with the global standards and to meet their own needs, with mixed use center, efficiency in water supply system, efficiency in power supply system, maximization of open spaces, green ecological buildings, and sustainable transportation system, waste management, etc. The researcher visited some of the new neighborhoods and compounds for residence in Grater Khartoum and noticed serious problems in the orientation of the buildings and on the services available in these neighborhoods, finding these solutions still far away from sustainable ones. This situation was compared to the one in global projects like AL Masdar city in Abu Dhabi, Bedzin Green project in UK and Siviano green project in USA.

This paper investigates the present situation of Ecological Neighbourhoods in Greater Khartoum, to assess whether they are sustainable ecological neighbourhoods and if so to what extent, the problems faced by them and possible solutions therefor. Accordingly, the researcher designed a rating system to evaluate three neighbourhoods in Grater Khartoum by comparing them to global systems.

2. Historical Background

2.1 LEED For neighbourhood development and others

LEED v3 for neighbourhood development came into vogue in 2009 and consists of five main categories, which are: smart location, neighbourhood design and pattern, green infrastructure and buildings, Innovation in design process and regional priority.

There are many Global green building councils around the world, some of which set up the Neighbourhood rating system like LEED for neighbourhood development. Ssimilarly, QSAS for neighbourhood was started in 2010, while ESTEDAMA, which added the liveable community category including some points to evaluate the neighbourhood, also started in 2010. LEED for neighbourhood development is applicable to many projects and it is easy to connect to United States green building council to manage your design, as the service is available through the internet.

However, LEED for neighbourhood development rating system does not include parameters like health, safety, emission category, community participation and environmental process as main categories and energy efficiency, water efficiency as waste management as separate categories. LEED announced LEED V4 for Neighbourhood development including more flexibility with strategies to fit the unique aspects of your project, performance based design, operation and design, smart grid and networking approach, material and resources, water and streamline documentation. (U.S.G.B.C, 2017).

Through this paper, the researcher will provide a sustainable assessment method suitable to a hot dry climate such as Greater Khartoum, in order to evaluate the Eco Neighbourhood in Greater Khartoum and this system will include all relevant parameters like energy efficiency, water efficiency, ecological building materials according to available natural resources and other parameters applicable to a hot, dry climate. The researcher expects to answer the research questions by applying this system to three case studies and evaluating the results. In addition, the system will evaluate this situation vis-a-vis sustainable environmental parameters and identify the problems and solutions therefor. This paper will also suggest a Sudanese Sustainable Rating System to evaluate ecological neighbourhood through the methodology of this research.

Rieck, A.(2012) discussed Masdar city in Abu Dhabi, and stated that the new green cities is about how we can control nature and highlighted such parameters for new green cities like: Energy Consumption, Energy storage, Transportation system, Waste Management, Mobility, Information Technology and Communications Technology. Peled, G.(2008) discussed the new Jerusalem eco housing project and some categories of eco neighborhood, viz., Energy Conservation, Waste Reduction, Water Conservation, Land Use, Transportation, Community Involvement, Health and Safety, Disaster Control, Wellbeing, Materials and Recycling, Urban Ecology and Footprint. Alderson, A. (2005) highlighted important categories for Eco- Village in Scotland, UK, like Energy, Telecommunications, Water and Sewage, Location, Solid Waste, Transportation, Ecological Environment, Design and Building, Economy and Social Issues and Education. Riis, C. (2014) discussed in her paper about Green Strategies in Copenhagen, designated as the European Green Capital in 2014. The concept takes into account the urban life scale before building scale, strategic urban development on a large scale, urban development and site specific plans in the medium scale and in the small scale, considers other ideas and projects, as for example Green pathway, Green roof and Green backyards.

2.2 Definition of Ecological Neighbourhood

United State Green Building Council defines Neighborhood Development thus: "*integrates the principles of smart growth, urbanism and green building into the first national system for neighborhood design'.* U.S.G.B.C (2012). It provides the balance between the income and food,

renewable energy, goods, materials and the outcome of organic waste recycling, materials recycling, minimize pollution and waste and emissions. See Figure 1.

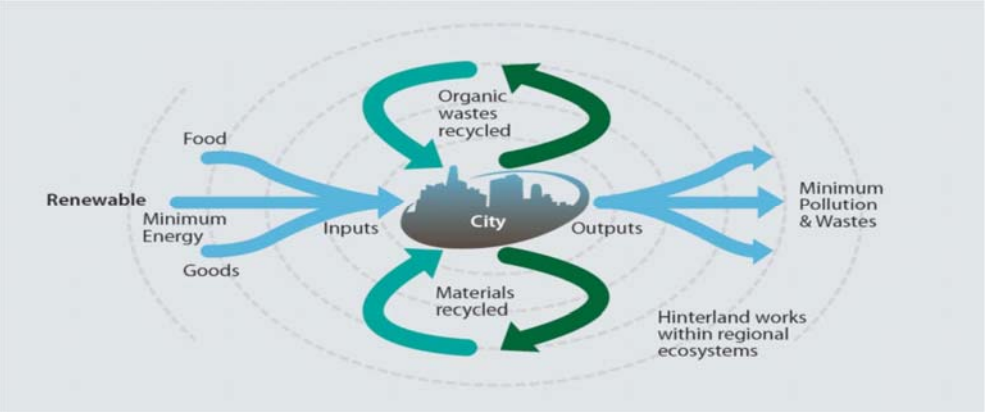

Figure 1 Circular metabolism: Cities reduce consumption and pollution, recycle and maximize renewables, Source: Ben Hamadou, R. (2012).

2.3 Theory of Traditional Neighbourhood

2.3.1 Walking distance

The traditional neighbourhoods' typology comprises a compact residential area with a variety of housing types and services like small shops, libraries and mosques and churches. The ideal size of a neighbourhood falls within the 1/4-mile measurement (400m.), which is the distance the typical adult can walk from centre to edge in approximately five minutes.

2.3.2 Mixed use centre

The second theory of the traditional neighbourhood says it should provide for mixed use, areas of concentrated activity – living, working, learning, playing, eating, and shopping, designed to accommodate pedestrians and transit use in addition to auto travel. See Figure 2.

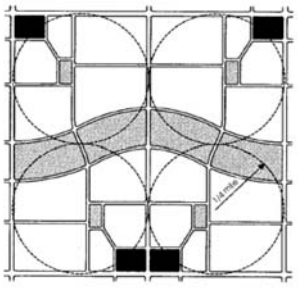

Figure 2 Traditional neighbourhood combination diagram: (Drawing: Courtesy: Duany Plater-Zyberk And Company. Source: Walters, D. and Luise Brown, L. (2004)

2.3.3 Neighbourhood centres

These are mixed-use activity points scaled to serve a trade area with a radius of less than three miles. Larger neighbourhood centres typically include a full-service supermarket or grocery store and serve no less than six neighbourhoods, with parking, Malls, etc.

2.3.4 Study of the Master Plan

The Master Plan should focus on a three-dimensional urban form, instead of two-dimensional plan diagrams that indicate land use only, which is the key message of the book *Three dimensions are better than two* by Walter (2004). Three-dimensional infrastructure of form and space allows long-term flexibility of use and operation. These issues include the impacts of changes in technology, social structures, economics, uses, architectural styles and development practices.

2.4 Theory of Sustainable Neighbourhood

UN HABITAT (2009) stated the environmentally sustainable urbanization requirements reduce greenhouse emissions, minimized and compact cities and use renewable resources.

Figure 3 shows a conceptual idea of mixed uses in a self-contained walkable neighbourhood node, Jenks, M. and Dempsey, N. (2005) stated that social, economic, and environmental justice depends heavily on mass transportation to incorporate a percentage of low-to-moderate-income families into every neighbourhood node.

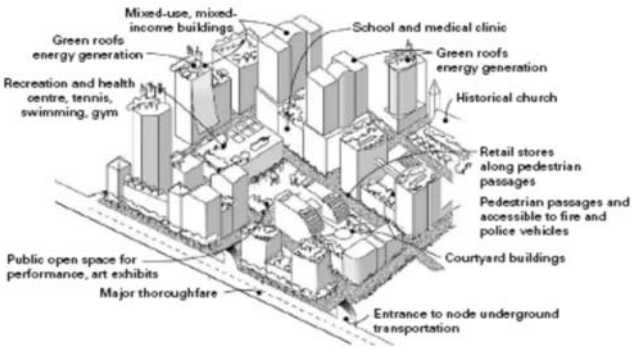

Figure 3 A conceptual idea of the mixed uses in a self-contained walkable neighbourhood node. Source: (Jenks, M. and Dempsey, N. (2005)

People are critically needed. Fire-fighters, police, health care workers, labourers, and food suppliers must live in close proximity, in order to provide immediate help. It should be a self-contained community that provides for schools, health care, police, fire protection, postal services, banking, open spaces for playgrounds and parks within walking distance.

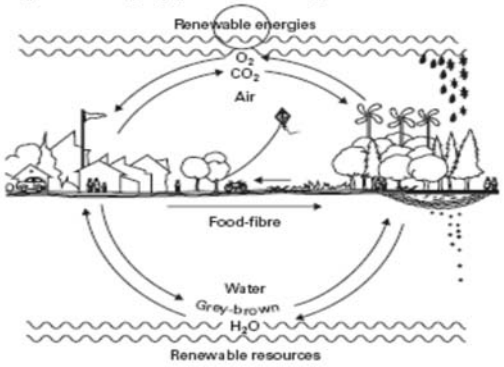

Figure 4 Sustainable cells of urbanization, Source: Jenks, M. and Dempsey, N. (2005)

Sustainable cell is provided a balance between human activity in human–environmental systems (HVAC _Heating Ventilating and Air-Conditioning) waste with the surrounding environment as well as human health with environmental systems of air, water, food, fibre (land), and energy for the community are modelled and measured to establish indicators for sustainability. See Figure (4). Jenks, M. and Dempsey, N. (2005) and Sassi, P. (2006).

2.5 Focus on Khartoum Conditions

2.5.1 Khartoum location

Abu Sin and Davis, (1991) wrote that Khartoum state straddles the confluence of the Blue and White Ni1e that covers some 28,000 square kilometers and covers about 2.17% of the total area of Sudan. It lies at latitude 15° 36' north and longitude 32° 3 east, with an altitude of 380 meters above sea level. El Agraa, O.M. and Shaddad, M.Y. (1988) discussed the location of Khartoum too. Khartoum was first made the capital of the Turkish-Egyptian rule in the 1830s.

Environmental factor
Khartoum faces four climates: Rainy season in the autumn, with precipitation ranging between 150 mm and 200 mm. In summer, the wind direction is South-South East and in winter, it is North and North –West. The temperature: *I*n summer, it ranges from 40°C to 50 °C, and in winter, between 10°C to 25°C. Humidity ranges between 20% in summer to 40% in winter.

Natural resources
Khartoum is rich in solar energy, wind energy, biomass energy and geophysical energy, as well as hydroelectric energy.

Political factor
Sudan has subscribed to several international Agreements, starting with Agenda 21 in 1992, the Kyoto protocol, the United Nations Framework Convention on Climate Change (UNFCCC) and has a working relationship with UN- HABITAT, UNEP, UNDP and NGOs, to establish sustainable projects in SUDAN.

Social factors
Earlier studies showed that Khartoum population is increasing and may have doubled in the last 20 years, to the level of 5,500, 000 according to the last census. Reasons for the increase include increasing migration towards Khartoum city, which affects services such as education, health, transportation, the quality of housing and waste management in Khartoum.

To provide and design a sustainable neighbourhood in Khartoum, we should consider all this information, taking into account the traditional and sustainable principles of designing an ecological neighbourhood. This will be discussed while considering the methodology of this research.

3. The Methodology

The researcher has undertaken a wide literature review, to identify the main principles of sustainable eco neighbourhood. Global standards leader LEEDV3 for Neighbourhood and development (Leader in Energy and Environmental Design) applied criteria like smart location, neighbourhood pattern and design, green infra structure and building, innovation in design and regional priority categories. On the other hand, The Environmental Assessment Method (BREEAM, 2017) applied categories like energy, health wellbeing, land use, pollutants, waste, ecology, innovation, materials and water, with different details and sub-issues.

The researcher identified the main categories to be applied in a hot dry climate like Greater Khartoum. These are: Sustainable Site (30 points), Neighbourhood Design, pattern and construction (39 points), Materials and resources (5 points), waste management system (5 points), water supply system (5 points), power supply system (4 points), Environmental process (1 point), health, safety and emissions (5 points), with details and sub issues indicated in table 1 of the Appendix.

The researcher added additional categories like Environmental design process, health safety, emission and community participation. The community in Greater Khartoum needs to be educated about sustainable design, and involve itself in improving the environment. These additional categories were discussed by the researcher in a previously published scientific paper (Abdelmoneim, H., 2016).

Comparison between the research method of assessment (Sustainable Eco Neighbourhood Assessment Method, SENAM) and LEED for neighbourhood development

Figure 5 shows the difference between the research method of assessment (Sustainable Eco Neighbourhood Assessment Method, SENAM), which has nine main Categories, carrying weightage as follows: Sustainable Site (30 points), Neighbourhood Design, pattern and construction (39 points), Materials and resources (5 points), waste management system (5 points), water supply system (5 points), power supply system (4 points), Environmental process (1 point), health, safety and emissions (5 points) and community participation. Figure (4.6) shows LEED for Neighbourhood Development which contains five main categories, which are: Smart Site (27 points), Neighbourhood Design and pattern (44 points), Green Infrastructure (29 points), Innovation in design (6 points) and Regional priority (4 points).

The researcher added Waste management, Material, Energy, Water and drainage system, Environmental Design Process and Community participation as new categories to the Sustainable Eco Neighbourhood, for a more comprehensive evaluation.

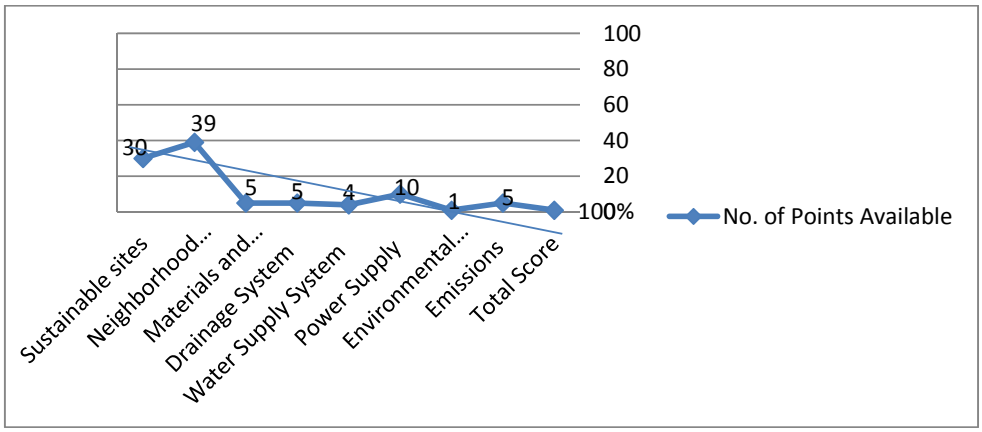

Figure 5 Sustainable Eco Neighbourhood Assessment Method, SENAM. Source**:** Designed by the researcher.

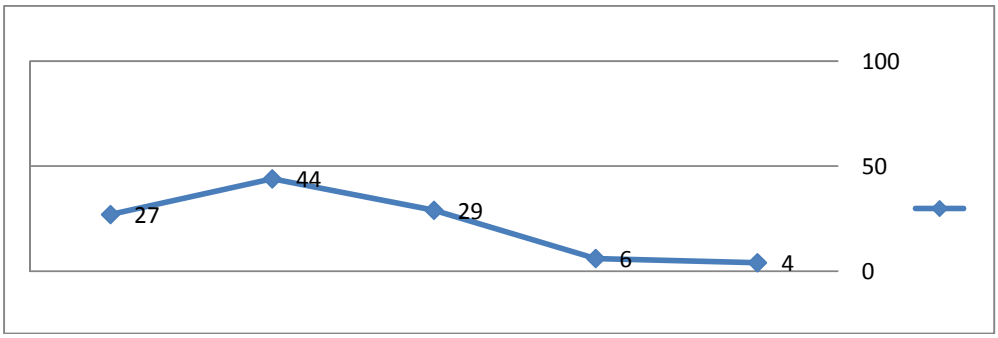

Figure 6 LEED V3-Neighbourhood Development, Source: LEDD for Neighbourhood Development

3.1 Summary of the Assessment System Applied on Eco Neighbourhood

3.1.1 Weightage, credits and percentage points:

Table 1 Weightage, credits factors. Source: Designed by the researcher

The Category	The Average Result	The Average Result by LEED ND, V3	The Evaluation by SENAM
Sustainable site	30%	Not certified	Weak
Neighorhood Design, pattern and construction	40%	Certified	Pass
Materials and resources	20%	Not certified	Weak
Waste management system	40%	Certified	Pass
Water supply system	27%	Not certified	Weak
Power supply	20%	Not certified	Weak
Environmental process	60%	Good	Good
Emissions	33%	Not certified	Weak
Community participation	27%	Not certified	Weak

3.1.2 The Scale System

Table 2 The scaling system. Source: Designed by the researcher.

The Mandatory	Mean	Points Availability
Yes ⟶	Means it's applicable	
	The most positive impact	3
	More positive impact	2
	Positive impact	1
No ⟶	Means it's not applicable	0
	Negative impact	-1

3.1.3 The System Certifications

This system gives four main certifications:
<35 - weak
(35 – 44 pts) - pass
(45 – 59 pts) - good
(79 – 111 pts or more) - excellent

4. The Field Work

4.1 The Locations

The research studies three Neighbourhoods in Khartoum, which are Residential villas, Arrak City and El Naser Apartments. See the site location in Figures 8 to 11.

Figure 8 The Location of Residential villas near the River Nile, Khartoum City, Sudan. Source: Google image 2017.

Figure 9 The second location is Araak Neighbourhood, Madani street, Khartoum City, Sudan. Source: Google image 2017.

Figure 10 The third location is Al Naser Neighbourhood, Africa street, Khartoum City, Sudan. Source: Google image 2017.

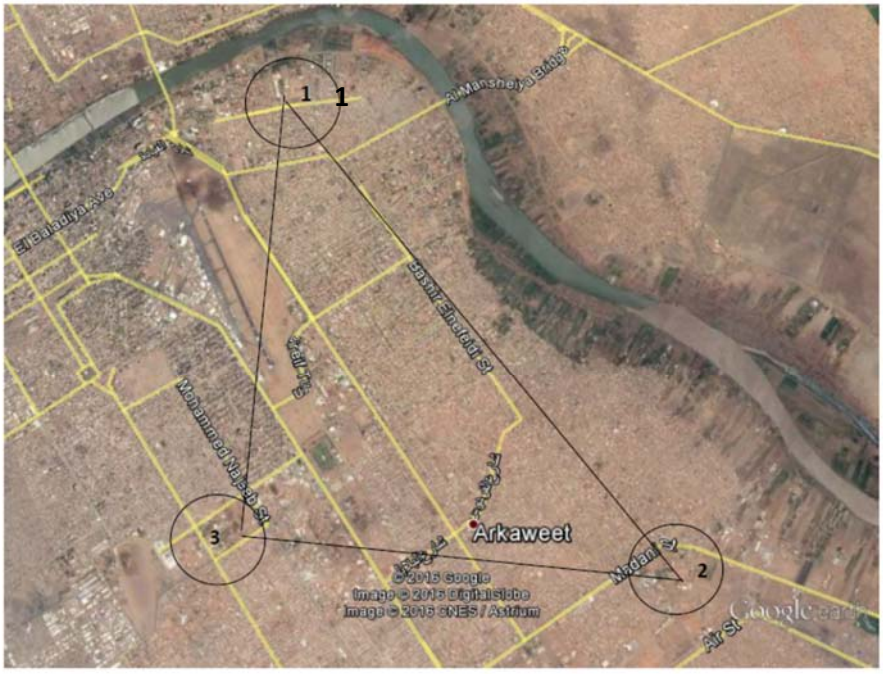

Figure 11 The three locations in perspective: Residential villas, Araak City and Al Naser Apartments, Source: Google image 2017.

4.2 Standard of Selection of the Case Studies

New Neighbourhoods and new urban planning areas. See satellite images. They applied new approaches in design concepts and environmentally sustainable ecological design, which had just been adopted in the 1990s and which took into account the Eco Design principles and the main categories. They were built by famous Consultant companies. Looking for applying Sustainable Neighbourhood Cell. The researcher was looking for proper technical solutions in services. Water supply, waste management and drainage system. Energy System. Site security and health awareness. Building materials were recycled and eco-friendly building materials. Looking for applying the latest new technologies in the field of eco design. Outdoor environmental control. Diversity in house type. Ecological treatments

4.3 The Application of (SENAM) to the Case Studies

The researcher applied the Sustainable Eco Neighbourhood Assessment Method-SENAM to evaluate the three neighbourhood case studies.

4.3.1 Updates of the Case Studies

In June 2017, the researcher started to make updates to the case studies and as per his supervisors instructions, he visited all the cases, starting with the research studies in the three neighbourhoods in Greater Khartoum, viz., Residential villas, Araack City and Al Naser Apartments . She found that most of the sites had not changed and no sustainable solutions had been added by stockholder.

4. The Results

The summary of the results of three case studies on the level of eco neighbourhood is presented in Appendix -1, and the result of each case study on the level of eco neighbourhood presented is presented in the following Tables and Figures.

Case Study 1 (The Residential Villa Type-B): Table 3 shows the result of the analysis of case study of the Residential Villas neighbourhood. Results: Sustainable Sites 23%, neighbourhood design, pattern and construction 38%, materials and resources 20%, waste management system 40%, water supply 40%, power supply 17% environmental process 60%, emissions and safety 60% the community participation 27%.Total result was ***39%***.

Case Study 2 (Arak City villa Type-D): Table 3 shows the result of the analysis of case study two on the level of neighbourhood. Results: Sustainable Sites 13%, neighbourhood design, pattern and construction 23%, materials and resources 20%, waste management system 40%, water supply 20%, power supply 25%, environmental process 50%, emissions and safety 20%Community participation 7%.The total result was ***29%***.

Case Study 3 (Al Naser Apartments): Table 6 shows the result of the analysis of case study three on the level of neighbourhood. Results: Sustainable Sites 53%, neighbourhood design, pattern and construction 60%, materials and resources 20%, waste management system 40%, water supply 20% power supply 17%, environmental process 70%, emissions and safety 20% the total Community Participation 27%.
Result was ***51%***.

5. The Results Shown in tables

5.1 The Result of the case studies on the Level of Neighbourhood

See Table 3, Table 8 and Figures 12 to 14.

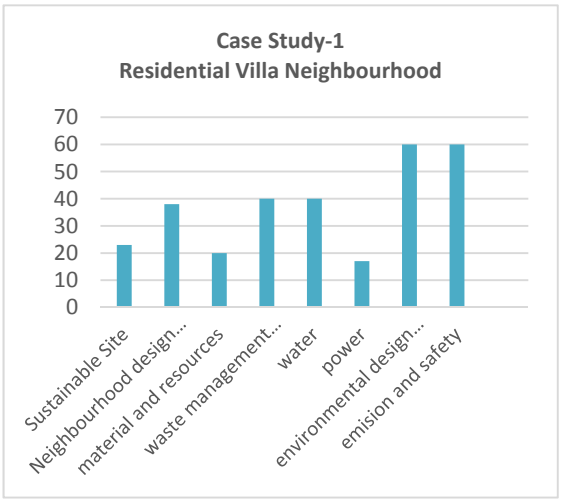

Figure 12 The results of Residential Villa Neighbourhood

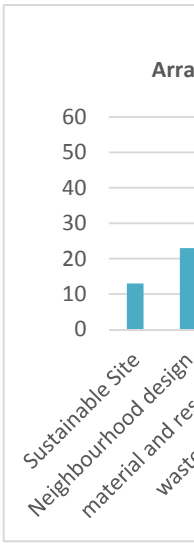

Figure 13

Table 3 The Average Results Of Main Categories.

Case Studies	Sustainable Site	Neighborhood Design, Pattern and construction	Material	Water Supply System
Residential Villa	23	38	20	40
Araak City	13	23	20	20
Al Naser Apartments	53	60	20	20
Average result	30	40	20	27

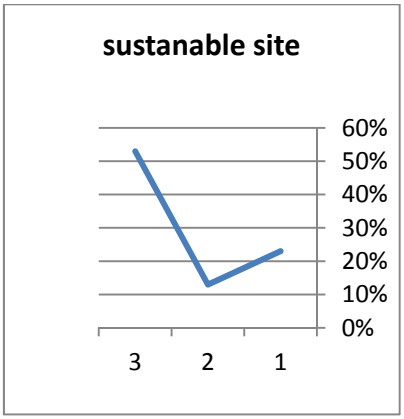

Figure 15 The Average result of Sustainable site

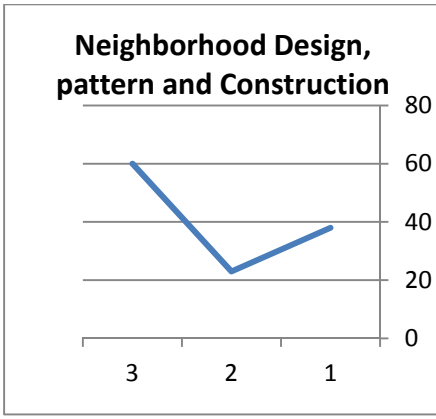

Figure 16 The Average result of Neighborhood, Design, Pattern and construction.

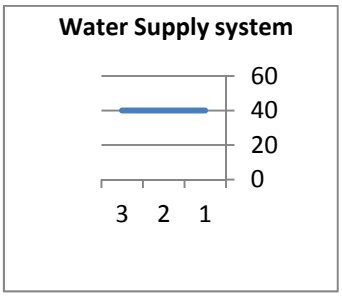

Figure 19 The Average result of Water supply system.

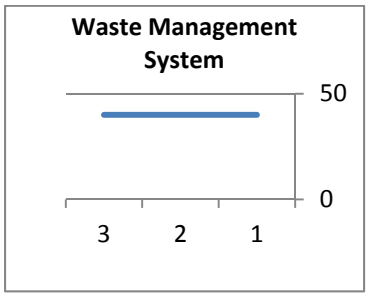

Figure 20 The Average result of waste management system

6. Discussion of the Results

6.1 Discussion of the results for each neighbourhood

The research has identified nine main categories of Eco Neighbourhood, which are: sustainable site, neighborhood design and pattern, materials and resources, drainage system, water supply system, power supply, emissions and safety procedure, environmental design process and community participation, as explained in the Method. The researcher proposes environmentally sustainable tools for Eco Neighbourhood, suitable for hot dry climates. The results were analyzed with SENAM

Table 4 The system of evaluation.

The Certification by SSRS	
< 35	**Weak**
(35 – 44 pts)	**Pass**
(45 – 59 pts)	**Good**
(60 – 75 pts)	**Very good**
(76 – 111 pts or more)	**Excellent**

Case Study 1 (The Residential Villa Type-B)
Table 3 shows the result of the analysis of case study one on the level of neighbourhood, with the weightage scores as per SENAM being as follows:
Sustainable Sites 23%, neighbourhood design, pattern and construction 38%, materials and resources 20%, waste management system 40%, water supply 40%, power supply 17%, environmental process 60%, emissions and safety 60% the community participation 27%.
Total result was *39%*. This result is a "pass".
The evaluation showed efficiency in designing a sustainable site, indoor environmental quality and outdoor thermal control, inefficiency in building form, materials, resources and services, such as drainage and water supply systems, power supply and emissions.

Case Study 2 (Arak City villa Type-D)
The Total Credit for the building was ***35 % for villa type D***
The evaluation showed efficiency in designing a sustainable site, indoor environmental quality, inefficiency in building form, materials and resources, and outdoor thermal control and services, such as drainage and water supply systems, power supply and emissions. The total result for the neighbourhood was *29%*, meaning weak result.

Case Study 3 (Al Naser Apartment, one Building
The Total Credit was 46 % for one apartment building type
The evaluation showed efficiency in designing a sustainable site, indoor environmental quality, inefficiency in building form, materials and resources and services such as drainage and water supply systems, power supply and emissions. The score indicates "Good". Result was *51% for the neighbourhood*. This result is good.

6.2 Discussion of the average result among the three neighbourhoods

6.2.1 Discussion of the Average Result

Sustainable site

Table 5 The certification system of SENAM and LEED V3 for Evaluating Eco Neighbourhood.

The Category	The Average Result	The Average Result by LEED ND, V3	The Evaluation by SENAM
Sustainable site	30%	Not certified	Weak
Neighorhood Design, pattern and construction	40%	Certified	Pass
Materials and resources	20%	Not certified	Weak
Waste management system	40%	Certified	Pass
Water supply system	27%	Not certified	Weak
Power supply	20%	Not certified	Weak
Environmental process	60%	Good	Good
Emissions	33%	Not certified	Weak
Community participation	27%	Not certified	Weak

The result of sustainable site is 30 % in the scale mentioned above, indicating the result of evaluation as "passing". It can be noticed from Figure (13) that Al Naser Apartment has a good neighbourhood design and and U -shaped pattern, with the building and site orientation being certified as good. However, the neighbourhood failed in providing the other solutions like local food production, diversity in housing type, neighbourhood mix used Centre.

Neighbourhood, Design Pattern and Construction

The result of neighbourhood design and pattern is 40 % in the scale mentioned and is evaluated as good. It can be seen from Figure 14 that Al Naser Apartment has a good neighbourhood design with a U shaped pattern and a good building design.

The Materials

The score relating to the material is 20%, and indicates a "weak" valuation. It is noticed from Figure 15 that Arack City Residential villas utilised eco building material in construction, like recycled building materials, eco cement, eco building materials, earth stabilised bricks, etc.

The Water Supply

The result of the water supply is 27%, signifying a "weak" value. We notice from Figure 17 that Residential Villas present a good solution in providing local water treatment station plant with highly efficiency. On the other hand, the other two sites provide poor solutions, with water being provided from the National Grid, which does not meet WHO standards for potable water. We need to increase the efficiency in water treatment, and we need to provide each neighborhood a local

water treatment plant, and adopt such solutions as rain water harvesting, recycling of grey water for irrigation, etc.

The Waste Management

The result of the waste management is 40, which indicates "pass". It is noticed from Figure 17 that all the case studies followed the same solution in drainage system which consists of a well and septic tank. This is the best practice solution at present in Greater Khartoum. Other solutions as biological treatment and surface run off are not found.

Power Supply

The result of the power supply is 20%, which is "weak". It was found that Residential villas and Arack City used electrical generation room and underground cable, to avoid environmental hazards resulting from use of high tension cables. Other solutions like solar energy or wind energy are not found.

Emissions

The average result is 33.3%, "weak". Compared to the result by LEED V3 for Neighborhoods Development, this result rates as "not certified". It can be noticed from Figure (16) that Residential villa provides good solutions in the buildings in controlling the gaseous emissions, through the provision of fire alarm system, smoke detectors, low green gas emissions and solid waste management. Such solutions are good in designing Eco Neighborhood. Araak City as well as Al Naser Apartments also provide exhaust fans in Kitchen and Bathrooms.

Environmental Design Process

The environmental design process is 60% and is evaluated as good. It is noticed from Figure (20) that Al Naser Apartments presented a good solution in environmental design. We should apply the environmental design process from the initial stages at all levels:
1-pre building phase
2-building phase
3-post building phase
Refer to chapter six, Figure 6.7

Community Participation

By comparing the average result 27 with the scale, this result rates as **weak. Comparing the result by LEED V3 for Neighbourhood Development this result rates as not certified**. It could be noticed from Figure 21 that Al Naser Apartments, residential villas, Arak City, Provide the same level in community participation which includes investors and consultants and the government. We should engage all levels and partners who include architects, planners, engineers; suppliers and contractors, agents in order achieve sustainable development.

7. Conclusion

Residential Villas	-	39% (Pass)
Arrak City	-	29% (Weak)
El Naser Apartments	-	59% (Good)

The research obtained different evaluations, of which El Naser apartments emerges as a good example on an ecological neighbourhood, with neighbourhood centre offering most of the services like sustainable site, care about safety procedures, a range of rising buildings with different solutions and variety in areas; these buildings have good ventilation and good

orientation and provide economic value as well. Arak city failed because they didn't adhere to building orientation codes, nor did they provide a complete range of services for everyday activities in the neighbourhood centre. The Residential Villas emerges weak in the results because there are 12 villas having inappropriate ventilation and orientation, along with a problem in the on-site drainage system. On the other hand, Residential Villa provides high safety, health, emission, telecommunication and services. Araak city offers good solutions for building design and services.

8. Recommendations

This study recommends managing the sustainable site, waste disposal system, water supply system, power supply and emissions, applying the principles of sustainable eco neighbourhood assessment, to evaluate such neighbourhoods in a hot, dry climate. Management of the power supply system, with adoption of renewable resources such as solar energy and wind energy, is recommended for managing the power shortage, vis-à-vis the National Grid. The research recommends use of local building materials and recycling technologies in building construction. The water supply system should be augmented and made more efficient through adoption of WHO standards in water treatment to meet WHO Standards. For the drainage system, the research recommends adoption of solutions like biological treatment, recycling of grey water to be used for irrigation and application of drainage net. The research recommends adopting such solutions as shaft and filters in the kitchen, fire alarm system, smoke detectors, etc. and the use of clean energy to minimize CO_2 emissions. Finally, we should apply an environmental design process right from the initial stage of the design. The research recommends applying the principles of eco- neighbourhood to such areas in hot, dry climates (See the applied sheet).

8.1 Sustainable Site

Smart Location, Control systems
Enhanced parking control, Reduced Automobile Dependence, Bicycle Network, walkable Streets, Pollution control in construction activities, noise prevention, controlling natural water feature, and avoidance of Floodplains.

Improvement of outdoor thermal environment

- Heat Island effect, Enhancement of landscaping on site, Public Transport Access, Maximization of Open space,
- Universal Accessibility,
- Community Outreach and Involvement,
- Ecological Awareness.

8.2 Neighborhood Design, Pattern and Construction

Design
Certified Green Buildings, Neighbourhood strategies, Affordable Rental Housing, Building Reuse and Adaptive Reuse, sustainable Historic Buildings, Minimization of Site Disturbance through Site Design, Site Orientation, Local Food Production.

Construction
Construction Management, Minimization of Site Disturbance during Construction.

Neighborhood Pattern
Diversity of Housing Types, Access to Active Public Spaces

Street Network
Reduce car parking, walking streets, Cycle parking, Transportation Demand Management

Ecological footprint
Local Food Production, independent food stores, Reduce food waste, Eco-scape (ecological-landscape)

8.3 Materials and Resources

Recycled Content for Infrastructure, Eco Building Materials used for construction, Eco Concrete, eco recycled building materials, enhancement of proper technologies in building materials industries.

8.4 Waste Management System

Ecological sanitation, Surface run off, Recycling of grey water, on- site Sewage Treatment: Septic Tank System, Solid waste classification and recycling.

8.5 Water supply system

Efficient water supply system, conservation of rainwater, recycling of grey water, conservation of water consumption.

8.6 Power supply

From the National Grid, Site electrical Station, Underground cable, generation of Solar energy, Solar energy heating system, solar energy cooling system, solar boiling, solar cooking, wind energy, availability of outdoor solar lighting, efficiency of Infrastructure Energy.

8.7 Environmental plan Process

Enhance environmental design process.

8.8 Safety and Emissions Systems

Land, fire alarm system, security, smoke detectors, Low greenhouse emissions, solid waste management, waste recycling.

8.9 Community Participation

In applying eco neighbourhood principles, we should involve: the Government sector, Investors, Developers, Agents, Project Managers, Architects, Planners, Contractors, Suppliers, Owners and Users, to make sustainable development a broad-based, people-based initiative.

8.10 The Environmentally Sustainable checklist and the certified

From the case studies and the analyses, the researcher has arrived at the results of this research and come out with measures suitable for Sudanese environment and its prevailing conditions.

< 35	- weak
(35 – 44 pts)	- pass
(45 – 59 pts)	- good (Best practices)
(60 – 75 pts)	- very good (Best practices)
(75 - 111 pts or more)	- excellent

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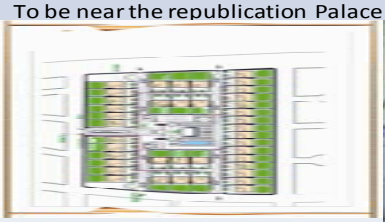
On The Level Of Eco Neighbourhood
Case Study-1
The Residential villas and villa type-B

Site Location:
The compound located in east Khartoum centre in Garden City area, on the west bank of the Blue Nile river, 2.5 km North-east of Khartoum International Air Port
To select the site, the challenge was to comply with the following conditions:
Near Khartoum Air port
To be built in a quiet area
To prevent the noise as far as possible
To be near the republication Palace

Hotel Service Classification: 5 Stars.
Infrastructure:
40 Separated Villas Each Villa consists of
One suite.
5 Rooms.
Main lobby.
Family lobby.
Kitchen.
Roof.

Presidential Restaurant.
Presidential Hall.
Conference Room.
Health Club.
Swimming Pool.
Tennis court.
Party area.
Gardens.
TV Stations: 40 Channels.
Business Centre.
Wireless Internet Access.



Pl.(4.2.121) South Elevation

Pl.(4.2.122) North elevation

Pl.(4.2.123) Fumes chaff

Case Study-2
The Araak City and villa type-D

29%=W

The Location

The city is distinctively located in south east khartoum, within the suburbs of capital,
off the junction of Sixty Street and Wad Medani
Road (main highway linking Khartoum and the
major cities).
The centre of Khartoum is easily accessible
with the airport only 4km away
Araak City is made up of five residential d istricts spanning an area over 200,000m2 with 510
villas and 420 apartments of different styles and sizes.
An area of 15,000m2 is allocated as a park that

Pl.(4.2.125) site location

Pl(4.2.129): Type –D location in Araak

Services

Araak City is clearly identified by its green areas, well-furnished roads and ready infrastructure. It has been constructed in a manner to ensure that the services foster a healthy lifestyle with families in mind. They include state-of-the-art leisure facilities, a shopping area and children's playground.
Araak City's modern utilities include:
Independent Water Network
Independent Electrical Network
Telephone Network
Irrigation Network
Sewage System (well+septictank)
Private Parks
Well-lit asphalt roads
Planted pavements
Sidewalks
Araak club

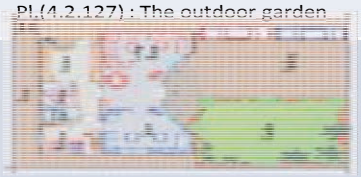
Pl.(4.2.126): Araak city

Pl.(4.2.130): The Main Elevation,

Specifications:

The villa plans were carefully designed to provide a functional, yet comfortable home catering to the needs of each member of your family. Different villa layouts and different villa sizes ensure that you'll find your perfect home.
Only the highest quality materials were used in the construction and finishing of the villas to guarantee, only the finest standards.
Some of the many unique characteristics and beautiful finishing touches of the villas:
Highest Quality Marble floors for all halls, kitchens, staircases.
Security Front Doors with beautiful wooden architraves

Pl.(4.2.127) : The outdoor garden



Pl.(4.2.131): Villa Type-D Ground Floor Plan

.
Elegant C
Complete
cooker ar
Split Unit
and Bedro
Fully Fitte
Water He
Private Fr
Separate
Parking G

Pl.(4.2.12

Pl.(4.2.13
First Floo

Section 2

Sustainable Construction

A Worker Engagement Maturity Model for Improving Wellbeing and Social Sustainability in Construction

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Abstract

The ethical management of Occupational Safety and Health (OSH) is one of several factors critical to 'Social Sustainability'. Research on Worker Engagement to improve OSH has identified Meaningful Discussion; Empowerment; Trust; Motivation; and Commitment as five important constructs. This paper reports on the findings of a UK funded research project, to develop a worker engagement maturity model for improving OSH. The model explains the various levels of each construct (termed 'indicator') that a worker goes through relevant to 'worker engagement maturity'. The methods involved 29 in-depth qualitative interviews to gain accounts of episodes of worker engagement, which were categorised using Nvivo with reference to the five constructs identified via an extensive literature review, then ranked based on feedback from expert focus groups. The ranked constructs (indicators) are based on a number of logically progressive worker maturity levels that build on the requirements of already existing levels. Final validation testing of the model will take place during 2017, but it has already undergone prima facie validation with the expert focus groups. The five indicators have their own hierarchical constructs e.g. 'Meaningful Discussion' begins with discussing issues affecting the individual worker to issues that affect other workers and eventually to those 'beyond the site gate' such as design processes. The 'Leadership and Worker Involvement' tool, developed by the UK HSE, focuses on organisational capabilities, but the model described here is specifically targeted at the construction worker. Worker engagement in OSH to improve overall social sustainability should include assessment using this 'worker-focused' model.

Keywords: engagement; health; involvement; maturity; safety; wellbeing.

1. Introduction & Background

Worker engagement research within the construction industry lies in the perception of its importance in predicting positive performance at work and improvement of construction Occupational Safety and Health (OSH). Generally, construction workers will support formal organisational goals if they understand how these goals benefit the business, themselves, their fellow workers, clients, and society as a whole. Organisations can have a very productive and engaged workforce when the workers are treated humanely and when they grasp these benefits. Workers that are actively involved in the organisation form a key element in the achievement of organisational objectives and worker engagement can represent a source of sustainable competitive advantage (Macey & Schneider 2008), thus making the real difference for an organisation's survival (Song Hoon et al. 2012).

Within the construction industry, many firms still adopt the traditional top-down, tightly controlled management models that worked relatively well in the industrial age by suppressing informal communications. In today's knowledge age, this is considered as a death knell as employers and employees are mutually dependent on continuous sharing of ideas and information, and most of the ideas and innovations are generated by meaningful collaborative relationships nurtured within emergent engagement systems. The construction industry needs to place major importance on identifying and improving the organisational engagement where the management (formal) and the workers (informal) overlap, see (Cameron et al. 2006; ECOTEC 2005). Under the right conditions, workers will begin to overlap more and more with the management elements of an organization's systems, processes, applied technologies and management structure. This overlapping spot is not reached through any sort of formal negotiation, rather, it is emergent. Consequently, it is within this area of engagement between the management and the workforce that most of the productive work and innovation takes place in most organisations, see (MacLeod & Clarke 2009).

There is also an important element of reciprocity in trust (Scholefield 2000). For workers to be engaged and to reinforce their commitment within an organisation; the employer should be willing to invest in the worker's wellbeing, making the workers feel valued and in return the workers will reciprocate directly with renewed employer loyalty and by working harder and more efficiently. The investment cost to the employer for helping the worker is repaid in multiples through greater performance levels. This can lead to higher levels of engagement, greater focus on achieving organisational goals and increased motivation at work which can significantly improve mental and physical wellbeing. According to Ehin (2013), for an organisation to succeed, its systems and practices need to have flexible capacity not only to support its organisational/business goals but also the physiological and mental needs of its workforce. From a management viewpoint, it has been recognised that every worker in an organisation persistently tries to maintain dynamic equilibrium within the social contexts they happen to be immersed in.

There are both legal and ethical requirements for management to collaborate with the construction workforce for the improvement of OSH. This study therefore considers approaches to the development of a worker engagement maturity model for the construction industry that will secure improved worker performance in a cost effective manner. Worker engagement is considered as an important aspect of maintaining that corporate knowledge base and of sharing it within the industry. The development of a worker engagement maturity model for the improvement of construction OSH is desirable because the industry is a fast-paced changing project organisation where management personnel and subcontractors are itinerant throughout the various stages of a construction project. For effective worker engagement in health and safety to become the norm, the effectiveness of corporate OSH engagement programmes should be assessed using a valid and reliable tool. Without the ability to assess construction workers' growth and effectiveness, opportunities to improve construction OSH performance and the potential benefits on construction site will be lost.

Research shows that worker engagement has many positive job outcomes such as job satisfaction and performance (Gruman & Saks 2011; Schaufeli & Salanova 2007), active coping style e.g. (Storm & Rothmann 2003) and creativity e.g. (Bakker & Xanthopoulou 2013). Given these significant contributions to organisational success, it is crucial for researchers and practitioners to comprehend the factors that lead to worker engagement. Although engagement has been associated with a wide range of positive job outcomes, however, studies have not focused on the contributory roles of meaningful discussion, empowerment, trust, motivation and commitment as five important indicators of worker engagement, even when trust on the organisation and empowerment have been found to be vital in many positive job attitudes (Shockley-Zalabak et al. 1999; Fedor & Werther 1996; Scholefield 2000). So, understanding the role of these five indicators is a key issue to generating positive job attitudes for engagement.

2. The Five Indicators

2.1 Meaningful Discussions

When discussions (face-to-face) are mediated by response or feedback and have direct impact on the capabilities of workers, such discussions can be considered as meaningful. Experience shows that within the construction industry, effective meaningful discussions are wholly dependent on individuals, teams and organisations. Also, because of the temporary and inter-disciplinary nature of most construction projects, the construction industry is often characterised by groups of workers that are peripatetic, unacquainted, working together on a project over a limited period of time before disbanding to work on other projects, (Dainty et al. 2006). The notion of meaningful discussions therefore ensures that the flow of information is effectively managed, messages are appropriately conveyed and workers are able to interpret and act on such information in a way that is consistent with the expected intents. Meaningful discussion is considered as a fundamentally social activity which includes engaging in conversations, listening to co-workers, networking, collecting information, and directing subordinates on issues relevant to safety and health of the workforce. Meaningful discussions will thrive better in a workplace when there are some predictive elements of co-worker knowledge, team tenure, co-worker and supervisory support, group orientation and group cohesion, see (Burt et al. 2008). Meaningful discussions can therefore be suggested as an improvement in communication, building relationships and trust, raising awareness of a

number of cultural developmental issues and getting feedback from individuals on site including the supply chain. Maloney & Cameron (2003) suggested that meaningful discussions can only take place when workers possess some elements of capability, i.e. training, experience and knowledge.

2.2 Empowerment

The concept of empowerment has its roots in practical matters such as intrinsic motivation, job design, participative decision making, social learning theory, and self-management (Liden & Tewksbury 1995). The core concept of empowerment involves giving the workers some sense of autonomy specific to their roles, increasing the motivation of workers at work by delegating authority to the lowest level in an organisation where a competent decision can be made (Conger & Kanungo 1988; Thomas & Velthouse 1990). The importance of measuring psychological empowerment was developed by Spreitzer (1995) capturing four sets of essential cognitions: 'meaning' (fit between work-role requirements and personal beliefs and values), 'competence' (work-specific self-efficacy), 'self-determination' (sense of choice in initiating and regulating actions), and 'impact' (perceived influence on strategic, administrative, and operating outcomes at work). Empowerment is considered as a motivational construct associated with 'enabling' a construction worker rather than simply delegating. Enabling such workers implies creating conditions for heightening motivation for task accomplishment through the development of a strong sense of personal efficiency.

2.3 Trust

Working together often involves interdependence, and construction workers must therefore depend on others in various ways to accomplish their personal and organisational goals. The workforce composition and the organisation of the workplaces are getting increasingly diverse within the UK construction sector. This increase in construction workforce diversity requires workers with very different backgrounds to come into contact and deal closely with one another (Jackson & Alvarez 1992). Therefore, trust is regarded as the measure of the willingness to take risk (i.e., be vulnerable) in a relationship (Mayer et al. 1995). Trust is a psychological state that involves the willingness of a worker to be vulnerable to another party (which can be a co-worker or manager) when that party cannot be controlled or monitored; an expectancy that another can be relied on. The perceptions of operative/supervisor characteristics comprising trustworthiness are antecedents of trust which are ranked in the forms of ability (skills and competencies), benevolence (grounded in mutual care and concern between workers), and integrity (e.g. worker's perception that the manager adheres to a set of principles that the worker finds acceptable) and all three components contribute to the prediction of trust.

2.4 Motivation

The theory of self-determination (Deci & Ryan 1985; Ryan & Deci 2000; Deci & Ryan 2008; Gagne & Deci 2005) which suggests universal psychological needs indicates that workers are motivated and display wellbeing in organisations to the extent that they experience psychological need satisfaction within those organisations. Motivation is the act of being moved to do something. This can be subdivided into two sub categories: unmotivated whereby a worker feels no impulse or inspiration to act and motivated where the worker is energised or activated towards an end goal. The Self-determination theory (SDT) focuses on types of motivation, rather than just amount, of motivation, paying particular attention to autonomous motivation, controlled motivation, and lack of motivation as predictors of performance, relational, and wellbeing outcomes. The SDT examines worker's life goals or aspirations, showing differential relations of intrinsic versus extrinsic life goals to performance and health and safety. The concept of motivation is hardly a unitary phenomenon because workers have different amounts and different kinds of motivation, (Ryan & Deci 2000). That is, workers vary not only in level of motivation (how much motivation), but also in the orientation of that motivation (what type of motivation). The concept of construction worker motivation is modelled after SDT based on the different reasons or goals that give rise to an action. The most basic distinction is between intrinsic motivation, which refers to a worker doing something

because it is inherently interesting or enjoyable, and extrinsic motivation, which refers to doing something because it leads to a separable outcome, (Ryan & Deci 2000). The quality of experience and performance can be very different when a worker is behaving for intrinsic or extrinsic reasons.

2.5 Commitment

The commitment of workers are the psychological bonds that they have to workplace targets (Klein et al. 2009), including organisations, individuals and groups within organisations, and goals and behaviours (Becker 1992; Vandenberghe 2009). Commitment of the construction workforce was ranked in three levels: citizenship commitment; compliance commitment; and conditional commitment. Citizenship commitment refers to workers' psychological attachment to their organisations caused by their identification with the objectives and values of their organisations. In other words, the workers are loyal to and choose to remain with their organisations because they want to (Meyer et al. 1993). Compliance commitment refers to the worker's psychological attachment to the organisation based on experiences that underline the appropriateness of remaining loyal or morally obliged to repay the organisation for benefits received from the organisation (Meyer et al. 1993). Workers with high compliance commitment will remain in the organisation because they believe it is morally right to do so and this can also be associated with the norms of reciprocity; workers helping each other out. Conditional commitment is a function of the perceived cost of a worker leaving an organisation. Workers feel a sense of commitment to their organisation because they feel they have to remain (Meyer et al. 1993). For the worker to do otherwise would be to give up favourable levels of personal status, seniority, remuneration, work schedule, pension, and other benefits acquired.

3. Objective

This paper reports on the study which is developing a worker engagement maturity model against which to assess 'meaningful discussion' in relation to OSH engagement. This is part of an inclusive model developed to encapsulate the levels of meaningful discussions, empowerment, trust, motivation, and commitment. This maturity model will potentially serve as a guidance tool that will be useful to workers and managers on construction sites in order to improve meaningful discussion on OSH, wellbeing and social sustainability in construction.

4. Methods, Design & Interviews

The objective of the research dictated a qualitative approach towards obtaining rich data giving accounts of 'worker engagement' episodes and describing circumstances and context. The research implemented the phenomenological research inquiry (qualitative design) which describes the lived experiences of construction operatives and supervisors about the phenomenon of worker engagement as described by workers; see (Creswell 2014). This was considered most suitable for this study because the type of description articulates the experiences for several operatives and supervisors who have all experienced different types of worker engagement. Phenomenological research design is based on strong philosophical underpinnings and it involves conducting interviews, see (Giorgi 2012).

Access to construction operatives and supervisors was facilitated by industry OSH experts who are also members of the Steering Group. A purposeful sampling strategy was adopted for selecting construction sites (made up of house building to large scale civil engineering projects) and workers from sites across the UK. The participants interviewed were engaged operatives and working supervisors i.e. an engaged operative is described as a worker who shows interest in health and safety issues, contributes to H&S and/or regularly attends H&S meetings; whilst a supervisor is a worker who encourages engagement and regularly discusses H&S issues with other co-workers.

Phenomenological studies typically involve three to 10 participants (Creswell 2014); but this study conducted an in-depth, semi-structured, face-to-face and open-ended, non-leading interviews with 29 operatives and supervisors until saturation was attained, (Charmaz 2014). Each interview lasted an average of 40 minutes and the process was audio recorded with note taking on site and later transcribed.

The development of the worker engagement maturity model involved using inductive and deductive logic. The inductive process involved working back and forth between the themes emerging from interviews conducted and the information from literature until a comprehensive set of themes were established (Creswell 2013). This involved collaborating and interacting with industry experts (Steering Group) via presentations and workshops in order to shape the emerging themes of the maturity model from the interviews.

The validation of the worker engagement maturity model and categorisations was implemented through workshops with members of the Steering Group iteratively. The rankings of the statements from operatives extracted from the interviews went through an iterative process with the expert focus groups using the Delphi technique. The Delphi technique is a widely used method for data gathering from teams of experts designed as a group communication process with the aim of achieving convergence of opinions; see (Hsu & Sandford 2007; Hasson et al. 2000). The visual representation of maturity model was developed deductively with members of the Steering Group from the categories of information acquired from interviewing the research participants to reach a logically certain conclusion. This was considered ideal working from the more general to the more specific context of worker engagement based on practical examples.

5. Analysis & Discussion

The ranking of maturity for worker engagement was conceived and developed by the researchers in collaboration with the industry experts. This resulted in assigning levels and criticality to the different indicators necessary for workers to progress through the different levels of growth and engagement, see Tables 1-5. The representation of factors radiates from a lower level to an optimal level which determines the level of maturity of operatives or supervisors. The lower levels generally reflect their immediate needs and surroundings and eventually to factors of higher levels needing interventions from the management. The significance of involving industry experts was to address complex issues of diverse views regarding assigning and categorising the levels of the different factors that impact on the maturity of construction workers as seen in Tables 1- 5.

Table 1 Meaningful Discussions Ranking Scale.

Level	Criticality	Meaning
1	Personal work area; housekeeping; and work environment	Hazards that directly affect/related to the worker
2	Welfare	Issues related to site welfare
3	Hazard spotting; site hazards; and hazard causes/procedures	Hazards that are associated to other workers
4	Proactive site solutions	Proactive discussions or proactive actions taken to resolve issues
5	Beyond the site gate: boardroom/other sites; designs; and mental health	Issues that are beyond the site gate needing some management interventions

Table 2 Empowerment Ranking Scale.

Level	Criticality	Meaning
1	Meaning ["Knowing"]	Worker's beliefs and values for health & safety is important, the worker knows the requirements of a work role and behaviours but don't take action
2	Competence ["Doing"]	Worker has the skills, capability, and personal mastery; compliant, takes action (reactive). Worker's belief in his or her capability to successfully perform a given task or activity
3	Self-determination ["Decision making"]causes/procedures	Proactive about work methods, pace and effort (within/inside the gate). Worker's sense of choice about activities and work methods.
4	Impact ["Influencing"]	Strategic, administrative or operations outcomes (beyond/outside the gate); making a difference; suggestions/decisions are followed up or supported by top management (impact). The degree to which the worker believes he or she can influence organisational outcomes.

Table 3 Trust Ranking Scale.

Level	Criticality	Meaning
1	Lack of trust	Absence of A, B, C; vulnerability is negative
2A	Ability	Trust in the ability of others to work safely and without problems
2B	Benevolence	'Genuine', company cares about worker; 2-way relationship; just culture
2C	Company Integrity	Confident that raising H&S concerns will be praised; honest; do what they say; management approachable and respected
3	Complete trust	All A, B, C are present; vulnerability is positive

Table 4 Motivation Ranking Scale.

Level	Criticality	Meaning
1	No motivation	Lack of motivation
2A	Externally Controlled - Extrinsic	Organisation driven e.g. money
2B	Introjected - Extrinsic	Guilt avoidance, ego enhancement
2C	Identified - Extrinsic	Strategic personal gains
2D	Integrated - Extrinsic	Self-motivated, self-determined
3	Intrinsic Motivation	Inherent, self-driven, job satisfaction; happiness; enjoyment, competence, autonomy

Table 5 Commitment Ranking Scale.

Level	Criticality	Meaning
1	Conditional Commitment	Commitment only when certain conditions apply e.g. remunerations, pensions; seniority etc. Commitment is dependent on self-interest; changeable; comes and goes based on situations
2	Compliance Commitment	Obliged to work to the rules due to investment in training, rewards and other benefits 'normative'
3	Citizenship Commitment	Commitment above and beyond compliance e.g. proactively promoting safety message; affective commitment i.e. enjoying, satisfaction from contributing to improved H&S standards

Figure 1 shows an exemplary output of the worker engagement cycle in practice. The worker engagement cycle starts with meaningful discussion as the initial core of the subjects discussed by the workers e.g. worker not happy with the PPE provided by the organisation and management considers the replacement cost as too high. Meaningful discussion will positively impact on H&S decisions thus making workers feel empowered to raise such issues as inappropriate PPE. The result of empowerment starts with competence which further leads to influencing H&S decisions which builds on the level of trust. This is when workers feel genuine benevolence and perceive that management is actually listening and responding to their immediate needs. The increase in trust regarding organisational integrity influences the motivation of the worker to move from extrinsic to intrinsic motivation where they inherently enjoy their tasks and look after their PPEs. The move from extrinsic to intrinsic motivation increases the commitment of the workers which eventually leads to more meaningful discussions e.g. a new cycle where proactive discussions about lone-working previously unknown to management is raised by the workers. It is only when issues related to personal work areas and welfare have been addressed and there is that element of trust (Scholefield 2000) in the management to act on problems, that a worker will have the confidence to raise other immediate issues that either impact them personally or their work environment. Engaging with workers in resolving immediate issues will reinforce some sense of empowerment, meaning, competence, impact and belief that they are being listened to (Conger & Kanungo 1988). This is when workers feel empowered and emotionally committed (Schaufeli 2013) to identify and raise other issues that pose as hazards to others.

6. Conclusions

Based on the initial results from this study, it has been identified that most construction workers are struggling to attain optimum levels of meaningful discussions, empowerment, trust, motivation and commitment except those that are highly involved as safety representatives or union representatives within the workplace. Worker engagement will need to go wider and farther for the operatives and working supervisors to meaningfully discuss issues up to the highest levels for every indicator in order to attain social sustainability.

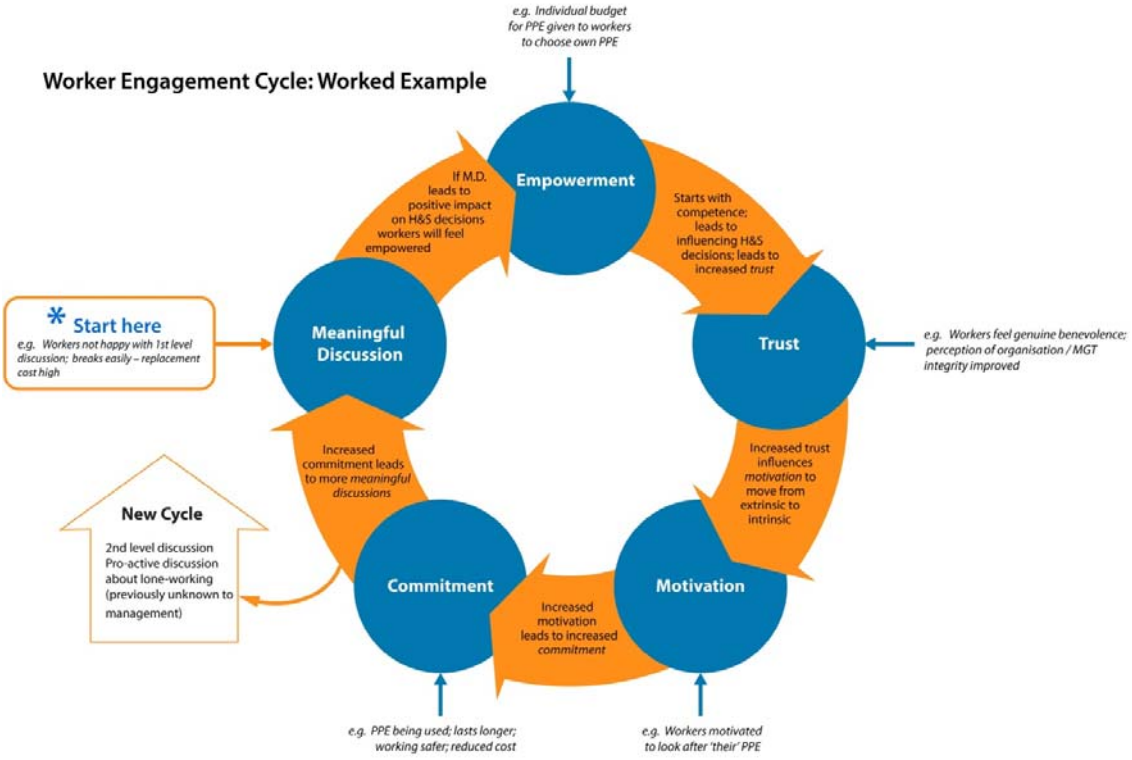

Figure 1 Exemplary output of Worker engagement Cycle.

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Feasibility of Insulation Applications on Existing Buildings in Turkey

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Abstract

It is possible to enhance the energy performance of existing buildings by upgrading the building envelope through insulation application on outer walls and ceiling. As insulation applications help the building spend less heating and cooling energies, they initial costs. The major objective of this study is to determine the feasibility of insulation applications in existing buildings. Within this context, an insulation application on a representative existing building in Turkey is economically investigated. Life cycle costing analysis (LCCA) approach is utilized in the analysis. The insulation application includes expanded polystyrene (EPS) application on the outer walls and stone wool application on the ceiling. As Turkey is composed of four temperature zones according to Turkish Standard (TS) 825, "Thermal Insulation Requirements for Buildings", the analysis is conducted for each temperature zone. Heating energy calculations are done according to TS 825. The costs of insulation applications are obtained by taking offers from suppliers. Economic analyses are repeated for a number of scenarios with different discount and escalation rates. Net savings (NS), internal rate of return (IRR), savings-to-investment ratio (SIR), and payback period (PBP) are calculated for the insulation investment in each zone. The results show that such investments are highly profitable. NS amounts are positive even in the worst scenario cases. Obtained IRR values are greater than 20% and SIR values are observed to be more than 2. PBP's are found to be less than 8 years.

Keywords: Energy efficiency; insulation applications; life cycle costing analysis; feasibility analysis; existing buildings.

1. Introduction

Energy is vital for the social and economic development of societies. After the energy crises of 1973, energy saving has become an essential part of national energy strategies. This situation is of prime importance for Turkey as it has to import 52% of the energy from abroad to meet the needs. (Bolattürk 2006). Energy consumption of the world has been increasing as a result of the increases in population, migration to large cities, and improvements in the standards of living. Although it is not possible to completely eliminate energy consumption, it is possible to use the energy in a much more efficient way. The energy consumption mainly takes place in four sectors, namely industrial, building (residential/commercial), agriculture, and transportation (Bolattürk 2008).

The energy consumption in building sector is the major part of the total primary energy consumption and has had a continuous growth since 1960s (Maleviti et al. 2013). It corresponds to more than 20% of the global energy consumption of delivered energy and about 10% of the global greenhouse gas emissions, both in developing and developed countries (IEO 2013). Energy users, from an individual home owner to a corporation or nation, have the tendency to pursue energy efficiency (Nikoofard et al. 2015). Energy efficiency is regarded as the best way to keep the energy demand under control and facilitate the transition towards a low-carbon future. This situation emphasizes the key role of residential sector as it has the highest cost-efficient potential for reducing CO_2 emissions (Ramos et al. 2015).

Reducing the energy consumption in buildings is one way of saving energy. A building envelope consists of the external walls, roof, basement, windows and doors. These parts are the interface of a building between the interior and outdoor environment. The common practice in existing buildings is to apply thermal insulation on the external walls and roof to reduce space heating and cooling costs. Although applying certain insulation materials on the building envelope has some disadvantages such as vulnerability to fire, insulation applications in general provide economic benefits to the building owners. The aim of this study is to investigate the

economic outcomes of insulation applications on existing buildings in Turkey. For this purpose, an insulation application on a representative existing building is economically analyzed using a life cycle costing analysis (LCCA) approach. The analysis takes the cost of insulation application and energy savings into account. As Turkish Standard (TS) 825, "Thermal Insulation Requirements for Buildings", takes only the heating energy into account, cooling energy savings are ignored. As Turkey is composed of four temperature zones according to TS 825, the analysis is conducted for each temperature zone. Economic analyses are repeated for a number of scenarios with different discount and escalation rates. Net savings (NS), internal rate of return (IRR), savings-to-investment ratio (SIR), and payback period (PBP) are calculated for the insulation investment in each zone.

2. Research background

There have been a number of studies in the literature investigating the feasibility of insulation applications. They have mostly concentrated on determining the optimum insulation thickness. Yu et al. (2009) conducted a study to determine the optimum insulation thickness for four cities in China. The study considered both the heating and cooling energies. Mishra et al. (2012) studied the optimum insulation thickness in India for different type of building walls. Dombaycı (2007) investigated the environmental effect of optimum insulation thickness and concluded that it is possible to decrease energy consumption by 46.6% and emissions of CO_2 and SO_2 by 41.5% with the application of optimum insulation thickness on the external walls. Dombaycı et al. (2006) studied the optimum insulation thickness in Denizli for five different energy sources, namely, coal, natural gas, LPG, fuel oil and electricity; and for two insulation materials, namely, expanded polystyrene and rock wool. It was concluded that a life cycle saving of 14.09 \$/m^2 and a payback period of 1.43 years can be achieved. In another study, Dylewski and Adamczyk (2011) studied both the environmental and economic benefits of thermal insulation on the external walls. The benefits were obtained for several versions of thermal insulation. It was found that thermal insulation made of polystyrene foam or ecofibre gave the best results.

3. Methodology

In this study, the feasibility of insulation applications is determined by using a representative building approach. Insulation is applied on the representative building. The external walls and ceiling of the building is insulated with expanded polystyrene (EPS) and stone wool, respectively. Insulation thicknesses are determined such that the insulated building would satisfy the conditions in TS 825. Economic analyses are conducted by taking the insulation cost and annual energy savings into account.

The representative building is a typical five-storey existing building in Turkey. The uninsulated building has a length of 25 m, a width of 20 m and each floor has a height of 3 m. Net height of each floor is 2.6 m. Gross volume (V_{gross}) of the building is 7500 m^3. The areas of the windows are 50 m^2, 20 m^2, 40 m^2, and 20 m^2 for south, north, east, and west directions, respectively. The details of the uninsulated and insulated buildings are shown in Table 1 and Table 2, respectively.

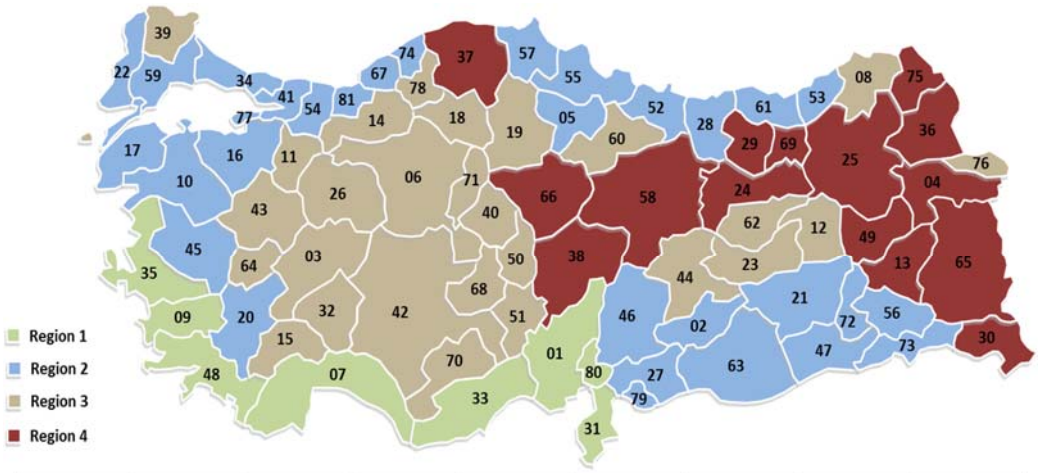
Table 1 Building Elements of Surfaces in Uninsulated Building.

Surface Losing Heat	Building Elements	Area
Outer, Infilled Wall	Inner plaster (2cm) + Brick (19cm) + Outer Plaster (3cm)	680 m^2
Outer, Reinforced Concrete Wall	Inner plaster (2cm) + Reinforced Concrete (25cm) + Outer Plaster (3cm)	535 m^2
Ceiling with Roof	Inner plaster (2cm) + Reinforced Concrete (12cm)	500 m^2
Basement in Contact with Soil	Timber Flooring (1cm) + Screed (5cm) + Reinforced Concrete (15cm) + Lean Concrete (10cm) + Crushed Stone (20cm)	500 m^2
Outer Doors	-	5 m^2
Windows	-	130 m^2

Table 2 Building Elements of Surfaces in Insulated Building.

Surface Losing Heat	Building Elements	Area
Outer, Infilled Wall	Inner plaster (2cm) + Brick (19cm) + Outer Plaster (3cm) + **EPS (x.cm)** + Outer Plaster (0.8cm)	680 m²
Outer, Reinforced Concrete Wall	Inner plaster (2cm) + Reinforced Concrete (25cm) + Outer Plaster (3cm) + **EPS (x.cm)** + Outer Plaster (0.8cm)	535 m²
Ceiling with Roof	Inner plaster (2cm) + Reinforced Concrete (12cm) + **Stone Wool (x.cm)**	500 m²
Basement in Contact with Soil	Timber Flooring (1cm) + Screed (5cm) + Reinforced Concrete (15cm) + Lean Concrete (10cm) + Crushed Stone (20cm)	500 m²
Outer Doors	-	5 m²
Windows	-	130 m²

The insulation is applied on the outer walls and ceiling of the building. The thicknesses of insulation materials depend according to the region the building is located in. As there are four temperature zones in the standard TS 825, insulation thicknesses are determined for each of them. The regions of Turkey according to TS 825 are shown in Figure 1. As Region 1 stands for the hottest parts of Turkey, Region 4 represents the coldest locations.



01 Adana	10 Balıkesir	19 Çorum	28 Giresun	37 Kastamonu	46 K. Maraş	55 Samsun	64 Uşak	73 Şırnak
02 Adıyaman	11 Bilecik	20 Denizli	29 Gümüşhane	38 Kayseri	47 Mardin	56 Siirt	65 Van	74 Bartın
03 Afyon	12 Bingöl	21 Diyarbakır	30 Hakkari	39 Kırklareli	48 Muğla	57 Sinop	66 Yozgat	75 Ardahan
04 Ağrı	13 Bitlis	22 Edirne	31 Hatay	40 Kırşehir	49 Muş	58 Sivas	67 Zonguldak	76 Iğdır
05 Amasya	14 Bolu	23 Elazığ	32 Isparta	41 Kocaeli	50 Nevşehir	59 Tekirdağ	68 Aksaray	77 Yalova
06 Ankara	15 Burdur	24 Erzincan	33 Mersin	42 Konya	51 Niğde	60 Tokat	69 Bayburt	78 Karabük
07 Antalya	16 Bursa	25 Erzurum	34 İstanbul	43 Kütahya	52 Ordu	61 Trabzon	70 Karaman	79 Kilis
08 Artvin	17 Çanakkale	26 Eskişehir	35 İzmir	44 Malatya	53 Rize	62 Tunceli	71 Kırıkkale	80 Osmaniye
09 Aydın	18 Çankırı	27 Gaziantep	36 Kars	45 Manisa	54 Sakarya	63 Şanlıurfa	72 Batman	81 Düzce

Figure 1 Regions of Turkey According to TS 825.

The insulation thicknesses are determined according to the conditions stated in TS 825 for existing buildings. The minimum thicknesses satisfying TS 825 are applied in each region. The EPS and stone wool thicknesses to be applied on the outer walls and ceiling are given in details in Table 3. For example, the minimum thicknesses that satisfy the conditions in Region 3 are 6 cm and 11 cm for outer walls and ceiling, respectively.

Table 3 Thicknesses of Insulation Materials.

Region	EPS Thickness (for outer walls)	Stone Wool Thickness (for ceiling)
Region 1	4 cm	7 cm
Region 2	5 cm	8 cm
Region 3	6 cm	11 cm
Region 4	8 cm	13 cm

As the insulation applications incur an initial cost, they reduce the annual energy requirements of the building and result in annual energy savings. The costs of the insulation applications are determined by taking offers from 3 different companies and taking average of them. The annual energy savings are determined by calculating the difference between the annual energy requirements of the uninsulated and insulated building. As the analysis involves the inflows and outflows of money on a yearly base, the energy requirements and savings are determined annually. Table 4 shows the cost of insulation applications and annual energy savings for each region. To clarify, while the cost of applying insulation on the outer walls and ceiling in Region 3 is 86,968 TL, the annual energy requirement of the building is reduced by 268,269 kWh/year.

Table 4 The Costs and Annual Energy Savings of Insulation Applications.

Region	Total Cost (TL)	Annual Energy Savings (kWh/year)
Region 1 (4cm+7cm)	77,582	160,409 – 56,821 = 103,588
Region 2 (5cm+8cm)	81,140	300,178 – 108,480 = 191,698
Region 3 (6cm+11cm)	86,968	413,385 – 145,116 = 268,269
Region 4 (8cm+13cm)	94,429	536,711 – 184,392 = 352,319

*1 TL=0.28 USD

4. Results and discussion

The cash flow diagrams are drawn and financial parameters (NS, IRR, SIR, and PBP) can be calculated after the cost of insulation and the annual energy savings are determined. The time period is assumed as 20 years. The cash flow diagrams are drawn for each region and for different combinations of discount and escalation rates. The discount rate is the rate at which future savings are discounted back to present. The escalation rate refers to the rate of increase in the energy prices. As these two rates are difficult to predict due to the uncertainties in the economic and political situations of the countries, three different values are estimated for each one and financial parameters are determined for all the combinations (9 combinations in total). The estimated rates are 7%, 9%, and 11%.

The energy price in the starting year is determined as 0.1031 TL/kWh (taxes added). The financial saving (TL) in year n is calculated by the following formula:

$$\text{Financial Saving (n)} = \frac{\text{Annual Energy Saving (kWh)}}{\text{Efficiency of the Heating System}} * \frac{\text{Energy Price (n}-1)+\text{Energy Price (n)}}{2}$$

To illustrate, financial saving in year 1 for Region 1 is calculated as follows:

$$\text{Financial Saving (1)} = \frac{103{,}588}{0.90} * \frac{0.1031+0.1124}{2} = 12{,}399 \text{ TL}$$

The efficiency of the heating system is assumed to be 90%. The cash flow diagrams have the cost of insulation in year zero and financial savings in the following years (20 years). Table 5 shows the cash flow diagrams obtained for a discount rate of 7% and escalation rate of 9%.

Table 5 Cash Flow Diagrams Generated for a Discount Rate 7% and Escalation Rate 9%.

Cash Flow Diagram	Years						NS (TL)	IRR (%)	SIR (-)	PBP (years)
	0	1	2	5	10	20				
Energy Price	0.1031	0.1124	0.1225	0.1586	0.2440	0.5777				
Region 1 (4cm+7cm)	-77,582	12,399	13,515	17,502	26,930	63,752	200,337	23.71	3.58	6-7
Region 2 (5cm+8cm)	-81,140	22,946	25,011	32,390	49,836	117,979	433,172	36.99	6.34	3-4
Region 3 (6cm+11cm)	-86,968	32,111	35,001	45,327	69,742	165,104	632,778	45.81	8.28	2-3
Region 4 (8cm+13cm)	-94,429	42,172	45,967	59,529	91,592	216,832	850,817	53.61	10.01	2-3

Table 6, Table 7, Table 8, and Table 9 shows the economic outcomes of insulation applications for all the regions.

Table 6 Economic Outcomes of Insulation Application in Region 1.

Discount Rate	Escalation Rate	NS (TL)	IRR (%)	SIR (-)	PBP (years)
7%	7%	151,960	21.60	2.96	6-7
7%	9%	200,337	23.71	3.58	6-7
7%	11%	261,480	25.82	4.37	6-7
9%	7%	112,477	21.60	2.45	7-8
9%	9%	149,926	23.71	2.93	6-7
9%	11%	196,912	25.82	3.54	6-7
11%	7%	82,073	21.60	2.06	7-8
11%	9%	111,421	23.71	2.44	7-8
11%	11%	147,964	25.82	2.91	6-7

Table 7 Economic Outcomes of Insulation Application in Region 2.

Discount Rate	Escalation Rate	NS (TL)	IRR (%)	SIR (-)	PBP (years)
7%	7%	343,647	34.73	5.24	3-4
7%	9%	433,172	36.99	6.34	3-4
7%	11%	546,322	39.24	7.73	3-4
9%	7%	270,579	34.73	4.33	4-5
9%	9%	339,882	36.99	5.19	3-4
9%	11%	426,834	39.24	6.26	3-4
11%	7%	214,315	34.73	3.64	4-5
11%	9%	268,624	36.99	4.31	4-5
11%	11%	336,252	39.24	5.14	3-4

Table 8 Economic Outcomes of Insulation Application in Region 3.

Discount Rate	Escalation Rate	NS (TL)	IRR (%)	SIR (-)	PBP (years)
7%	7%	507,494	43.47	6.84	2-3
7%	9%	632,778	45.81	8.28	2-3
7%	11%	791,125	48.16	10.10	2-3
9%	7%	405,240	43.47	5.66	3-4
9%	9%	502,225	45.81	6.77	2-3
9%	11%	623,909	48.16	8.17	2-3
11%	7%	326,503	43.47	4.75	3-4
11%	9%	402,505	45.81	5.63	3-4
11%	11%	497,145	48.16	6.72	2-3

Table 9 Economic Outcomes of Insulation Application in Region 4.

Discount Rate	Escalation Rate	NS (TL)	IRR (%)	SIR (-)	PBP (years)
7%	7%	686,281	51.19	8.27	2-3
7%	9%	850,817	53.61	10.01	2-3
7%	11%	1,058,775	56.04	12.21	2-3
9%	7%	686,281	51.19	8.27	2-3
9%	9%	850,817	53.61	10.01	2-3
9%	11%	1,058,775	56.04	12.21	2-3
11%	7%	686,281	51.19	8.27	2-3
11%	9%	850,817	53.61	10.01	2-3
11%	11%	1,058,775	56.04	12.21	2-3

The results show that insulation applications are highly profitable investments. The profitability of the investment increases as the average temperature of the region decreases. It is possible to make greater savings in the colder regions. The NS values show that net present worth of the investments are always positive and can go up to 1 million TL in Region 4. IRR values are greater than 20% even in the worst scenarios and can go up to 56% in the coldest region. The SIR values are greater than 2 and PBP are always less than 8 years.

5. Conclusions

In this study, the feasibility of insulation applications on existing buildings in Turkey is investigated with a representative building approach. Within this context, a life cycle costing analysis (LCCA) approach is used to economically analyze the insulation applications. The cost of the insulation application and the savings obtained by reducing the annual energy requirements are considered in the analysis. The annual energy requirement of the building is determined according to Turkish Standard (TS) 825, "Thermal Insulation Requirements for Buildings". As there are four temperature zones of Turkey in TS 825, the analysis is conducted for each temperature zone separately. Cash flow diagrams are generated to calculate some financial parameters including net savings (NS), internal rate of return (IRR), savings-to-investment ratio (SIR), and payback period (PBP). The financial parameters are obtained for different combinations of discount and escalation rates.

The results indicate that the insulation applications are highly profitable investments. The colder the region is, the higher the profitability of the investment becomes. Thus, the owners of the uninsulated buildings are highly encouraged to apply insulation in their buildings. This would not only be a good investment, but also a good way of protecting the environment. The CO_2 emissions can be radically reduced by decreasing the annual energy requirements of the buildings. The governments are also advised to promote the insulation applications. It is the responsibility of the government to create green environment and insulation applications are expected to contribute to the quality of the environment.

This study is mainly based on the thermal insulation requirements applicable in Turkey. However, it is possible to apply it in other countries with their own standards. The results are expected to change according to the climatic conditions of the country and the corresponding thermal standard. As each country has its own standards, it would be possible to compare the results and see the feasibility of insulation applications in these countries.

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Incorporating Sustainability in Risk Assessment of Construction Projects

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Abstract

There are standard procedures proposed for risk management (RM) such as "ISO 31000:2009 *Risk Management Principles and Guidelines"* that provides principles, framework and a process for managing risk. However, RM is still among the most popular research topics in project management domain as there is a lack of consensus on the definition of risk as well as the contextual factors affecting its level. Many authors argue that although complexity, vulnerability, uncertainty, risk and resilience are concepts of growing interest, there is a lack of structured synthesis of these concepts and their relationships. More research is needed to understand risk-related phenomena and factors. In this paper, we will use the term "risk-related factors" to denote all project and environment related factors affecting the probability of occurrence and impact of risks (such as sources of vulnerability, complexity and resilience). Sustainability is also integral to project risk management as a risk-related factor as well as a source, an objective and a perspective. In this paper, we will review risk assessment and sustainability studies in the project management literature and discuss how risk assessment can be improved by better understanding risk-related factors and incorporating sustainability into risk models. A conceptual framework for risk assessment incorporating sustainability will be presented.

Keywords: Sustainability, Risk, Risk assessment, Construction.

1. Risk, Complexity and Sustainability

According to Society of Risk Analysis (SRA), the field of risk analysis deals with developing knowledge about risk-related phenomena and processes, triggering events and event chains, and also new concepts, theories, frameworks, approaches, principles, methods and models to understand, assess, characterize, communicate and manage risk, in general and for specific applications. Project Management Institute lists risk management (RM) as one of the knowledge areas of project management (PMBOK 5th Edition). Although there are standard procedures proposed for RM such as "ISO 31000:2009 *Risk Management Principles and Guidelines"* there are still efforts to develop new process models especially for specific types of projects incorporating different perspectives. There is also a lack of consensus on the definition of risk as well as the contextual factors affecting the level of risk. Thome et al. (2015) argue that although complexity, uncertainty, risk, and resilience are concepts of growing interest, there is a lack of structured synthesis of these concepts in the project management literature. Further research is necessary on understanding dynamics of risk-related factors in order to develop effective RM strategies in projects.

In the project management literature risk is defined as "an uncertain event or condition that, if it occurs, has a positive or negative effect on the project's objectives" (PMBOK, 2013). Risk is a multidimensional construct with different definitions and indicators depending on the field of research. For example, in finance, risk is the fluctuation around the value of an expected return. In decision theory, risk is expressed by probability distributions. In the area of health, safety and reliability engineering, risk is the product of the probability and harm of an event. The word "risk" can be used as the source of a potentially adverse consequence (such as political risk), the event itself (such as delay risk) or sometimes as the probability of occurrence of an adverse event (such as risk of an earthquake). SRA (2015) defines an element which alone or in combination with "other elements" has the potential to give rise to some specified consequences as "risk sources" or "risk agents". In this paper, the "other elements" mentioned in this definition will be denoted as "risk-related factors" meaning that these factors interact with risk agents, leading to different scenarios and affect project performance in various ways.

The risk-related factors can be sources of vulnerability, complexity and resilience. The ability of a system to withstand risk agents is defined as vulnerability. There is a causal relationship between vulnerability, risk sources and consequences in a project. Risks may originate from the system complexity – systematic uncertainty (internal) or external conditions. From the perspective of project management, Perminova et al. (2008) define uncertainty as *"a context for risks as events having a negative impact on the project's outcomes, or opportunities, as events that have beneficial impact on project performance".* The risk emergence process should be understood well and sources of uncertainty should be explored for effective risk assessment.

Bakhsi et al. (2016) mention that projects are becoming more complex, in both their structure and their context and in addition to the organizational and technical complexities, project managers have to consider a growing number of parameters (e.g. environmental, social, safety and security) and a growing number of stakeholders, both inside and outside the project. Complexity can be viewed as *"the inability to predict the behaviour of a system due to large numbers of constituent parts within the system and dense relationship among them"* (Bakhsi et al. 2016). There are different views about the relation between risk and complexity. Fang and Marle (2013) argue that the complexity of a project leads to the existence of a network of interdependent risks. Qazi et al. (2016) define "knowns" in a project as "complexity" and the "known unknowns" as risks considering complexity and risk as two separate concepts. Both uncertainty and complexity can be considered as drivers and antecedents of risk. Qazi et al. (2016) argue that adopting a disintegrated approach of evaluating complexity and risks in silos results in undermining the synergistic effect of interacting complexity attributes (drivers) and complexity induced risks which may lead to selection of sub-optimal risk mitigation strategies. Although the standard RM process; namely: risk identification (risk characterization); risk analysis; risk evaluation; risk mitigation; and risk monitoring – is generally adopted in the literature of project risk management, there is a need to consider "complexity" together with "risk factors" and the interdependency between risks and complexity should be considered during risk assessments.

Juttner et al. (2003) argue that known uncertainties trigger risk mitigation strategies, while unknown uncertainties drive efforts towards resilience. The term resilience is defined as "the capability and ability of an element to return to a stable state after a disruption". According to SRA (2015), a resilient system has the ability to; respond to regular and irregular threats in a robust, yet flexible (adaptive) manner, to monitor what is going on, including its own performance, to anticipate risk events and opportunities, and to learn from experience. Traditional risk management is based on estimation of probability and impact of risks whereas in situations involving large uncertainty, aim of risk management is to construct a resilient project system rather than prediction of how project system behaves under different scenarios.

There are limited studies in the project management literature about how risk-related factors and the interrelations between different risk sources can be considered during risk assessments. Although project risk registers/risk checklists are widely used in practice (also recommended in PMBOK); as they work on the underlying assumption that risks exist independently from one another, risk assessments using risk checklists usually do not reflect the real project conditions. Williams et al. (1997) argue that "the impacts that some risks have might compound the impact of others – so the effect of two risks might be more than the sum of the two individual effects thus reflecting systemicity". Although there are various efforts, there is still a need to further explore the risk emergence patterns in projects (Fidan et al., 2011; Yildiz et.al., 2014, Liu et al., 2016) and develop a formalism to demonstrate the interrelations between all the risk-related factors affecting project performance. Effective project governance structures can only be constructed if this phenomenon (complex system) is understood well and effectively characterized.

Moreover, in the project management literature, risk assessment is usually carried out considering the iron triangle (cost, schedule, quality) which gives a limited scope for project success under various scenarios. The future of risk assessment and management is discussed by Aven (2017). He argues that different situations (such as large uncertainties and emergence) require different types of methods and approach for RM. He particularly points out the importance of different perspectives required in various decision-making problems such as societal risk decision-making. He argues that the link between sustainability and risk is an emerging research topic and sustainability as a perspective should be incorporated into risk decision-making. Sustainability is a "perspective" that must be reflected into project performance criteria and it is a risk-related factor that increases complexity and uncertainty in

projects. The sustainability risk and its management is a mature research topic in domains such as supply chain management as argued by Fahimnia et al. (2015). However, there are limited studies in the domain of project management that link concepts of risk and sustainability (Aarseth et al., 2017).

In this paper, we will concentrate on "sustainability" as a risk-related factor and a performance criteria, also as a "perspective" in RM of construction projects.

2. Project Management Literature on Sustainability

Sustainability is defined as sustainable utilization of natural resources. Brundtland Commission defines sustainable development as the one that meets the needs of the present without compromising the ability of future generations to their own needs. Sustainability is about balancing the social, environmental and economic goals which are referred to as the three pillars of sustainable development. Sustainability agenda refers to protection of the environment, enhancing social prosperity and improving economic performance (Abidin and Pasquire, 2007).

Projects significantly contribute to growth in the countries in which they are executed but on the other hand, may pose challenges in terms of sustainability-related goals when their impacts on the society, environment and economy are considered. Aarseth et al. (2017) argue that sustainability is a fairly new topic in the project management literature and current project management frameworks do not effectively take social and environmental issues into account. They argue that the iron triangle should be challenged and sustainability should be embedded into project constraints and goals.

Different researchers approach sustainability from different angles such as; sustainability of impacts, sustained existence of an enterprise, sustainability risk or sustainable/green manufacturing or construction. Researchers propose different models/frameworks to incorporate sustainability into traditional project management functions such as value management (Abidin and Pasquire 2007; Al-Saleh and Taleb 2010) ; construction project portfolio management (Siew 2015) supply chain management (Cheung and Rowlinson 2011) and stakeholder management (Mathur et al. 2008). Also, researchers proposed implementation of some strategies to ensure sustainability. After a detailed literature survey in the project management field, Aarseth et al. (2017) categorise the sustainability strategies used in the projects such as; setting sustainability goals and policies, developing sustainability practices and competencies and putting sustainability emphasis on processes like design, supply chain management and portfolio management. The level of sustainability achieved in a project will definitely depend on the strategies implemented. Sustainability strategies should consider the level of uncertainty and therefore the risks that decisions may impose on the natural and social environments, in addition to the investment costs that are required to make supply chains more sustainable (Giannakis and Papadopoulos 2016).

Construction industry has a special importance for sustainable development. Sustainable construction was originally used to describe the responsibility of the construction industry in attaining sustainability (Hill and Bowen 1997). Kibert (1994) defines sustainable construction as "creating a healthy built environment using resource-efficient, ecologically-based principles". The dimensions of sustainable construction have been identified such as economic, biophysical, technical, social dimensions and its states/levels are tried to be quantified (Hill and Bowen 1997). Researchers usually focus on its different dimensions and balance between them. For example, Edum-Fotwe and Price (2009) focus on the social dimension of sustainability analysis and develop a social ontology for appraising sustainability of construction projects. Some researchers try to measure the level/state of sustainability using different indices. Dobrovolskiene and Tamosiuniene (2015) developed a composite sustainability index for the construction projects which can be integrated into project portfolio management. Sustainability strategies and frameworks are also widely discussed in the construction management literature. Hill and Bowen (1997) argue that it is necessary to give an indication of how sustainability principles may be used in practice. They argue that which sustainability principles to apply to a specific project determines the state/level of sustainable construction such as weak, strong, very strong etc. They identified process oriented principles of sustainable construction and a framework for the attainment of sustainable construction. Technical aspects of sustainability such as choice of materials, technology etc. are widely discussed as well as techniques/tools to assess sustainability. For example, various researchers considered life

cycle assessment (LCA) as a critical approach to ensure sustainability. Ortiz et al. (2009) reviewed research on LCA applied in the building sector.

Sustainability as a "perspective" in project management requires a systems/integrated approach, collaborative effort, life cycle focus, multidisciplinary approach and what-if thinking. Thus, it calls for a risk perspective and scenario analysis. Risk analysis methodology is critical to assess whether sustainability objectives are achievable and risk management is critical to formulate robust strategies to ensure sustainability under various scenarios. Thus, methodological integration is needed as well as blending of approaches (risk and sustainability perspectives). In the next section, we discuss why and how sustainability can be incorporated into risk management.

3. Sustainability and Risk Management

There are various studies about why sustainability as a "perspective" should be incorporated into RM as well as how methods of RM can be improved to tackle sustainability issues. Sustainability can be defined as a "goal/objective", "perspective/approach", and/or "risk-related factor" within RM framework. Fahimnia et al. (2015) adopt RM perspective to sustainability, by taking into account the risk that is related with the business decisions and their effects on biophysical, social and financial ecosystems. They used the term "sustainability-related risk management" which takes into account sustainability risks. It is observed from previous studies that, the researchers usually try to identify "sustainability risk", define its sources, assess its level and formulate strategies to manage sustainability risk. However, not all dimensions of sustainability and their overall impacts on sustainability have been investigated thoroughly yet. Tang and Zhou (2012) note that the research agenda is maturing in the area of recycling and remanufacturing, while environmental and social sustainability risks are two areas that deserve future attention.

There are some other studies that consider "methods" about how sustainability can be incorporated into RM. Klibi and Martel (2012) argue that "scenarios" developed for risk analysis must not only consider random business-as-usual events, but also high impact disruptions such as impact on environment etc. affecting level of sustainability and they propose a method to generate these scenarios as well as predict their outcomes. Some researchers believe that new methods should be developed to consider relations between various concepts such as sustainability and risk. Kifokeris and Xenidis (2016) argue that an integrated framework for the notions of risk analysis, constructability and sustainability in the lifecycle management of projects has to be developed as a first step towards the establishment of a comprehensive "methodology".

It is evident that sustainability is a broad concept that has many dimensions (economic, environmental, social, technical etc.) and considering all dimensions increase uncertainty in projects and lead to complex relations between various project components (tasks, actors, performance criteria etc.) which should be considered during risk modelling and risk management.

4. Sustainability Incorporated Risk Assessment in Construction Projects

Construction projects are known to be high-risk undertakings because of their technical and organizational complexity, and also their vulnerability to external conditions such as physical and environmental conditions as well as political and socio-economic conditions. RM has been a popular research topic in the construction management literature starting from 1980s. Researchers proposed various methodologies for construction risk management (Al-Bahar and Crandall, 1990; Wang et al., 2004; Del Cano and De la Cruz, 2002) and worked extensively on "risk identification and analysis" in specific types of construction projects (such as tunneling, nuclear power plants etc.). They have adopted various statistical techniques (such as Bayesian networks, Monte Carlo Simulation etc.), fuzzy risk assessment techniques and hybrid methods (failure mode and effect analysis with fuzzy logic etc.) to "quantify" risk in construction. Although there are many efforts for risk quantification and prediction of cost overrun as well as delay, there are very limited studies about understanding the risk-related factors in construction projects that utilize sustainability perspective. In this paper, we argue that a sustainability perspective is required for risk assessment of construction projects necessitating revision of the methods, processes and models. Following are some of the thoughts that could

form the underlying ideas of a research study on how sustainability can be incorporated into risk characterization (identification), modelling and assessment:

- Sustainability as a "goal": The risk assessment process depends on the performance criteria defined for the project. Thus, from the sustainability perspective, sustainability-related goals should form the basis of risk assessment. "The level of sustainable construction" planned to be achieved in the project can be defined and a performance indicator such as sustainability index can be identified. It is believed that sustainability should be a goal by itself and should be considered in RM rather than a source of threat/risk that have an impact on the iron triangle (budget, time, quality). The factors that incorporate uncertainty and have potential impact on the "level of sustainability" are defined as the risk factors (such as climatic conditions etc.) , whereas the factors that affect impact of risk events on project can be identified as vulnerability factors (such as choice of materials, technology, site conditions etc.) for sustainability. Consequently, risk models should incorporate sustainability-related goals (or indicators) as well as risk-related factors that may affect level of sustainability.
- Sustainability as a "risk-related factor": Sustainability dimensions (environmental, social etc.) can be identified as sources of uncertainty (risk agents) or complexity factors that may have an impact on all project performance indicators. Because the sustainability dimensions such as environment and social dimensions have longer term impacts when compared with the project duration, uncertainty is higher. Sustainability-related risks can be relatively easier to identify, however, their impact and probability assessment is more complex.

Based on the two perspectives above, traditional RM "process" and "strategies" shall also be revised to take into account of sustainability issues:

- As assessment of level of sustainability and identification of sustainability risks require contribution of different disciplines (such as social, environmental, economic, technical) and stakeholders, communication between stakeholders and collaboration of all parties is critical in risk identification, modelling and management. Risk identification and characterization stages should be designed to ensure this multi-stakeholder approach.
- The overall construction value chain (primary activities such as feasibility, design, construction as well as support activities such as logistics, planning etc.) should be considered during risk assessment rather than the construction phase itself. The risk models should cover all phases, tasks and interrelations.
- Life cycle assessment should be a part of risk analysis. Risks should be identified considering the life cycle and risk management plans should cover life cycle rather than the project duration.
- The risk models should consider various goals (time, cost, level of sustainability, etc.), their interrelations and risk-related factors. An integrated approach is required for understanding overall project success, its variability under different scenarios, level of risk, complexity and resilience. Modelling causal-chains and complexity is required.
- Moreover, the sustainability perspective requires a new "methodology" for risk assessment. Traditional risk assessment approach based on probabilities and evidence-based assessment may not work for sustainability incorporated risk management as it involves situations where there is not enough evidence to formulate scenarios and attach probabilities to those scenarios. Aven (2017) argues that traditional statistical methods and techniques are not suitable, as relevant supporting models cannot easily be justified and relevant data are missing for cases involving "deep uncertainty". As sustainability-related factors have deep uncertainties, it is very difficult to determine probabilities and their impact on the project. Thus, probabilistic approaches can hardly be used for risk assessment incorporating sustainability. Alternative approaches to deal with uncertainties are discussed by Cox (2012).
- Moreover, as discussed earlier, known unknowns trigger risk mitigation strategies, while unknown unknowns (usually sustainability-related factors) drive efforts towards resilience. Risk response strategies shall be more about designing a resilient system that has the ability to; respond to regular and irregular threats in a robust manner. Establishing early warning systems and eliminate failures by quick alerts would be important to design a resilient system rather than risk-informed strategies such as risk reduction and transfer. Deep uncertainty requires decisions made over time in dynamic interaction with the system. A dynamic risk management system has to be established to monitor the project

and update plans considering emergence of risks and propagation of risk-related factors in the project system.

It is apparent that more research is necessary to check the applicability of the conceptual framework explained above. It is believed that case-based research is necessary to address how sustainability incorporated RM shall be implemented in practice. It is believed that applicability of the alternative approaches as depicted in Table 1 can be studied and comparative studies can be conducted to reveal their benefits. Forthcoming research by the authors will investigate risk and complexity in mega projects. Interviews with several construction professionals will be conducted and cognitive mapping technique will be utilized to understand strategies, policies, processes and tools necessary to incorporate sustainability in the management of mega construction projects.

Table 1 Sustainability incorporated risk assessment and traditional risk assessment.

Risk	Traditional risk assessment	Sustainability incorporated risk assessment
Metrics	Iron Triangle	Level of sustainability
Sources	Project and country level	Social and environmental
Focus	Design and construction processes	Construction value chain
Coverage	Project duration	Project life cycle
Experts	Project management team	Multi-disciplinary team having different perspectives
Assessment method	Evidence-based	Assumption-based
Strategy	Elimination and control	Resilience

5. Conclusions

In this paper, it is proposed that project risk assessment should consider emergence of risk-related factors and causal chains of uncertainty, complexity and risk in projects. Also, considering the impact of projects on environment as well as economic, social and political impacts, a sustainability perspective is needed in project management. Sustainability incorporated RM has to take into account sustainability as a goal and as a risk-related factor. The process and strategies used for sustainability incorporated RM should be different than traditional risk management approach. Life cycle assessment, multi-stakeholder, integrated and dynamic approach for risk assessment is needed as well as designing resilient project systems. More research is necessary on sustainability-incorporated RM and the validity of the conceptual framework presented in this paper has to be tested by real case studies.

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The Renegotiation of Private Finance Initiative Design-Build-Finance-Operate Road Projects in the UK

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Abstract

Government across the world have been procuring infrastructure projects through Public Private Partnership (PPP) because of its many advantages. The main advantage is the efficiency it offers regarding value for money (VfM). In spite of these advantages, the procuring authorities are faced with numerous VfM implementation challenges, which necessitate a swift shift to Private Finance 2 (PF2) in the instance of the UK. One of the significant implementation challenges affecting value for money is contract renegotiation. Its effect is more pronounced in the water and transport sectors of numerous countries and has become a subject of concern for the stakeholders especially the public sector stakeholders. This background prompts the evaluation of the renegotiation of Private Finance Initiative (PFI) Design-Build-Finance-Operate (DBFO) road projects in the UK. An exploratory research method based on literature review and qualitative interviews are adopted. The findings reveal that there are instances of changes and renegotiation in PFI (DBFO) road projects to varying degrees. The case studies further show that road DBFO's are characterised by more changes to the contract than a renegotiation of the contract, and there is no evidence of adverse renegotiation impact on the VfM criteria identified by the respondents. Hence, renegotiation does not necessarily have to adversely affect the value for money criteria or result to non-achievement of VfM for the public sector as established by the literature. The ongoing research, therefore, advances and extend the findings of this preliminary research to other case studies towards proffering robust solutions to the problem of VfM achievement in PPP road projects renegotiations.

Keywords: Renegotiation, Changes, Private Finance Initiative, Design-Build-Finance-Operate, Road Projects.

1. Introduction

Roads across developed and developing countries facilitate significant modes of transportation when compared to other means of transportation. Literature shows that the transport sector accounts for about 25 percent of the total PPP contracts of the developing world (Guasch et al., 2014). Because of the significant adoption of roads as the main means of transportation across countries, there has been a lingering challenge facing governments of both developed and developing countries in the provision of roads economically and efficiently (Akintoye and Chinyio, 2005). Government across the world have been turning to PPP to facilitate the delivery of roads infrastructure across the globe to address this problem. Fatokun et al. (2015) substantiate that this by indicating that the shortcomings inherent in other procurement forms, which are adopted for infrastructure projects delivery encourages the use of PPP for the delivery of transport infrastructure. Hence, PPP has been adopted across countries for infrastructure projects delivery including road projects because of its many benefits over traditional procurement.

PPP is a joint working relationship between the private sector and public bodies in which the two parties agree to pool their respective resources and share the risks of the proposed infrastructure projects for mutual benefit and in the interest of members of the public or taxpayers (Fatokun et al., 2015). Though numerous governments have adopted PPP because of its many advantages, considerable questions have emerged, which are premised on the ability of PPP to deliver VfM for the public sector amongst others(Sarmento, 2014 and Adair et al., 2011). The Value for Money (VfM) questions in PPP road projects is sometimes because of events, which usually necessitates the renegotiation of the contract during the implementation process (Acerete et al., 2010).

Renegotiation may be necessary at some points during the implementation of PPP road projects to ensure that the project stays on track and in accordance the objectives defined at the inception of the project. However, the experience of most renegotiations in infrastructure projects delivery including roads reveals that the VfM objectives of the procuring authority and the user's satisfaction have not been addressing. Instead, they have increased the costs to the detriment of the users. Hence, renegotiation is the bane to the achievement of VfM for the public sector and utility and satisfaction for the users in some Latin American countries, Portugal and Spain. (Guasch et al., 2014; Sarmento, 2014 and Acerete et al., 2010).

The evidence of renegotiation across these countries further substantiates that there are frequent renegotiation and overestimations of traffic in road concessions (Baeza and Vassallo 2010, and Acerete et al. 2010). In spite of all these renegotiation studies in the transport sector, little is known in the context of UK road concessions renegotiations regarding outcomes and VfM impacts (Makovsek, 2014). This paper, therefore, seeks to evaluate PFI (DBFO) road projects renegotiation instances regarding the main factors leading to renegotiations and their impacts on VfM criteria.

2. Overview of the Renegotiation of Public Private Partnership Road Projects

Renegotiation can be construed to take place in a concession contract when there is a change which necessitates the amendments of the terms of the original contract (Sarmento and Renneboog, 2014a). This definition implies that there can be changes without contract modifications. However, changes necessitating amendments of the initial contract is called renegotiations. However, there cannot be a renegotiation without modification of the contract. Road projects have recorded a high percentage of renegotiations in many countries in comparison to other transport modes, particularly in Latin America and the Caribbean (Guasch et al., 2014; Bitran et al., 2013; Guasch et al., 2008), US (Gifford et al., 2014), Portugal (Sarmento, 2014), Spain (Acerete et al., 2009) and Greece (Nikolaidis and Roumboutsos, 2013). The high incidence of renegotiations in the transport sector can be attributable to some factors among which falls under the economic, technical, institutional, regulatory, contractual, administrative and managerial, political, social and environmental categories (Fatokun et al., 2016).

Engel et al. (2006) explain that between the year 1985 to 2000, considerable numbers of PPP infrastructure projects were procured in Latin America among which up 41.5% of these PPP projects leads to the amendments of the contract (i.e., renegotiation). A cursory view of these renegotiations reveals that more road projects are renegotiated in the transport sector of most countries (Acerete et al., 2010 and Baeza and Vassallo, 2010) excluding the UK. The findings of the renegotiations incidences in their respective percentages across selected region and countries are in Table 1.

Table 1 Renegotiations of PPP Projects in Selected Regions. Source: Mackovsek et al. (2014).

Region/Country	Sector	% of renegotiated contracts	Source
Latin America & Caribbean	Total	68%	Guasch et al. (2014)
	Electricity	41%	
	Transport	78%	
	Water	92%	
India	All sectors	0%	Guasch et al. (2014)
US	Highways	40%	Engel et al. (2011)
France	Highways	50%	Athias &Saussier (2007)
	Parking	73%	Beuve et al. (2013)
UK (Scotland)	All sectors	22%	NAO 2003
	All sectors	51%	CEPA 2005

Since there is no extensive and categorise data on the characteristics of renegotiation in PPP road projects in the UK as shown in Table 1 as only generalised information, which cuts across all sector are indicated. This paper, therefore, evaluates and assess Private Finance Initiative (PFI) Design Build Finance Operate (DBFO) road projects in the UK to provide empirical findings regarding the characteristics and outcomes of the renegotiation on VfM. Further

assessment of the impacts of the renegotiation on VfM criteria is compared with the literature results to allow for a robust conclusion on the renegotiation of PPP road projects in the context of UK experience.

Certain factors lead to the renegotiation of PPP projects including roads. In France, opportunism has been identified as the bane of contract renegotiation (De Brux, 2010). These include the submission of a low bid by the concessionaire, delay of jobs for wrong reasons, poor quality performance on employment, misuse and abuse of a position of responsibility in international PPP procurement of general infrastructure projects, etc. (Odoemena and Horita, 2014).Also, there are some specific changes which constitute factors that can lead to the amendments of the terms of the original contract in PPP road project undertaking in particular. The literature establishes the changes, which are capable of driving the public and private sector stakeholders as follows:

Significant changes in economic circumstances of regulated markets can inform renegotiation requests by either the operator, the government or both stakeholders (Cruz et al., 2015 and Bitran et al., 2013). An unexpected change in the economy due to macroeconomic conditions beyond the control of the parties, e.g., financial crises, fluctuations in currencies, the election of the new administration are among the factors leading to renegotiation(Guasch et al., 2014). These factors result in changing PPP regulation, which affects the rights of the operator.

- Changes in infrastructure or concession design scope and layout before and during construction as a result of error or poor concept (Guasch et al., 2014 and Bi and Wang 2011).
- Change in cost, e.g., capital cost, construction cost, financing cost, operation cost, maintenance cost and other cost changes, etc. cost. (Cruz and Marques, 2013 and Baeza and Vassallo, 2010).
- Change in construction delivery time. (Sarmento, 2014).
- Change in payment mechanisms and stages (Soomro and Zhang, 2010).
- Change in the financial position of the concessionaire or shareholders.
- Change to break even period of SPV.
- Change in estimated or projected traffic level. (Dominques and Zlatkovic, 2014).
- Change in the profits envisaged by the Special Purpose Vehicle (SPV) (Fatokun et al., 2015).
- Project refinancing during the process of implementation.
- Modification of the shadow tolls paid by the government.
- Cost overruns at stage completions (Adair et al. 2011).
- Specification changes during technical development of the project (Cruz et al., 2015 and Bitran et al., 2013).
- Change in the standard or level of technical skills and expertise (Reside and Mendoza, 2010).
- Variations in the operational and maintenance performance of the project
- Changes in the government or concessionaire revenue during the implementation of the concession (Sarmento, 2014)
- Changes in users demand and preference (Guasch et al., 2007).
- Changes as a result of additional works (Sarmento, 2014).
- Change in the priorities of the governments especially after elections (Engel et al., 2009).
- Unilateral change by the government(Cruz and Marques, 2013).
- Changes in design due to environmental reasons, delays in expropriation, and changes in traffic below the forecast level. (Cruz et al., 2015,Baeza& Vassallo, 2010;).etc.

3. Research Methodology

The study was designed to comprise two stages. The first stage involves a preliminary research conducted at inception to establish the research gap, problem, aim, and objectives of the study. The second phase includes extensive literature review, which preceded the preliminary research. The third stage includes a preliminary research, which adopts case study interviews on two respondents from both primary stakeholders involved in the renegotiation process. The data obtained from these respondents are adapted to pilot the advanced research. The meetings are aimed at bridging the gap between the findings of the literature revolving around other countries such as Latin American countries, Portugal and Spain, etc. and the scarcity of research on renegotiation studies in the UK.

The case studies interviews are qualitative and seek to ascertain the characteristics of the renegotiation regarding the nature and impacts of the road concession renegotiations on VfM. The findings provide the needed information on the features and peculiarities of UK (DBFO) road projects renegotiation amongst others. These afford the opportunity to compare the results objectively to conclude the impacts and outcomes of the renegotiation regarding VfM achieved for the public sector. The data collected are analysed using descriptive statistics and through a thorough evaluation and discussion of the respondent's words transcribed verbatim.

4. CS1 and CS2 Changes and Renegotiation

The case studies which are CS1 and CS2 are conducted to ascertain and establish the instances of changes and renegotiations and to discuss findings on PFI (DBFO) road projects in the UK. The case studies provide an avenue to collect data on specific changes and renegotiations. The results as shown in Table 1 reveals that 63% of changes are made to the CS1. There is the evidence that 47% of these changes lead the amendment of the contract. These imply that 16% of the changes identified in Table 1 are part of the 53% responses received regarding the non-existence of contract amendment on the CS1. These suggest that there are incidences of changes to the contract more than a renegotiation of contract on CS1. Also, 70% of the respondents agree on the existence of the listed changes on the CS2 while 42% of the changes lead to the amendments of the terms of the contract. These findings also corroborate the findings on CS1, which shows that there more changes are effected on the PFI (DBFO) road projects in the UK rather that renegotiation of the contract.

The respondents identified the changes, which leads to the renegotiation on both case study projects, i.e. (CS1 and CS2). These changes include changes to infrastructure or concession design scope and layout, change in maintenance cost, specification changes during technical development of the project, changes as a result of additional works. Also, other changes leading to the renegotiations on CS1 are shifts in the financial position of the SPV and shareholders, review processes to specified changes envisaged and refinancing of the project during implementation. The CS2 further evidenced the following distinct changes leading to the amendment of the contract: change in capital cost, change in operation cost, unilateral changes to design during project execution, change in payment mechanism and stages, cost overruns at stage completions and change in maintenance performance of the project.

The findings of this study reveal that the projects are characterised by changes to the contract than the renegotiation of the contract terms and the results of Table 1 indicates that the renegotiation occurs in the construction or technical stage of the PFI (DBFO) road projects implementation. Thus, the renegotiation can be said to be on the average and less than changes which occurred in the case studies. These findings contrast previous literature findings on renegotiation in other countries, which indicates a high incidence of renegotiations in PPP (DBFO) contracts, particularly in the water and transport sectors

The preliminary research study reveals that there are instances of changes and renegotiation on both case study projects as shown in Table 2.

Table 2 Changes and Renegotiation on the Road DBFO Case Studies.

S/N	Factors	Case Study 1 (CS1)				Case Study 2 (CS2)				Remarks	
		Change Occurrence		Contract Amended		Change Occurrence		Contract Amended			
		Yes	No	Yes	No	Yes	No	Yes	No	CS1	CS2
1	Changes in infrastructure or concession design scope and layout	√		√		√		√		Reneg.	Reneg.
2	Change in capital cost		√	-	-	√		√		No reneg	Reneg
3	Change in construction cost		√	-	-	√			√	None	Change
4	Change in financing cost		√	-	-	√			√	None	Change
5	Change in operation cost	√		√		√		√		None	Reneg.

6	Change in maintenance cost	√		√		√		√		Reneg	Reneg.
7	Other changes in cost		√	-	-		√	-	-	None	None
8	Unilateral changes of design concept during project execution	√			√	√		√		Change only	Reneg.
9	Change in construction delivery time		√	-	-		√	-	-	None	None
10	Change in payment mechanisms and stages		√	-	-	√		√		None	Reneg.
11	Change in the financial position of the concessionaire or shareholders	√		√		√			√	Reneg.	Change only
12	Review processes to specified changes envisaged	√		√			√	-	-	Reneg.	None
13	Change to break even period of SPV.		√	-	-	-	-	-	-	None	None
14	Change in estimated or projected traffic level.	√			√	√			√	Change only	Change only
15	Change in the profits envisaged by the Special Purpose Vehicle (SPV).	√			√	√			√	Change only	Change only
16	Refinancing of the project during implementation	√		√			√	-	-	Reneg.	None
17	Modification of the shadow tolls paid by the government		√	-	-		√	-	-	None	None
18	Cost overruns at stage completions		√	-	-	√		√		None	Reneg.
19	Specification changes during technical development of project	√		√		√		√		Reneg.	Reneg.
20	Change in the standard or level of technical skills and expertise	√			√	√			√	Change only	Change only
21	Changes to PPP legal or procurement framework		√	-	-		√	-	-	None	None Reneg.
22	Changes in construction project performance	√			√	√		√		Change only	Reneg,
23	Changes in operational performance of the project	√			√	√			√	Change only	Change only
24	Changes in maintenance	√			√	√		√		Change only	Reneg.

	performance of the project										
25	Changes in the revenue	√			√	N/A	NA	-	-	Change	None
26	Changes in users demand and preference	√			√	√			√	Change only	Change
27	Changes as a result of additional works	√		√		√		√		Reneg.	Reneg.
	Total Number (Frequency)	**17**	**10**	**8**	**9**	**19**	**6**	11	8		
	Percentage (%)	**63**	**37**	**47**	**53**	**70**	**22**	**41**	**30**		

5. Impacts of the Critical Changes and Renegotiation on VfM Criteria

The findings of the study reveal that some of the changes and renegotiation falls under the design, technical, economic environmental factors for both case studies respectively and have impacts on the identified VfM criteria indicated in Table 3. For CS1, Specification changes during the technical development of the road project and changes as a result of additional works ranked highest in their respective level of impacts on the performance of the road network, increase the income, revenue and profit of the SPV respectively. However, changes in the standard and level of technical skills and expertise impact performance of the roads and also increase the quality of the road outputs.

The results shown in Table 3 further corroborates the submission of the private sector respondent on CS1 which indicates that there is an increase in performance of the road concession product and quality of the road outputs as a result of the changes to specification and additional works. The profit of the SPV is found to increase as a consequence of the renegotiation occasioned by changes to specification during the technical development of the project. The increase in the income and revenue of the SPV occurs as a result of the additional works introduced on the CS2. The findings on CS2 corroborates that of CS1 as there is evidence of increased performance and quality as a consequence of a change in the standard of project technical skills and expertise. The critical changes and renegotiation and their respective impacts on VfM criteria established for both PFI (DBFO) road projects are indicated in Table 3.

Table 3 Impacts on Value for Money Criteria.

S/N	Changes/Renegotiation Factor	Project	Impacts on VfM Criteria					Freq.	Rank
			1	2	3	4	5		
1	Specification changes during technical development of the road project	Case Study 1 (CS1)	√		√	√		3	1
2	Changes as a result of additional works		√		√	√		3	1
3	Unilateral changes to specifications		√		√	√		3	1
4	Change in the standard and level of technical skills and expertise		√		√			2	3
5	Unilateral changes of design concept during project execution		√					1	4
6	Change in estimated or projected traffic level						√	1	4
7	Changes to risk allocation because of environmental factors, e.g., winter months, snow, rain, etc.					√		1	4
S/N	**Critical Factors Leading to Renegotiation**	**Project**	**Main Impacts**					**Freq.**	**Rank**
			1	2	3	4	5		
1	Specification changes during technical development of the project	Case Study 2 (CS2)	√		√	√		3	1
2	Changes as a result of additional works		√		√		√	3	1
3	Change in infrastructure concession design scope and layout		√	√				2	3
4	Change in the standard or level of technical skills and expertise		√		√			2	3
5	Unilateral changes to specification		√		√	√			

6	Changes of design concept during project execution		√					1	5
7	Change in maintenance performance of the project						√	1	5
8	Change in estimated or expected traffic level						√	1	5

6. Impacts on VfM Criteria- Key

1= Increase in performance of the product
2 = Decrease in contract time/duration
3 = Increase in Quality of outputs
4 = Increase in SPV's profit
5 = Increase in revenue/income of the SPV

Summarily, technical and constructional changes have positive impacts on both CS1 and CS2, which reflects an increase in performance of the product, outputs of the project and increase in quality. Though, the findings revealed that there is an increase in the profits and income of the SPV as a result of the additional works included, changes in the estimated and projected traffic level and specification changes. These suggest that the renegotiations favours the SPV and corroborates the findings of the literature which indicates that most renegotiations in PPP infrastructure projects (including road projects) usually address the profitability objectives of the private sector (Acerete et al., 2009).

The increase in SPV profit and income is as a result of additional works, specification changes, change in estimated traffic level and changes to risk allocation occasioned by environmental factors, etc. Other categories of changes do not lead to increase in the profit of the SPV. Contrastingly, the VfM objectives of the procuring authority seem to be met regarding the performance of the product and improved the quality of the outputs amongst others. Hence, renegotiations could positively impact the VfM criteria.

7. Conclusion

The findings of this preliminary research reveal the nature and characteristics of the renegotiation of road DBFO projects in the UK and conclude that there is evidence of more changes on the road DBFOs rather than a renegotiation of the contract. A further view of the changes established in the literature and administered on the respondents reveal that noticeable changes identified as the factors leading to the renegotiation mostly fall within the technical stage of road project implementation. These factors include changes in infrastructure or concession design scope and layout, specification changes during the technical development of the project, changes due to the inclusion of additional works and changes in maintenance cost during the operation of the road network respectively.

The findings of the study further indicate that the changes leading to the amendment of the original contract have varying impacts on the VfM criteria. The changes made to the specifications at the technical development of the road DBFO projects for both case studies results to increase the performance of the road network, increase in the quality of the roads network and profit of the SPV. These result also applies to changes occasioned by additional works amongst others. There is evidence of an increase in performance of the product, decrease in contract time and increase the quality of the outputs. The only exception with regards to the impacts of the renegotiation on VfM criteria is that where there is the addition of assets and specification changes, there is the evidence of an increase in the profit od the SPV and increase the revenue or income of the SPV respectively.

The paper, therefore, concludes that the findings of this study contrast the literature, which indicates a high incidence of renegotiation in PFI (DBFO) road projects as there are more instances of changes to the contract rather than renegotiations. The few examples of renegotiation reveal that the impacts of the changes leading to the amendments of the original contract are mostly positive except in few instances where the SPV records some increase in profit as a result of the additional works. These findings suggest that VfM is achieved for the public sector. Thus, renegotiations of PPP concessions especially in the road sector does not necessarily have to lead to non-achievement of VfM for the public sector.

8. Recommendations

The achievements of VfM for the public sector is as a result of the adoption of measures, which ensure the VfM results achieved in the case studies. The following recommendations, therefore, emanate from the respondents that participated in the research interviews:

- Establishment of standards of performance for SPVs as a requirement for initiating payment for a renegotiation request;
- Need to freeze or place an embargo on the standards for materials, work requirements and the quality of work done by the operatives (amongst others) if necessary;
- Establishment of contract review processes and needs with the aim of effecting defined or allowable changes to the contract;
- The inclusion of hand-back requirements, i.e., salvage value of the road project or level of depreciation allowed at delivery or handover. However, the following must be dictated by the public sector: the inclusion of project plan reviews (e.g., every three years) to monitor the performance of the project and particularly of VfM;
- Fixing of penalty points for non-performance with applicable limits to SPVs before contract takeover by the client, etc.

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Leadership Styles and Construction Site Workers' Performance

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Abstract

The role of effective leadership in the management of manufacturing industries has received greater attention, in contrast to construction industry. This paper examines transformational, transactional and laissez-faire leadership models and their relationship with construction site workers' performance. The data for the study comprises 50 supervisors and 125 site workers drawn from large and medium-sized construction firms in Nigeria. Correlation and regression analyses were carried out to determine the relationship between the three leadership styles and construction sites workers' performance. The findings show that leadership styles exhibited by supervisors influence construction site workers commitment and behaviour. Ability to set clear standards of performance, show care and love, demonstrate integrity, trustworthiness and act as a best role model to workers on sites are strong influencers of workers' performance. Construction site workers expect that their achievements be recognized and rewarded either with monetary or with non-monetary benefits. The study concludes that transformational and transactional leadership styles of site supervisors have positive and significant relationship with site workers' performance outcomes compared to laissez-faire leadership model. Consequently, we recommend that these two leadership styles should be deployed by factory supervisors and other management staff in dealing with their subordinates.

Keywords: Construction, supervisor's leadership styles, performance, site workers.

1. Introduction

Around the globe, there is a shift of emphasis from organisational management to organisational leadership. The paradigm shift from management to leadership is dictated by global economy down turn within the last two decades. Leadership in both public and private organizations significantly influence productivity, profit and workers performance (Flin & Yule, 2004; Hopkins, 2007; Hughes & Ferrett, 2010). The premise even exists that legislation and trade unions alone cannot promote organisational effectiveness and worker's welfare substantially (Abu-Khader, 2004; Lee & Austin, 2011). Consequently, leadership styles of managers at all levels of management in an organisation have been suggested to be critical factors in determining organisational success.

Leadership in an organisational context has been linked to a process by which a manager, supervisor or team leader influences others to accomplish set goals/objectives. However, achieving the organisational set goals resides with workers. Therefore, workers' performance dependent upon the leadership styles exhibited by managers, supervisors or team leaders(Hughes & Ferrett, 2010).Though, leadership in construction site is a very complex issue and often subjective, an understanding exists that 'good leadership is good business' and the tenet that productivity and workers performance are influenced by leadership quality remains unproven (Flin& Yule, 2004; Naoum, 2011). In addition, poor leadership of the site managers, supervisors or team leaders not only impacts on overall projects performance and stakeholders profit margins, but also has a serious negative impacts on workers' performance (Krause, 2003; Geller, 2008; Sunindijo&Zou,2012). However, workers' performance is a function of the leadership qualities exhibited by site managers, supervisor or team leaders who are the conduit between the workforce and management. It has also been noted that

monetary incentive can influence workers' attitude and behaviour, but it has its limitation with regard to workers' commitment and performance (Rowsline & Lingard, 2005).

The importance of leadership and interpersonal skills of sites personnel were also noted by Achua & Lussier (2010) and Sunindijo & Zou (2012) as key drivers of a successful organization. However, it has been found that leaders often lose focus, resulting in poor performance. Therefore, the inappropriate leadership of managers and site supervisors not only affect production, but it has a serious negative impact on workers' commitment and performance (Sunindijo & Zou, 2012). It has also been noted by Yukl (2010) that lack of relevant capabilities such as intelligence, interpersonal skills and leadership qualities among project personnel are some of the constraints in discharging their site management responsibilities. Nonetheless, researchers and scholars have asserted that there is a great relationship between organizational success and its commitment to leadership practices. Therefore, appropriate leadership style at the site levels is not only an important ingredients for achieving optimal projects performance, but also a major factor in promoting workers' commitment and performance.

Findings from the empirical research and qualitative review on leadership and leaders' behaviours suggest that leaders, who exhibit transformational leadership style promote trust and employee-management relationship (Bass & Bass, 2008; Yukl, 2010). For instance, Zohar (2002) noted that site supervisors who demonstrate the following transformational leadership behaviours: leading by example, communicating a clear vision to workers, motivating workers, involving workers in decision-making, inspiring and aligning workers to think outside the box will build trust and team-spirit among the worker-force. In the other hand, leaders with transactional leadership styles that actively monitor work progress, provide clear standards and expectations for reward on performance will also achieve employee/workers' commitment and performance (Bass & Bass, 2008). Conversely, empirical data had shown that laissez-faire leadership styles that turn blind eye on work standards and workers' welfare, have negative consequences in terms of organization's productivity, profit and workers' performance (Yukl, 2010). This type of leadership may not be ideal style for construction sites with people of cultural variations.

The aim of this paper is to examine transformational, transactional and laissez-faire leadership models and their relationship with construction site workers performance. In this regard, the specific objectives of the study are to:

- determine the extent to which construction site supervisor's transformational leadership style promotes workers' performance,
- examine if there is a relationship between transactional leadership style of site supervisors and workers' performance, and
- assess if laissez-faire leadership style of site supervisors has any significant impact on workers' commitment and performance.

2. Literature Review

2.1 Overview of Transformational, Transactional and Laissez-faire Leadership Models

Over the decades, research attentions have been focused on the relationship between effective leadership and employee job satisfaction and commitment, particularly in the service and manufacturing sectors, in contrast to construction industry. Leadership and employee job satisfaction and performance according to Achua & Lussier (2010) has emerged in recent time as one of the most important disciplines in industrial management. Studies conducted by Lees & Austin (2011) concluded that effective leadership is considered as an important tool for increasing employee performance and team effectiveness. Although, few or no research in respect of supervisors' leadership style and construction workers' performance has been conducted particularly, in the developing countries like Nigeria, but leadership skills and leaders' behaviours have become a prerequisite for successful organization in the 21st century business environment (Naoum, 2011). Organizational productivity, profitability and workers' performance according to Lees & Austin, (2011) and Cooper, (2011) can only be enhanced through effective leadership and leaders' behaviours. Table 1 illustrates the effects of the three leadership styles on workers' commitment and performance.

Table 1 Illustration of three leadership styles. Source: Adopted from Naoum (2011: 156).

Leadership style	Researcher	Argument
Transformational leadership style	Burns (1978 cited in Yukl, 2010); Naoum (2011)	Focus on leaders'behaviour in terms of vision and ability to inspire followers to achieve organizational goals. Transformational leadership is associated with a creating trust, inspiring, motivating and influencing workers (charismatic).
Transactional leadership style	Bass, 1985 cited in Yukl, 2010: 75); Northouse, 2010)	Leaders define performance standards and offer rewards for meeting task objectives, motivate employees to attain performance standards and meet task objectives, in exchange for reward with less concerned of inspiring employees or attending to their individual needs
Laissez-faire leadership style	Bass et al. (1997)	Decisions are delayed, and reward for involvement is absent.

2.1.1 Transformational leadership style

Transformational leadership was first articulated by Burns (1978) and later expanded by Bernard in 1990 cited in Achua & Lussier (2010: 203). The theory was developed from an earlier work on charisma in political leaders. It postulates three components of leadership: transformational, transactional and laissez-faire. Transformational leaders are charismatic, inspiring, stimulating and considerate. Transformational leaders provide followers with a sense of purpose; portray an image of success, self-confidence and self-belief. These leaders articulate share goals and develop mutual understanding and describe an attractive future to followers (Achua & Lussier, 2010: 203).

Transformational leadership are dominant in many western workplaces today (Lutchman et al, 2012), in contrast to what obtain in the developing countries like Nigeria. They further stated that leaders who exhibit transformational leadership qualities, show genuine concern, are transparent, act with integrity, resolve complex problems and support a developmental culture that is needed in the construction site to promote employee commitment and performance. However, these attributes of transformational leadership are grossly lacking in the developing countries, particularly at the site level. This could be the reason for the poor projects and workers performance in the industry. Transformational leaders are described as influential, inspirational and charismatic. This type of leadership style is highly needed at the site levels for optimal organisational effectiveness including workers performance.

2.1.2 Transactional Leadership style

The transactional leadership model was first developed by Blanchard and Hershey (1972 cited by Wefald & Katz, 2007; Northouse, 2010). According to Northouse (2010), the transactional leadership model of Blanchard and Hershey is widely used today for developing interpersonal skills of managers and supervisors. It has been argued that the development of leadership skills among frontline managers and supervisors could influence their leadership qualities, thereby creating a better manner of dealing with workers which would result in high productivity, compliance to policy standard and workers' commitment and performance.
Transactional leaders, as argued by Achua&Lussier (2010), are leaders who offer incentives and/or punishment that are contingent on the followers' performance of meeting agreed standards. Transactional leaders gain compliance from workers, set goals and obtain agreement on what is to be accomplished, monitor performance and administer reinforcement. It is argued that a proper application of transactional leadership style can enhance workers commitment and performance. However, Lutchman et al (2012) argued that

transactional leadership model may not be effective in a diverse workforce such as construction sites. This view is shared by Geller (2008), who stated that transactional leadership styles may not be ideal in construction site management because of cultural variations among workers. However, transformational and transactional leadership models or approaches have their merits and disadvantages. It can be argued that leadership styles and behaviour exhibited by leaders are dictated according to tasks, organizational structure and situations.

2.1.3 Laissez-Faire Leadership

Laissez-faire leadership is a passive kind of leadership style (Wefald & Katz, 2007). There is no relationship exchange between the leader and the followers. It represents a non-transactional kind of leadership style in which necessary decisions are not made, actions are delayed, leadership responsibilities ignored, and authority unused. This kind of leadership might not be ideal for management of construction site workers.

2.1.4 Leadership styles and workers' performance

On construction sites, supervisor or team leader is the key person standing between management and the workforce. His leadership style and behaviour in managing the workforce and controlling construction activities on site is the greatest factor in achieving organizational success and workers' performance (Lutchman et al. 2012). Similarly, Filn and Yule (2004) noted that leadership and leaders behaviour motivate and inspire workers for exceptional performance. For decades, there exist empirical evidence linking organizational successes and leadership qualities of frontline managers or supervisors.

Behling & McFillen (1996 cited in Lutchman el al. 2012) developed a model of charismatic/transformational leadership in the United States of America and confirmed that there is a strong link between frontline managers' leadership style and high performance. In support of the relationship between transformational leadership and organizational effectiveness Yukl (2010) and Lutchman et al (2012) argued that transformational leadership style and behaviour of frontline managers/supervisors encourages trust and openness thereby creating a work environment characterised by us. Stressing further the positive relationship between transformational leadership style and organizational success, Zohar (2002) maintains that supervisors who exhibit transformational leadership qualities not only achieve mutual trust among workers but also increase production.Thus, both empirical and anecdote evidence have shown that transformational leadership style could engender trust, commitment and motivate workers for exceptional performance.

Workers feel belonged when they are consulted on decisions-making concerning them. A participative relationship as argued by Mangham (2006) enables workers to contribute to affairs that help to shape the organization for better rather than simply playing a passive role as recipients. Simard & Marchand (1994 cited in Flin and Yule 2004) observed that cooperative supervisory-workgroup relationship and participative management styles were rated as most important predictors for creating harmony between workers and supervisors leading to workers' performance.

When a site supervisor or a team leader according to Yukl (2010) reinforces production through rewards and bonus system, such a leader exhibits transactional leadership style. Luria (2010) compared transformational and transactional leadership style of supervisors and workers relationships in manufacturing and heavy industry worksites in North America concluded that leaders who demonstrate transactional leadership style achieve higher productivity and compliance. Recent studies that examined the effectiveness of transactional leadership style of supervisors in hospital environment found that it encourages productivity and safety behaviours among workers. Effective control and supervision of the workforce is very important for maintaining and sustaining organizations standard and compliance. Nonetheless, there is no empirical evidence on positive relationship between organizational effectiveness and laissez-faire leadership, but literature abound that on organization where leaders who exhibit laissez-faire leadership style the workplace will be characterised with delay in decision-making process and also absence of monetary rewards and incentives to workers. However, Northouse (2010) and Naoum (2011) state that the differences in various leadership styles hinge on the leader's behaviour, organizational structure and situations.

Therefore, the foregoing theoretical considerations provided the basis for generating the following three hypotheses that are put forward for empirical testing.

3. Methodology

To achieve the aim and objectives of this study, quantitative research method was adopted. The assumption underlying quantitative method to research is that it seeks to gather factual data and study the relationships between them. According to Leedy and Ormrod (2010) the information gathered is therefore coded in the form of numbers that can be quantified and summarised. Thus, the analysis of data collected yields empirical results and conclusions drawn from the observation of the results based on theory and surveyed literature.

The Multifactor Leadership Questionnaire (MLQ) developed by Avolio & Bass (2004) was used to gather information from the respondents. The MLQ is a rater-report questionnaire consisting of 50 items measured on a five-point Likert-type scale of 1 (minor) to 5 (major) was used. Four sub-themes were used to asses transformational leadership style: influence, inspiration, motivation, role model), while three items were used to assess transactional leadership style (contingent rewards, management by exception) and two items were used to assess laissez-faire leadership style (turn blind eye on work standard and lack of relationship exchange between the leaders and workers). Consequently, the respondents were randomly selected from supervisors and site workers drawn from large and medium sized construction firms within the South-West Geopolitical zone of Nigeria. The Bass and Avolio MLQ scale was adopted in this research because of its internal consistency, validity and reliability, which have been empirically tested.

Two hundred and eight questionnaires (208) were administered and one hundred and eighty- five (185) questionnaires were completed and returned resulting in response rate of 89%. Data collected were analyzed using the Statistical Package for Social Sciences (SPSS 17.0). Descriptive analysis was used to analyze the socio-demographics data of the respondents while multiple regression and Pearson's Product Moment correlation were used to test the research hypotheses. All statistical tests were performed at 5% level of significance.

4. Results and Analysis

The socio-demographics information of the respondents indicates that 50 numbers (28.57%) of the respondents are supervisors and 125(71.43%) are both skilled and unskilled site workers. Respondents in the age bracket of 20 years and below were 51 (29.14%), 26- 35 years were 72 (41.14%) while 52 (29.71%) were 36-50 years and above. With regard to educational qualification, 38 (21.71%) had primary education, 87 (49.71%) had secondary education and below, 37 (21.14%) were Ordinary and National Diploma holders 13 (7.43%). In terms of number of years the respondents have been involved in construction industry; 107 (61.14%) for 10 years and above while 68 (38.86%) indicated that they have been in construction for 20 years and above.

Table 2 presents the empirical findings of the relationship between the independent variables (transformational, transactional and laissez-faire leadership styles) of supervisor and site workers' performance. The results of regression analysis revealed a significant positive relationship between transformational leadership style and workers' performance. (ß= 0.631, t calculated = 4.490, t tabulated =1.96, p< 0.05). Transactional leadership style of site supervisor accounted for 10.5% variation in workers' performance (r square = 0.205). The results of the regression analysis also revealed a significant positive relationship on workers' performance (ß = 0.582, t calculated = 3.533, t tabulated =1.96, p< 0.05). Laissez-faire leadership style accounted for 0.001% variation in workers' performance (r square = 0.001). The result of the regression analysis indicated that laissez-faire leadership model of site supervisors have no relationship with workers' performance and organizational effectiveness (ß = -0.002, t calculated = -000, t tabulated =1.96, p< 0.05).

Table 2 The multiple regressions between the independent variables and dependent variable.

Variables	R	R^2	ΔR^2	df	ΔF	B	SEB	ß	t
	.567	.432	.234	175	33.741				
constant						24.807	526		47.521
WP	1					.763	.092	.761	6.231***
TRF						.652	.712	.631	4.490**
TRS						.532	.641	.582	3.533**
LF						-001	-001	-001	-002

****P<...001, **P<.01.Dependent variable: WP = worker performance, TRF=Transformational leadership, TRS = transactional leadership and LF=Laissez-faire leadership*

Based on the values in Table 2, the highest beta coefficient was (beta = .761), which indicates that performance of construction site workers are influence by the leadership styles of supervisors. Transformational leadership style has the strongest positive relationship with site workers' performance (beta = .631), followed closely with transactional leadership style with (beta= .582). The beta value for laissez-faire leadership has the smallest value (-.001) indicating that it has no relationship with the dependent variable, workers' performance. The multiple regression model for worker performance in standard score unit, and the findings suggest that transformational and transactional leadership style of site supervisors/team leader could positively improve site workers' performance.

Table 3 Pearson Product-Moment Correlations Between independent and dependent variables.

Variable	1	2	3	4	5
Worker Performance	1				
Transformational leadership	.631	1			
Transactional leadership	.582	.572**	1		
Laissez-Faire leadership	-001	-001	.-002		

**p<.01

Table 3 presents the result of Pearson Product-moment correlations between independent variable worker performance (WP), transformational leadership, transactional leadership and laissez-faire leadership style of construction site supervisor. Result obtained showed a significant positive relationship between transformational leadership and transactional leadership style of site supervisor ($r = 0.705$, $p<0.05$). Also, a significant positive relationship was obtained between transactional leadership style and organizational performance ($r=0.402$, $p<0.05$). Therefore, both leadership styles relates positively with organizational performance. The result also found that there is no correlation between laissez-faire leadership style of site supervisor and worker performance.

5. Discussion of Findings

The findings show that transformational leadership style has a positive relationship with site workers' performance. These findings corroborate the work of Yukl (2010) and Lutchman et al (2012) that transformational leadership style and behaviour of frontline managers/supervisors encourages trust and openness thereby creating a work environment characterised by us. When workers feel belonged in an organization they will be motivated, thereby putting in their best, which result higher productivity and better performance. Also, the results reveal that transactional leadership style is positively associated with workers' performance. This finding is supported in that Luria (2010) who compared transformational and transactional leadership styles of supervisors and workers performance in manufacturing and heavy industry worksites in North America. They found that leaders who demonstrate transactional leadership style achieve higher productivity and compliance to organizational policy and work standards. laissez-faire leadership style was found have a negative and

insignificant relationship with workers' performance. Yukl (2010) argues that a leader who exhibits laissez-faire leadership style does not involve workers in decision-making process and Flin & Yule (2004) state that there is absence of monetary rewards or incentive to workers in laissez-faire leadership style. Thus, this type of leadership may not be ideal for construction site management where majority of the workers are illiterate and from different cultural backgrounds.

6. Conclusion and Recommendations

This study has provided incisive insights into the impact of transformational, transactional and laissez-faire leadership styles on workers' performance. The study discovered that both transformational and transactional leadership styles of supervisors or team leaders have a significant positive impact on organizational performance while laissez-faire leadership style was found not to have any positive relationship with workers' performance. The study found that transformational leadership style of site supervisors had a stronger positive relationship with workers' performance and organizational effectiveness than transactional leadership style.

Based on the research findings, the following recommendations are made:

- Transformational leadership style is derived from trustworthiness, charismatic, fairness, sincerity, honesty and integrity. Therefore, transformational leadership style of site supervisor/team leader is an absolute requirement for creating a motivated workforce that could result in better worker performance.
- Committed and disciplined workforce is highly desirable for an organization to maintain optimal production and compliance to standards. Transactional leadership style of site supervisor/team leader has the qualities to fill in the gap.
- Site supervisors should be empowered through leadership training, as education will not only gives the receiver knowledge, but wisdom to control and monitor others.
- Future research efforts should be directed at the sub-components of the broad leadership styles

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The Implementation of Green Building in the UAE: Challenges and Critical Success Factors

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Abstract

The implementation of the green building concept has attracted significant attention over the past decade in the UAE. However, the review of the literature indicated that this area is not adequately addressed. The research objectives seek to identify the challenges facing the implementation of green building and the critical success factors that would facilitate and enhance this implementation. The study applied a mixed method approach that embraced a survey of 500 individuals who represented various categories of stakeholders. The survey used a questionnaire that included a list of challenges and a list of critical success factors. In addition, a set of 8 interviews were scheduled to verify and explain the findings of the survey. The survey attracted 243 responses and 4 interviews were conducted. A statistical frequency analysis ranked the identified 29 challenges and 27 critical success factors then factor analysis yielded 5 groups of challenges and 4 groups of critical success factors In addition, the statistical analysis indicated the lack of awareness of the concept, benefit and practice of green building in the UAE. The interviews' findings verified the findings of the survey and suggested that the government has to provide significant incentives in the form of reduced energy and water tariffs for green buildings that would stimulate the market and entice the shift towards green building in the private sector. Further research is needed to investigate the impact of this recommendation on the economics of the building market in the UAE.

Keywords: Green Building, Sustainability, Challenges, UAE.

1. Introduction

In the UAE, the construction industry is a main contributor to the GDP; the resource demand of this sector is one of the highest in the country (Salama & Hana, Green buildings and sustainable construction in the United Arab Emirates, 2010). However, the construction industry in Dubai is considered a relatively young industry, with a noticeable boom that has happened over the past two decades. The increase in air-conditioning demand and the dependence on natural gas in the UAE is the main cause that the nation is one of the largest carbon-emitters per capita in the world. Hence, sustainable development became a vital concept for the nation (Salama & Hana, Green buildings and sustainable construction in the United Arab Emirates, 2010). In the UAE, there are 2 systems currently being used to rate how "green" a building is; the LEED system that was developed by the United States Green Building Council (USGBC)and is applied by Dubai as the basis for the intended shift towards green buildings, initiated in 2012 and started to see some light in 2016. The second is the Pearling system, developed by Estedama, an Abu Dhabi based building design methodology used to drive the "Abu Dhabi 2030" plan. Estedama, which in Arabic means sustainability, is an initiative developed by the emirate of Abu Dhabi, UAE as part of is "Plan 2030".this plan 2030 was created to produce a greener and more sustainable city which can set an example to other cities in the region. Estidama is not only targeted at buildings and structures, but the aim around the initiative is to create whole communities and cities to be more sustainable. This can be achieved by balancing out the "four pillars of Estidama": Environmental, Economic, Cultural and Social. (ADUPC, 2010). However, researchers and practitioners are still discussing the financial benefits investing in green buildings (Issa et al., 2010). This is especially applicable in the Middle East region as most of the clients would only care about the premium cost of the building and would usually give the project to the contractor with the lowest bid during the tendering phase.

This study aims at investigating the level of awareness of the concept of green buildings in the UAE as well as identifying the challenges facing the shift towards green buildings and the critical success factors required to enhance the delivery of green building projects in UAE.

2. Literature Review

The philosophy of building green emerged as a modern method to encourage environmentally friendly construction by using greener materials, reducing the use of fossil fuels and reducing waste products (AlSaber, 2013) whether or not the buildings system is successful is mainly dependant on the competency of the companies developing it to be able to achieve the quality and efficiency required (Castro-Lacouture *et. al*, 2009) (Hwang & Ng, 2013). Nonetheless, there are many other challenges that are faced during the construction of a green building. Previous research indicated that among the key identified challenges; lack of awareness of the benefits of green buildings green (Iwaro & Mwasha, A review of building energy regulation and policy for energy conservation in develping countries, 2010)& (AlSaber, 2013); the lack of awareness among professionals who prefer to stick to the methods they know than try out something new because of the risks associated with reliability and effectiveness of a new or unknown product. (Pearce & Vanegas, 2002) & (Flanagan et al., 1987); the process of getting an approval for using new green technologies that are new can be a very lenghthy process which affects the planning process of the project (Tagaza & Wilson, 2004) , (Zhang et al., 2011) &(Eisenburg et al., 2002); top management support (Tam *et al*., 2006) and Ball (2002); client related changes, (Berke, 2002); the related organizational and procedural issues are the main barriers for green building developments as opposed to the school of thought that elects the lack of innovative technological advances or rating tools (Hakkinen & Belloni, 2011)& (Zou & Zhao, 2014); effective leadership and team work (Lam *et al*., 2010); avoiding conflicts of interest (Swift, 1999); availability of specifications and effective communications,(Hwang & Ng, 2013) and (Tagaza & Wilson, 2004); general and managerial knowledge to be combined with skills that extend beyond the traditional technical aspects of engineering (Edum-Fotwe & McCaffer, 2000); contractual issues (Chen & Yu, 2005) and (Chan & Suen, 2005); the percived increase in cost of around 4% (Kats *et al*., 2008) despite the reported savings in energy consumptions of 33% on average.

3. Methodology

A mixed methods approach was applied to this study that embraced a survey of 500 individuals in the UAE were approached using a questionnaire (0-10 scale where 5 being the neutral mid-point) that included two lists; 29 challenges facing the implementation of green building and 27 critical success factors (CSF) for successful implementation that were identified from the literature review as shown in Table(1). In total 243 responses were gathered. A statistical analysis examining the descriptive statistics and frequency distributions was used to identify and rank the identified challenges and CSF. Due to the number of challenges and CSF identified, a data reduction technique; factor analysis using the principal component method was applied in order to cluster the challenges and CFS into meaningful groups. In addition, a set of 8 interviews with experts in the construction management were planned but only 4 were conducted as 4 of the experts were not available. The interviews aimed at verifying the findings of the survey.

3.1 Level of Awareness of the Green Building Concept

Both the challenges and the CSF survey results indicated that the most prevailing mode is 5; representing the "do not know/cannot decide" category. This reflects clearly on the first objectives of the study. The majority of the sample surveyed could not decide or did not know the level of importance of the surveyed challenges and CSF which indicated the low level of awareness of the green building concept and practice.

Table 1 The List of Challenges and Critical Success Factors (Summary of Lit. Review).

S.N	Challenges	S.N	Critical Success Factors
C1	Top management's directive for environmental awareness	**F1**	Economic environment
C2	Concerns of stake holders and related parties	**F2**	Social environment
C3	Implementing environmental regulations via contractual framework	**F3**	Policy Support
C4	Conflicts of interest (e.g. suppliers providing specifications)	**F4**	Natural Environment
C5	Bias towards particular products or processes	**F5**	Available Technology
C6	Well-defined liability for detrimental effects of final product	**F6**	Building operation status
C7	Risk of using green specifications	**F7**	Project complexity
C8	Availability of advanced green technology for construction purposes	**F8**	Building age
C9	Whole Life cycle considerations for projects	**F9**	Site and location limitations
C10	Availability of materials based on their renewability/recyclability	**F10**	Clients' awareness of Energy Performance Contracting (EPC)
C11	Awareness of green performance assessment of buildings	**F11**	Organizing skill of leader
C12	Availability of proven green specification model clauses	**F12**	Team members' technical background
C13	Adopting green practices or procedures (eg waste management)	**F13**	Communication skills
C14	Availability of green product information from reliable sources/databases	**F14**	Clients' and energy companies' awareness of the sustainable development theory
C15	Availability of Verifiable green performance criteria for performance based specifications	**F15**	Sustainable development strategy planning
C16	Availability of Clear requirements of green characteristics for prescriptive specifications	**F16**	Control mechanism of sustainable development strategy
C17	Availability of Verifiable green performance criteria for performance based specifications	**F17**	Available financial market
C18	Higher costs for green construction practices and green material	**F18**	Awareness of financing institute to Energy Performance Contracting EPC
C19	Technical difficulty during the construction process	**F19**	Credit of clients and energy savings companies
C20	Risk due to different contract forms of project delivery	**F20**	Project financial status
C21	Lengthy planning and approval process for new green technologies and recycled materials	**F21**	Savings share
C22	Ambiguity about green technologies (Lack of Experience)	**F22**	Task and risk allocation
C23	Greater communication and interest are required amongst project team members	**F23**	Trust
C24	More time is required to implement green construction practices onsite and complexity of construction	**F24**	Effective coordination
C25	Documentation and cost of LEED certification	**F25**	Develop appropriate organization structure
C26	Lack of awareness of the concept and benefits of green buildings	**F26**	Project objectives control mechanism
C27	Perceived Increased operating cost	**F27**	Accurate measurement and verification
C28	Lack of clear federal policy		
C29	Instability of Economic conditions		

4. Survey Data Analysis

4.1 Identified Challenges and Critical Success Factors

On the other hand the mean did not seem to provide clear distinguish between the different challenges and the same was the case for CSF. Hence, it was decided to undertake another course of action that built on the frequencies of the scores 6 and more, for both challenges and CSF. The frequency analysis provided a better dispersion of the challenges and the CSF which was therefore used to rank the most and least critical challenges and the most important and the least influential CSF as shown in table (2). The findings of the frequency analysis clearly reflect on the second and third objectives of the study. The identified top ranked challenges and CSF are aligned with the triple bottom line of the green building concept as endorsed by Murray and Cotgrave (2007) which embraced and integrated the three dimensions; economic; environmental and social. In addition, the findings seemed to be in agreement with the work of Richardson and Lynes (2007) that identified four main categories; leadership; sustainable targets; financial vision and communication.

Table 2 Most and Least Important/Influential Challenges/CSF.

S.N.	Description	Freq. %	CSF No	Description	Freq. %
.	Availability of materials based on their renewability/recyclability	72.8	**5**	Available Technology	74.9
C13	Adopting green practices or procedures (eg waste management)	72	**12**	Project members' technical Skills	74.5
C14	Availability of green product information from reliable sources/databases	70.8	**2**	Social Awareness of GB benefits	73.3
C11	Awareness of green performance assessment of buildings	70	**15**	Government's Role in Sustainable development strategy (SDS) planning	70.8
C8	Availability of advanced green technology for construction purposes	67.9	**3**	Clear legislation enforcing GB	70.4
C23	Greater communication and interest are required amongst project team members	67.5	**11**	Effective leadership	69.5
C18	Higher costs for green construction practices and green material	65.4	**4**	Availability of required GB material	69.1
C26	Lack of awareness of the concept and benefits of green buildings	64.6	**14**	Clients, project managers and energy companies' awareness of the sustainable development theory	69.1
C3	Implementing environmental regulations via contractual framework	64.2	**1**	Stable Economic environment	67.9
C24	More time is required to implement green construction practices onsite and complexity of construction	64.2	**6**	GB experience level amongst project team	67.5
			7	Project scope clearly defined	67.5
Least Influential Challenges/ Least Important CSF					
C4	Conflicts of interest (e.g. suppliers providing specifications)	51.7	26	Project change control mechanism	58.8
C5	Bias towards particular products or processes	51	27	Accurate measurement and verification of as-built works	58.8
C17	Availability of Verifiable green performance criteria for performance based specifications	40.9	**9**	Site and location limitations	57.2
C7	Risk of using green specifications	39.1	**18**	Awareness of financing institute of Energy Performance Contracting EPC and GB in general.	56.8
			21	Savings share amongst stakeholders	56.8

Typically, the findings of the survey reflects on the UAE specific context and hence it was imperative to project it on the findings of Salama and Hana (2013), who developed a green building strategic model for the UAE that integrated the findings of Richardson and Lynes (2007) with the four pillars of sustainability set by Estidama (ADUPC, 2010). The four pillars which are; economic; environmental; social and cultural were reflected in the identified CSF and challenges in general and the top ranked ones in particular. The findings of the survey identified challenges and CSF that combined the four pillars of Estidama with the four organisational categories of Richardson and Lynes (2007) which confer meaning and confidence on the findings of this study and further verify the model established by Salama and Hana (2013). For example, CSF number; 6,7,11 and 12 are more linked to the organisational context whereas the CSF numbers 1, 2, 3,4 and 14 are more in the domain of the four pillars of Estidama. Similarly, Challenges number; 11; 13; 14; 18; 23 and 24 can be linked to the organisational context whereas challenges number; 3; 8; 10 and 26 can be classified under the four pillars of Estidama.

The list of least important CSF draw the attention to the infant stage that the green building practice is currently in at this point in time in the UAE as mentioned by Salama and Hana (2010). Hence, on the one hand, there is more emphasis on the strategic and higher level aspects compared to the technical and operational details such the control mechanism (CSF 27); accurate measurements (CSF 26) and site limitations (CSF 9). On the other hand, due to the early stages the awareness of the financing institutions (CSF 18) and the perceived savings among stakeholders (CSF 21) have not developed yet. The same rationale can be applied to justify and explain the least critical challenges which are more related to the technical and operational details such as conflict of interest (CSF 4), bias towards specific products (CSF 5) and performance criteria (CSF 17). The lack of awareness of importance of risk with the green building practice (CSF 7) reflects the infant stage the industry is witnessing as well as the overall lack of awareness that was previously illustrated by the dominance of the score 5 being the prevalent mode as above mentioned.

4.2 Grouping of the Indentified Challenges and CSF - Factor Analysis

Due to the significant number of challenges and CSF identified, it was resolved that a data reduction technique would be suitable to cluster those challenges and CSF under a more meaningful groups. This decision was further justified after conducting a correlations analysis among challenges and CSF respectively. In addition, the KMO (Kaiser-Meyer-Olkin Measure of Sampling Adequacy) scored a very healthy 0.9 and the Bartlett's test of Sphericity was significant indicated that the factor analysis is suitable for this data set (Hair *et al.*, 2010). The findings of the initial extraction of the factor analysis using principal component method did not reflect clearly distinguished components as indicated by the loading of the different challenges and CSF on the various components. Therefore, it was resolved to rotate the axes using Varimax technique which provides orthogonal axes i.e. treats multicolinearity (Hair *et al.*, 2010). With an Eigen value of 1, the analysis yielded 8 principal components for the challenges and 6 principal components for the CSF. This solution was compared with 5 principal components for the challenges and 4 for the CSF based on the scree plot (Hair *et al.,*2010). It was resolved that the latter provides more meaningful findings. The clustering of each principal component was based on the loading of each factor on the relevant component as shown in tables (3&4). The reduction of factors to 5 factors only has resulted in minor changes in the identified categories of factors. Only, the Risk factor has disappeared and challenge number 7 (C7) did not load significantly on any of the factors. It is worth noting that C7 was the least important on the ranking list. In addition, the loading of some challenges under this solution resulted in shifting some challenges from one category in a rational manner. For example, the awareness Factor under this solution included some of the challenges such as C20 and C27 where the perceived higher operating costs and the risk can be argued to be due to the current level of awareness.

Table 3 Five Principal Components after Rotation for Key Challenges.

PC1	Specifications	PC2	Awareness	PC3	Economic	PC4	Environmental	PC5	Contractual
C14	0.78	C18	0.735	C23	0.704	C1	0.775	C6	0.727
C11	0.729	C19	0.716	C25	0.672	C2	0.675	C5	0.645
C17	0.729	C22	0.602	C29	0.659	C3	0.639		
C16	0.693	C27	0.54	C28	0.555	C4	0.546		
C13	0.671	C26	0.53	C24	0.506				
C10	0.662	C20	0.469	C21	0.505				
C12	0.637								
C8	0.633								
C15	0.62								
C9	0.6								

Table 4 Four Principal Components after Rotation for CSF.

PC1	Socio Environmental	PC2	Management / Organisational	PC3	Financial	PC4	Economic
F4	0.75	F9	0.758	F19	0.684	F18	0.744
F5	0.735	F24	0.717	F22	0.67	F15	0.64
F6	0.725	F27	0.692	F20	0.578	F21	0.574
F2	0.725	F13	0.655	F16	0.56	F17	0.553
F3	0.668	F8	0.641	F25	0.555	F14	0.466
F7	0.576	F12	0.621				
F1	0.497	F11	0.54				
F10	0.445	F26	0.496				
		F23	. 402				

The same techniques used above for clustering the challenges using the principal component with Varimax rotation was applied to the CSF using the loading of each CSF on different factors (components). The 6 components identified in the first solution were reduced to 4 only, where the two organisational components were logically merged into one and the technical component was disintegrated. The 4 components provided a higher level of factors whereby some of the technical CSF identified under the 6 component solution have been merged into the organisational/ management factor. The findings of the factor analysis for the CFS identified 4 main categories of CSF; Environmental/social; Organisational; Economic and Financial which is aligned with the findings of the literature review as in indicated in the findings of Salama and Hana (2013) and Richardson and Lynes (2007). The challenges, on the other hand, identified 5 main categories of challenges; Availability of Specifications; Awareness of the green building concept, practice and benefits; Economic; Environmental and Contractual. The concern about the availability of specifications in general and about various aspects is in alignment with the findings of Salama and Hana (2010) which claimed that the green building practice in the UAE was in the infant stage. It seems that despite the time elapsed; the green building practice in the UAE has not clearly emerged from this stage, so far. The concern about the level of Awareness which came as the second key challenge verifies the findings of the statistical analysis based on the descriptive statistics of the data set where the mode for the majority of the identified challenges was "do not know/cannot decide" category. The findings of the factor analysis complemented the findings of the frequency analysis and reflected on the three objectives of the study. The challenges and CSF (2^{nd} and 3^{rd} objectives) were identified and discussed. In addition the findings of the analysis indicated the significant lack of awareness of the green building concept and practice (1^{st} objective).

5. Discussion of the Findings of the Interviews

The interviews aimed at verifying the findings and seeking expert opinion explaining the findings of the statistical analysis. The interview sample followed a purposive sampling method whereby 8 experts in construction management from academia and practice were approached. Four academics in the discipline of construction management and 4 senior project managers were invited. Only four accepted the invitation. One senior academic and 3 senior project managers were interviewed. All four had over 20 years of experience in construction project management. The senior academic holds PhD in construction management and two of the senior project managers hold MSc degree in project management. The interviews script comprised 6 questions reflecting on the objectives of the study while linking to the findings of the survey.

5.1 Level of Awareness of the Green Building Concept

One of the interviews was very brief whereby the interviewee who is a senior project manager in construction had the view that the green building concept is not and will not be popular in the UAE even in the near future. The reasons presented were mainly related to the specific context of the UAE. According to this point of view, the UAE enjoy abundance of resources and this is emphasised in the extravagance in spending on various aspects such as the consumption of water and energy that exceeds many other countries on per capita basis. Hence, the need which is the key driver for change does not exist. Embracing this point of view, this interview was very brief as the interviewee was reluctant to address the rest of the questions on the script since it was obsolete, from his point of view. When asked about the serious measures the UAE government has been taking trying to implement and even impose the green building practice, the answer was that this is most likely going to be limited to the public sector. The interviewee justified his point of view by giving the example of Dubai that is trying to impose the green building regulations since 2012 and so far relatively a few steps have been achieved, particularly in private sector.

On the other hand, the other three interviews were more informative and provided insightful depth on the issue of awareness. In general, all there interviewees agreed with the findings of the survey data analysis confirming the lack of awareness of the green building concept, benefits and practice. All three interviewees agreed that the level of awareness was portrayed at different levels. For example, one of the interviewees; a project manager stated that there is sheer lack of awareness of the benefits of the green building compared to the traditional building. There is a general misconception that green buildings are more expensive and that the additional cost at the building stage is not justified. Another interviewee stated that the limited level of awareness is due to the lack of knowledge about the technical aspects of green building, both at the design stage and the implementation stage.

5.2 Identified Challenges and Critical Success Factors

The three interviewees who completed the interviews agreed, in general, with the findings of the factor analysis. The general view was that the identified categories are significant for both the challenges and the CSF. The identified five main categories for the challenges, particularly the availability of specifications, the level of awareness and the organisational related challenges resonated well with the three experts. There is a strong view that was shared among the interviewed experts that the change has to happen from within rather than being fully imposed. There is still the need for a legislative framework that would guide and perhaps initiate the change (Salama and Hana, 2013). However, in order to sustain this change, the various categories of stakeholders have to be convinced and motivated. This will take the implementation of green building practice in the UAE to the next level rather than the current limited phase that is mainly illustrated in the public sector buildings.

It was the least critical challenges as identified by the statistical analysis that attracted the attention of the experts. There was a common consensus that the ranking of those challenges as least important indicated the lack of awareness of the concept, benefits and practice of green building. Particularly the challenge number 7 about risk management when implementing green building was identified by experts as a critical challenge facing the implementation of green building in UAE within the private sector because risk has significant impact on insurance

of buildings; an issue that currently concerns green building experts in the UAE. The interviewed experts agreed with the CSF identified by the factor analysis. The general comment that seemed to be reiterated in all three interviews was that the three categories; social / environmental; economic and financial seemed generic and imperative but they were interested to focus the discussion on the organisational factor for the same discussed above when asked about the challenges. The least critical success factors attracted the attention of the interviewed experts, particularly the CSF 21; the savings share among stakeholders and CSF; the awareness of financing institutes of energy performance. Both supported the view of the interviewed experts about the lack of awareness since both factors should be among the significant CSF. When asked about the suggested recommendation to enhance the awareness of green building in the UAE, there were different views. One of the interviewed experts expressed his concern due to the nature of the UAE demographic context whereby the majority of the population are expats who do not view the UAE as their home country and they see that their stay in the UAE is for a limited period of time. Hence, the majority would opt for renting rather than buying property. This meant that those who own are different from those who use the building. In other words, the owner is not reaping the whole life (long term) savings due to green building reduced consumption of energy and water, typically paid by the tenant. On the other hand there is no evidence that green buildings attract higher value for rent in the housing market that would entice owners to create demand. The interviewed experts suggested that until this changes the driver for and awareness of green buildings will be limited. The three experts stressed that in the UAE, the word of mouth is very effective and this has to be utilised in promoting the green building concept. However, there must be incentives and this perhaps needs government actions such as the reduced tariffs for energy and water for green buildings compared to traditional buildings. This can create market forces and through the market mechanisms the demand will derive the supply. In conclusion, the interviews verified and confirmed the findings of the statistical analysis and provided further insightful depth about the challenges facing the implementation of green building in the UAE.

6. Conclusions and Contribution to the Construction Management Research Agenda

There is a clear lack of awareness and was illustrated in the emergence of the availability of specifications as one of the key challenges despite the already available specifications in the form of the systems currently available and implemented by the UAE government both in Abu Dhabi and Dubai. The statistical analysis identified five main categories of challenges facing the implementation of green building in the UAE. Those included; availability of specifications; awareness; organisational factors; environmental factors and contractual factors. In addition, the statistical analysis identified four main categories of CSF that can enhance the implementation of green building in the UAE. Those included; socio-environmental factors; organisational factors; economic factors and financial factors. The conclusions of the study suggested that in order to enhance the implementation of green building, the government has to provide significant incentives in the form of reduced energy and water tariffs for green buildings that would stimulate the market and entice the shift towards green building in the private sector. Further research is needed to investigate the impact of this recommendation on the economics of the building market in the UAE. The findings of this research can position this study on the research map in the same group with previous researchers who conducted studies on the same topic such as Salama and Hana (2010) and (2013); Murray and Cotgrave (2007); Richardson and Lynes (2007) and others. This study claims to have significant contribution to the knowledge in the context of green building in Dubai for two main reasons; there is generally limited literature on the critical success factors for the implementation of green buildings and particularly in the context of UAE using such a large sample. In addition, the specific context of UAE with the majority of the population as expats living in UAE for limited number of years and mostly tenants rather than owners, makes the UAE quite unique in terms of social aspects. Hence, it was worth investigating the level of awareness, challenges and CSF in this unique context.

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Potential Use of the Sewage Sludge in the Production of Light Weight Aggregate

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Abstract

Providing smart solutions for waste sewage sludge disposal has been an interesting subject for many researchers towards a sustainable recycling processes. This process has a major environmental and economic impact in many countries (Hope, 1986). Sludge is produced as a byproduct in sewage waste water treatment plants which includes different types and amount heavy metals where its disposing creates serious problems for a sustainable environment (European Commission-DG Environment, 2001). Also in some countries sewage sludge is used as a fertilizer, this has not been preferred in north Cyprus. Currently, the produced sewage sludge has been dumped in open area which is causing serious environmental problems. This paper aims to investigate the potential use of the sewage sludge in the production of lightweight aggregate as an alternative disposing method of the sludge. In this study, sewage sludge was mixed with clay in different proportions and sintered in a muffle electric furnace at a temperature ranged from 1100˚C to 1200˚C at various durations. The properties of the product obtained was investigated in laboratories, and it showed the characteristics of light weight aggregates.

Keywords: Sewage sludge, Light weigh aggregate, Waste, Sustainable recycling processes.

1. Introduction

Many researches and government organizations have developed different methods of disposing sludge after is treated in order to minimize the hazards, pathogens of sludge that may contaminate our environment. Due to the growth of urban areas around the world, municipalities have been obliged to find alternative methods at wastewater plants for treatment and disposing sludge due to the high cost of transporting the sludge and other constrains imposed by heavy traffic and legislations imposed. Wastes generally have three possible places to be disposed; air, earth and ocean. However, these three places are no longer safe where the wastes can be eliminated without hazardous effects (Hope, 1986).

Sewage waste water is treated in Nicosia city at the New Water Treatment Plant (NWTP). This NWTP is serving for both communities of Nicosia, Turkish and Greek Cypriots since July, 2013. It was estimated that the NWTP would treat about 30,000 m^3 of waste water every day to produce;

- Treated water for irrigation purposes.
- Renewable bio-gas (methane), and
- About 3000 tons of bio-solids are estimated to be produced annually as natural fertilizer.

The sludge produced is being dumped in the open areas since the operation of the New Water Treatment Plant to be air dried for further use in agriculture purposes. However, legislations of using the sludge as fertilizer have not been set yet by the municipality. Furthermore, farmers did not accept the concept of using the sludge as natural fertilizer. Therefore, sludge has not been used as it was planned and it has been accumulating with a range about 1600 tons/month in the open areas causing local environmental problems due its unpleasant view and odor (Sewerage Department of Nicosia Turkish Municipality, 2016).

Disposing sewage sludge has taken a place in construction industry where it has a potential use in lightweight concrete production (Celik and Bayasi, 1995), lightweight aggregate production (Bhatty and Reid, 1989; Chiou *et al.*, 2006; Mun, 2007; Hemmings *et al.*, 2009; Huang and Wang, 2013), ceramic production (Anderson and Skerratt, 2003; Smol *et al.*, 2015), road construction (Lind *et al.*, 2008) and brick manufacturing (Durante Ingunza *et al.*, 2010; Weng *et al.*, 2003).

Lightweight aggregate (LWA) can be obtained from natural and synthetic resources. It was used first time as a natural resource from volcanic origins since Roman Empire until these days such as Pumice and Scoria. However, the resources of natural lightweight aggregate are limited to specific regions where volcanic activities occurred. These resources were not enough to provide the natural lightweight aggregate in other regions besides increasing the demands of porous aggregate due to the development of other concrete applications at the end of the 19th century. Since then, researches started developing alternative methods to produce lightweight aggregate and that was until the beginning of the 20th century but the production was limited to foaming the blast-furnace slag. However, the production of lightweight aggregate was improved by pelletizing and expanding the blast-furnace slag in the beginnings of 1970's leading to producing lightweight aggregate with less vesicular surface in these days (Newman and Choo, 2003).

2. Production of LWA

Lightweight aggregate can be produced based on two techniques; agglomeration and expansion. When the raw materials are heated to a temperature about or more than 1100˚C, they are melt and fused together to form the aggregate and this technique is called agglomeration. The other technique is performed when argillaceous materials are heated to fusion temperature then steam or gas is generated simultaneously with pro-plasticity point and aggregates is bloated, this process is called bloating or expansion. The pro-plasticity point is normally between 1100˚C and 1300˚C. However, the fusion process depends on the sources of the raw materials used and their chemical composition (Newman and Choo, 2003).

Sewage sludge ash with a mean particle size of 35 μm was incinerated at a temperature ranged from 1040˚C to 1100˚C and for different firing durations in between 10 to 30 minutes and the aggregate obtained had a specific gravity ranged from 1.55 to 0.52 and from 2.02 to 0.57 for pellets and slab aggregates respectively (Bhatty and Reid, 1989). Similar approach has been adopted to produce lightweight aggregate by mixing up to 30% of sewage sludge with sewage sludge ash under different thermal treatment ranged from 1050˚C to 1150˚C for 10 to 20 minutes. The aggregate produced had a bulk density ranged from 1.82 to 0.76 g/cm^3 (Chiou *et al.*, 2006). Clay with particle size ranged from 300 to 100 μm has been used to produce lightweight expanded clay aggregate and it has been found out that increasing firing temperature from 900˚C to 1200˚C has a positive influence on the characteristics of expanded lightweight aggregate produced where the expansion took place between 1050˚C to 1150˚C. Furthermore, increasing holding time of incineration from 10 to 20 minutes has also a positive effect as well on lowering the bulk density of lightweight expanded aggregate (Ozguven and Gunduz, 2012).

3. Material & Methods

The procedure followed in this study was adopted from some comprehensive studies related to producing lightweight aggregate by using similar raw materials. Materials were subjected to incineration at different temperatures ranged from 1100˚C to 1200˚C. However, some of the samples used were melted and others exploded at 1200˚C. Therefore, incineration took place at a range of 1100˚C to 1150˚C. The raw materials used were clay, sewage sludge and sewage sludge ash. Clay was collected from local clay brick factory at Haspolat area then it was dried and milled to pass 150 μm sieve with a specific gravity of 2.63. The sludge was collected from disposing areas near the New Water Treatment Plant in Haspolat, Nicosia, and then it was oven dried for 24 hours, then it was milled to pass 150 μm sieve with specific gravity of 1.62. Sewage sludge, which was obtained from previous step, was incinerated in a pilot-scale furnace at 850˚C for two hours to produce and then it was milled to pass 75 μm sieve with a specific gravity of 2.90.

Figure 1 Illustration of raw materials used in this study.

Three different combinations were used for this study; clay with sewage sludge (C&SS), clay with sewage sludge ash (C&SSA) and sewage sludge ash and sewage sludge (SSA&SS) and mix proportions used are shown in **Error! Reference source not found.**.

Table 1 Mix proportions of raw materials.

Raw Material	Combination 1 (C1)					Combination 1 (C2)					Combination 1 (C3)				
No of mix	**-**	**M1**	**M2**	**M3**	**M4**	**-**	**M1**	**M2**	**M3**	**M4**	**M1**	**M2**	**M3**	**M4**	**M5**
Clay (%)	-	75	50	25	0	-	75	50	25	0	-	-	-	-	-
Sewage sludge (%)	-	25	50	75	100	-	-	-	-	-	100	75	50	25	0
Sewage sludge ash (%)	-	-	-	-	-	-	25	50	75	100	0	25	50	75	100

All mix proportions will be named according to this table using certain abbreviation symbols. For example;

- C1M1: refers to combination 1 and mix number 1 where the mix consists of 75% clay with 25% sewage sludge.
- C3M3: refers to combination 3 and mix number 3 where the mix consists of 50% sewage sludge with 50% sewage sludge ash, and so on.

Only two raw materials for each mix were used and mixed with an adequate amount of water to form the dough and then spherical pellets were formed by hand with a diameter ranged from 5 – 10 mm.

The pellets then were subjected to incineration ranged from 1100˚C to 1150˚C at two holding times; 20 and 30 minutes and then cooled to room temperature. Specific gravity aggregate produced was performed according to ASTM C127 (2007).

4. Results and Discussion

4.1 Combination 1 – C&SS (clay + sewage sludge)

In this combination, the materials were combusted at 1150˚C for 20 minutes and lightweight aggregate was obtained as it is shown in Figure 2. It can be observed that specific gravity generally reduces as much as the amount of sewage sludge in the mix and this may be due to the presence of organic and pathogenic materials (Andreoli *et al.*, 2007) in sewage sludge which creates more voids in the inner structure of the aggregate produced during the incineration. The best results were obtained from second and third mix (C1M2 & C1M3) with specific gravity of 1.37 and 1.03 respectively. Both mixes also which have given non-vesicular lightweight aggregate except C1M4 which has a porous surface in spite of its low density.

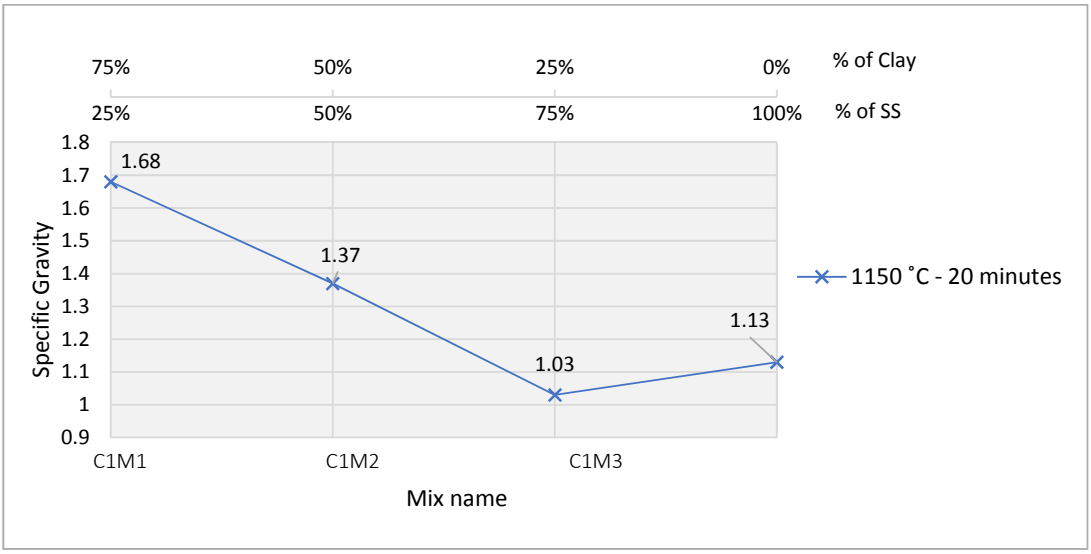

Figure 2 Specific gravity of LWA made from clay and sewage sludge (SS).

4.2 Combination 2 – C&SSA (clay + sewage sludge ash)

The incineration process was performed at 1100˚C through two different holding times; 20 and 30 minutes and specific gravity of the aggregate obtained ranged from 2.02 to 1.34 as depicted in Figure 3. Both incineration process has shown similar trend where mix C2M2 (50% clay with 50% sewage sludge) has produced the heaviest aggregate in this combination, then there was almost steady decrease in specific gravity up to 1.34 and 1.37 for 20 and 30 minutes holding times respectively. It was also observed that increasing the amount of SSA from 75% to 100% has produced lightweight aggregate with strong and non-vesicular surface. Increasing holding time from 20 to 30 minutes has slightly increased the specific gravity for C2M2. However, it has almost no significant effect on C2M3 and C2M4 where the low densities were obtained. So, it is recommended that the materials are incinerated for 20 minutes for an economic point of view.

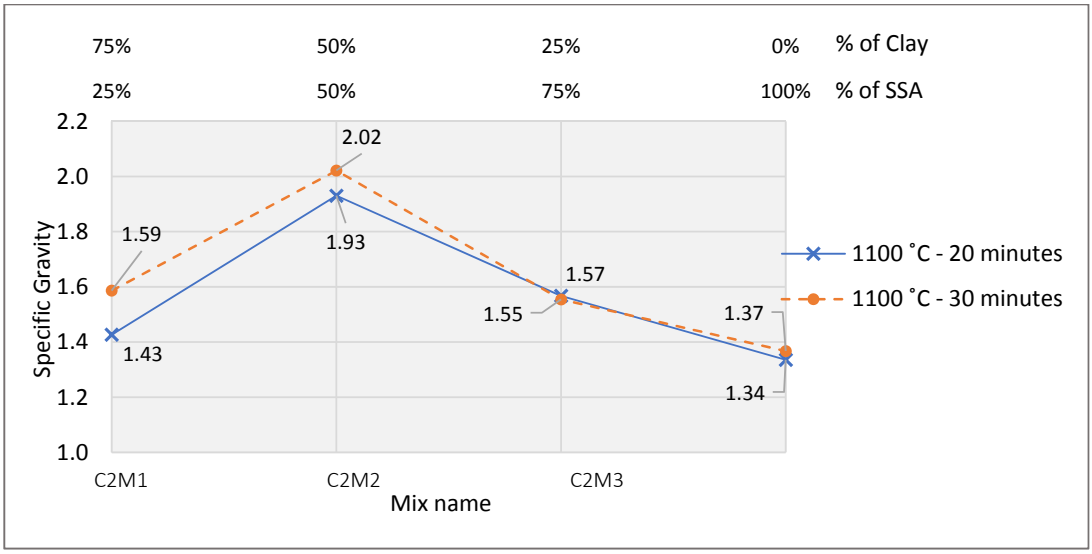

Figure 3 Specific gravity of LWA made from clay and sewage sludge Ash (SSA).

4.3 Combination 3 – SSA&SS (sewage sludge ash + sewage sludge)

Incineration process followed here was similar to combination 2 (1100˚C for 20 and 30 minutes). The content of sewage sludge in both stages has a reverse relationship with specific gravity (See Figure 4). Not only the specific gravity has affected by the amount of sewage sludge, but also, the porosity of the surface texture has reduced. Increasing incineration holding time from 20 to 30 minutes has reduced the specific gravity slightly for the mixes with high amount of sewage sludge ash from 100% up to 50% of the total mix (C3M1, C3M2 and C3M3). However, C3M4 and C3M5 have been effected in a different way, where the specific gravity has slightly increased by increasing holding time of incineration as it is shown in

Figure.

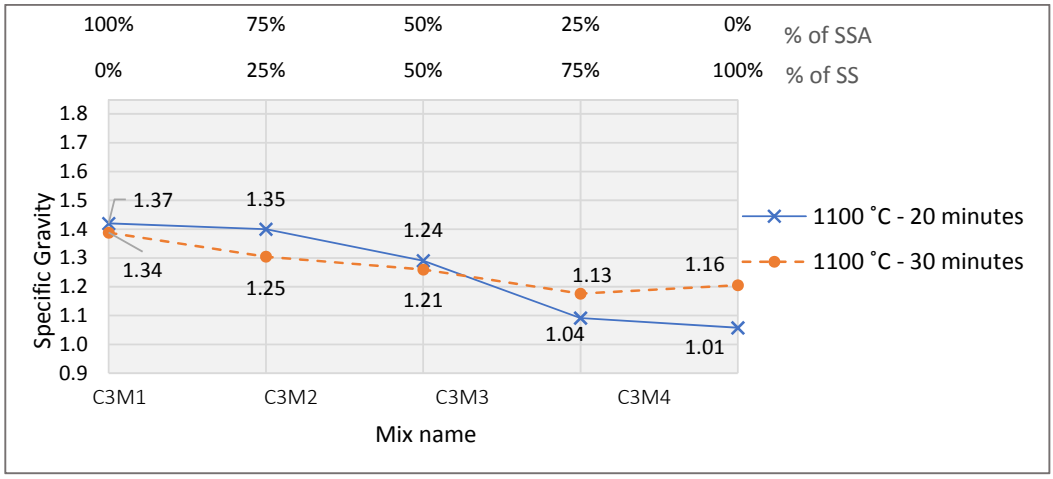

Figure 4 Specific gravity of LWA made from sewage sludge ash (SSA) and sewage sludge (SS).

5. Conclusion

For all combinations, the quality of lightweight aggregate produced in this study was mainly dependent on proportions of raw materials especially the amount of sewage sludge. Time of incineration has an effect on improving the porosity of surface texture of lightweight aggregate that has high amount of sewage sludge and. However, it has slight influence on specific gravity obtained.

For an economic point of view, all materials need drying and grinding processes. However, lightweight aggregate produced from the first combination (clay & sewage sludge) requires less time and cost where the incineration is performed only one time.

Incineration of sewage sludge is considered as one of the effective disposing methods of sewage sludge where the volume can be reduced significantly up to 96% (Andreoli et al., 2007) and also requires emission closed system for pathogens and gasses and special filters. However, it's a preferred method in spite of the high cost (Bresters *et al.*, 1998). In this study, producing sewage sludge ash throughout the incineration at temperature of 850-900˚C for 2 hours, has caused a significant reduction in the total weight by more than 94% of fresh sludge and up to 66% of the dried sludge. So, if the incineration process is considered to be performed as a disposal method in Nicosia, there will be a potential use of the ash in the production of LWA.

Further work is required to obtain more accurate results of material proportioning by using small mixing margins with an increment of 5% at the zones of the lowest values of all previous combinations. The amount of heavy metals of sewage sludge will be also measured before and after the production of lightweight aggregate to build a general idea how lightweight aggregate can provide an alternative disposal method with less environmental impact.

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Improving Construction Organization Performance through BIM and 3D Laser Scanning

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Abstract

The construction industry productivity is an essential aspect dominating on project failure or success, which directly associated with the reduction of waste produced during the project lifecycle, especially with material and resource wastages during the construction process. The current design and planning processes consume more time and effort to achieve the desired outcome and lack of decision-making supplies for predicting subsequent risks. This problem is related to intellectual waste caused by the intensive amount of data that need proper information management among project stakeholders which will also affect collaboration and communication during the project lifecycle. A gradual structure of the provided literature presents the emerging challenges of the construction industry and suggests that BIM and laser scanning have the potential to overcome such issues including construction projects within the UAE, which is referred to by the IMF as one of the most important countries of the GCC with a continually growing construction industry. Hence, it was important to determine the types of intellectual waste within different projects' stages to perceive the current methods employed for reducing wastage impact on UAE construction productivity. The findings revealed common issues during construction stage such as meeting the clients' expectations alongside the antibiosis between time management and waste management, which always occurs when adopting traditional methods. The conclusions were achieved through conducted qualitative interviews with UAE construction experts. It is based on literature review findings and the gathered data analysis which helped to evaluate whether the newly emerging technologies, such as Building Information Modeling (BIM) and Three-dimensional laser scanning contribute to reducing intellectual waste during different project stages (brief, design, and construction). The study aims to be a mixed platform to reduce wastage of design by providing the necessary information to project stakeholders and by providing an automatic work plan which is managed in a systematic way by BIM

Keywords: Construction Industry, automation, waste reduction, project lifecycle, Building Information Modeling (BIM), Laser Scan.

1. Introduction and Rationale

The purpose of construction waste reduction is very essential. International reports indicate that most of the solid wastage in the UK came from the Construction Industry (Liu *et al.*, 2015). Meanwhile, the Construction Industry criticised for its poor performance due to several issues, such as generalising the management process on a large number of projects where each project is a unique product. Also, the lack of adopting new technologies and depending on traditional methodologies which seem to be safer for "profit stabilisation, therefore, many implementations and studies been introduced to manifest this problem through introducing new technologies and techniques which are construction related and design related as well.

Mentioning design related technologies have its importance as leading guides for construction processes, where the briefing stages involve all design process components from planning, data gathering and providing the required shop drawings for establishing the works on site. Alreshidi, Mourshed and Rezgui (2016) stated that most of the construction problems came from the lack of efficient information management, especially in large-scale projects, because of the complexities and fragmentation present in intensive information within the project lifecycle and the supply chain. (Figure 1)

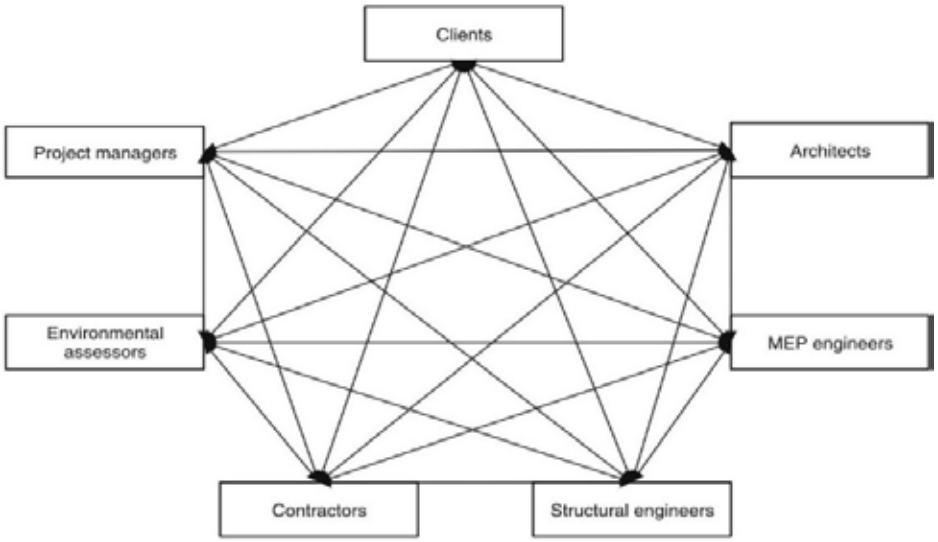

Figure 1 Exchange of Data in Conventional Construction Projects. Source (Alreshidi, Mourshed and Rezgui, 2016).

This gap occurs as a result of the poor utilisation of waste elimination methods or the total absence of these techniques, essentially Benchmarking, Lean and Total Quality Management (TQM), which drove researchers to investigate new technologies that could ease the utilisation of these techniques or even provide monitoring systems for waste control. Building information modelling (BIM) can fill this gap, based on full computer-aided programmes which provide different categories of building components with its modified specifications and measurements (Cheng and Ma, 2013).

This study aims to evaluate waste savings in UAE construction projects through adaptation of BIM. The Construction Industry is suffering from a tremendous amount of wastages whether in materials, time or effort. This research will focus on newly adopted technologies that could ease the construction management process and minimise both time and effort required during the design stage and ensure a high-quality outcome.

2. An Overview on Construction Industry Wastage

2.1 An Overview on Wastage

Wastage occupies 57% of the Construction Industry's productivity compared to 12% of the Manufacturing Industry (Aziz and Hafez, 2013). Kofoworola and Gheewala (2009) stated that wastage is a result of the demolition, renovation and construction processes, which includes damaged products or materials used during works on the site. As the massive amount of waste produced by the construction industry cause economic and environmental problems (Paz and Lafayette, 2016), that 90% of construction and demolition waste (CDW) can be reused. Further, Lu and Yuan (2011) suggested the Reduction process which is one of the best methods to manage waste and was concluded from the 3Rs (Reuse, Recycling & Reduction), which is very efficient in reducing the generation of waste and the elimination of environmental issues. Adding for that, it reduces the cost of disposing of construction waste and transportation.

Another effective strategy to reduce waste is to manage and reduce construction waste at an early stage that the productive and efficient design, which expects future comprehensive details of construction can contribute to the reduction of waste materials which classified as non-essential. Gamage, Osmani and Glass (2009) showed the four most important causative sources of waste in procurement systems (design systems) which are:

- Avoid early coordination with project stakeholders.
- Lack of communication and coordination within the project.
- Weak responsibilities allocation.
- Incompatible procurement documentation.

Hence, the relation between time waste management and material waste management is evident that one will be affected by the other and vice versa. Time waste management is essential; it reflects how well the project's design team understand the required processes to finalise the design phase and to deliver the necessary shop drawings for construction establishment. Otherwise, a failure will emerge in achieving the main project's aims on time, which causes additional processes within the construction and design phases that would not add any value for the end customer, these extra activities became waste and will involve reworks (Koskela, 1992).

2.2 Intellectual Waste / Design and Time Waste Sources:

Figure 2 depicts the fragmented delivery process and dependency on traditional communication methods which are based on paper works contribute to generating more errors and omitted documents. Many efforts have been implemented through adopting new approaches such as design-build path, engaging web-based services in sharing project documents, and the usage of three-dimensional CAD models. The mentioned techniques have assisted in the reduction of time waste which associated with conflicts caused by paper-based document's errors which can result in repeated delays (Eastman *et al.*, 2011). Nevertheless, such techniques require an additional time to develop the estimation of the expected design's data, which includes critical information such as; structural details, energy use measures, cost evaluation…etc. Thus, the time waste during the design stage is associated with its conventional management and traditional operations' nature. Hence, wasting time during the design process emerges through the following:

- A major issue lies in the content's vagueness within the client's document, which may result in other difficulties when seeking approvals. Moreover, the client may push for further modifications during the design process without perceiving that these variations would lead to redesigning from scratch (Aftab Hameed, Ismail Abdul and Mohamad Faris Abul, 2014).
- Another issue represented in the inefficient flow of data (Koskela, Ballard and Tanhuanpää, 1997). Especially in complex designs, that Tribelsky and Sacks (2011) emphasis on the stability of information flow to avoid unexpected outcomes, also, they assume that such data form the raw material for designers which can clarify the design aim and assist them while designing.
- A further issue referred to by Tribelsky and Sacks (2011) which is very important, that it must be on the designers to wait for updates to the current design from clients. Where many companies have multiple projects, and they subject their developers to work on the tasks of another project while waiting for updates on the current project, this process is adversely affecting the concentration of the design team and make them more susceptible to distraction from the goal of the current design.

Previous papers published in the last 25 years by Koskela (1992), Latham (1994) and Egan (1998) invited to an improvement in construction that Egan (1998) required the Construction Industry to boost and improve the procedures for adopting new technologies. While Koskela (1992) mentioned that the construction industry does not need to adopt new technologies but it needs to change the entire procedure of its processes to maximise the product quality with increased profitability.

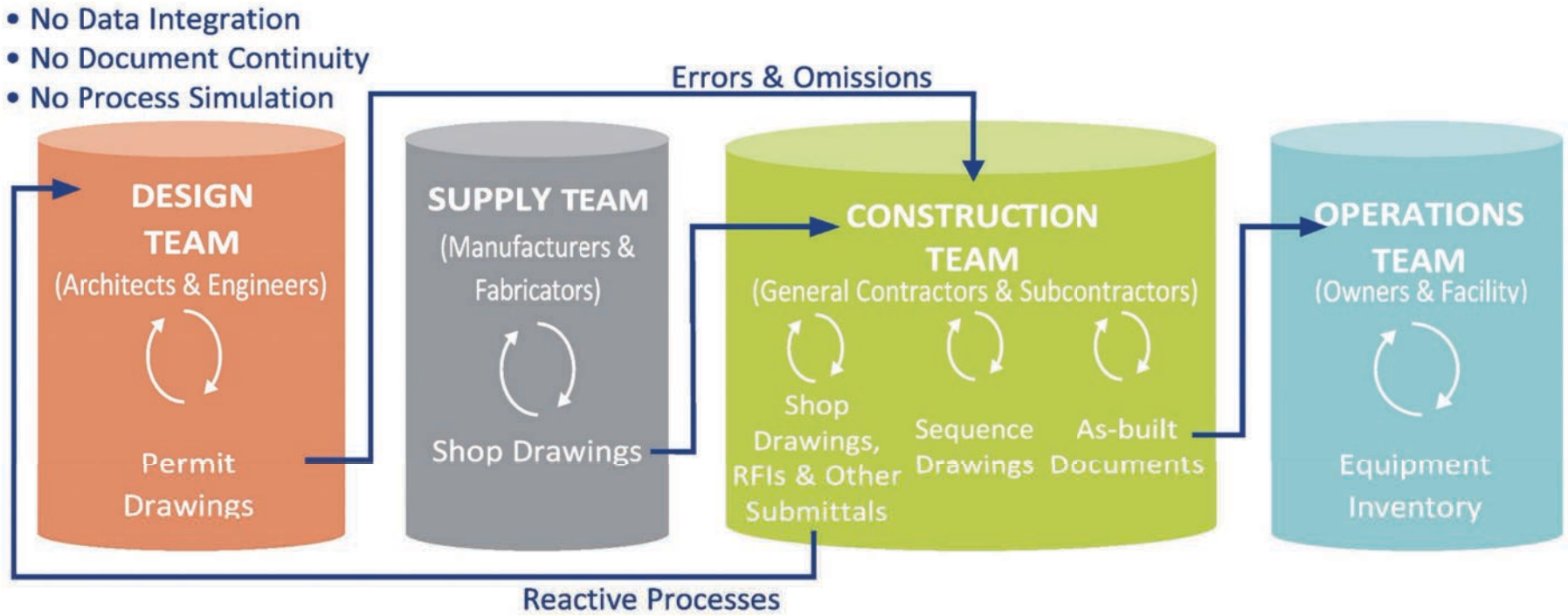

Figure 2 Conventional Design, Construction, and Operations Process. Source (Systèmes, 2014)

3. Building Information Modeling (BIM) and Three-Dimensional Laser Scanning (3-DLS)

3.1 The Need for Laser Scanning and BIM

Till recently, the newly invented automation tools had been adopted in the construction industry such as, BIM and three-dimensional laser scanning (3DLS), which becae necessary for the Construction Industry (*Erin Fallon*, 2012) as a result of the afforded cost reductions and the abbreviated tasks from measurements on-site. Further, 3DLS provides a major assistance in creating three-dimensional models, 360-degree figures of the scanned location and in the meantime, it can make evaluations on all site situations. All the advantages above will contribute to enhancing discussions among project's practitioners and parties involved, mainly to guarantee solutions for customers.

3.2 Categorization of Three-Dimensional Laser Scanning

3.2.1 Pre-construction Laser Scanning

Pre-construction information (PCI), as it is also called pre-construction planning (PCP) process, is critical to be collected and prepared before any new construction due to its provided assistance in project construction and the guaranteed decision making (Abbas, Din and Farooqui, 2016). Conventionally, such data includes the current land condition in comparison with the proposed design, the project's information (components) and the type of land to be excavated. Figure 3 shows the process for building a digital site model. Figure 4 and 5, however, depict examples of laser scanned facilities.

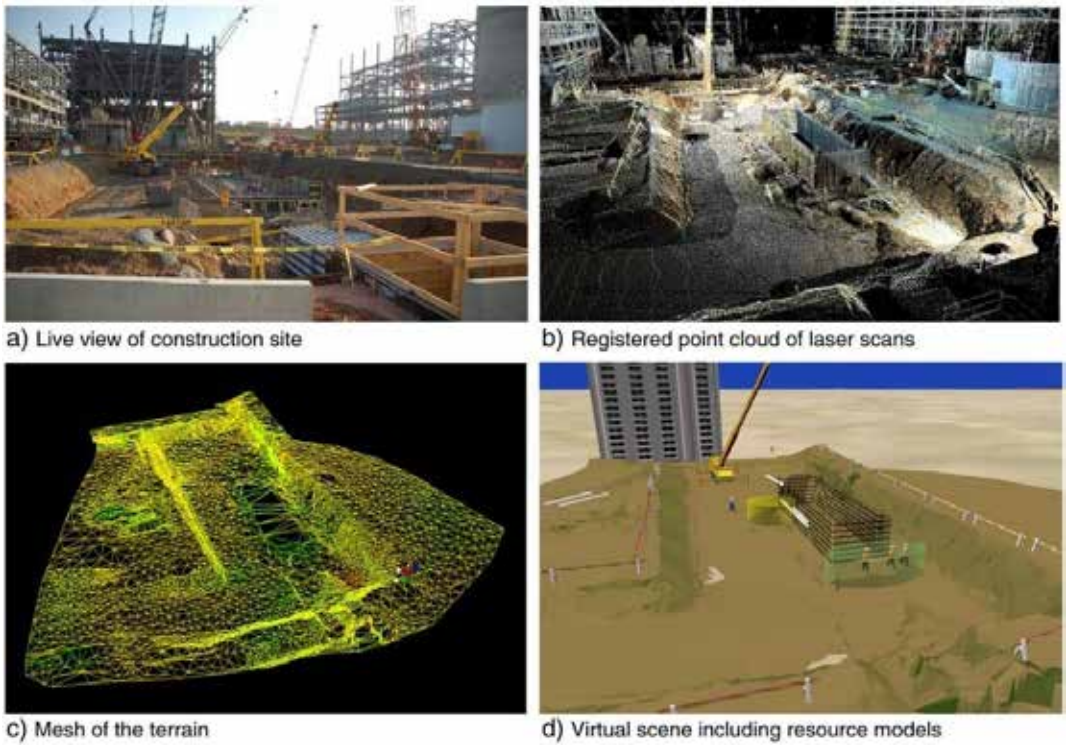

Figure Error! No text of specified style in document.**2** Sequence to build a digital site model from point cloud data. Source (Cheng and Teizer, 2013).

Table Error! No text of specified style in document.**1** Different PCP aspects. Source (Abbas, Din and Farooqui, 2016).

	PCP Aspects	Explanation
1.	Project Scope (PS)	The process of a project is defined and prepared for fast execution approach.
2.	Area & Site Investigation (ASI)	The design process of geological investigation & defining political & security issues of the area.
3.	Team Selection (TS)	Effective communication strategy within the team selection of a contractor.
4.	Design Review Coordination (DRC)	Reviewing of drawings according to specifications and coordination among designer, consultant, and contractor.
5.	Constructability (CONS.)	The conceptual planning (regarding performance of schedule, quality, cost, and safety) phase of a project.
6.	Value Engineering (VE)	Identifying alternative ideas for accomplishing the project function at the lowest cost.
7.	Risk Analysis (RA)	Chances of delays due to accidents during construction of a project and their respective outcomes.
8.	Safety in Design (SID)	The initial integration of hazard identification and risk assessment methods into the design process.
9.	Long Lead Procurement (LLP)	The early procurement of material to accommodate it for long procurement spans.

3.2.2 As-built Laser Scanning

As-built LS systems had proven its efficiency in renovation works, or development of an existing structure, where more difficulties occur due to the outdated or non-existing drawings (Hayes and Richie, 2015).

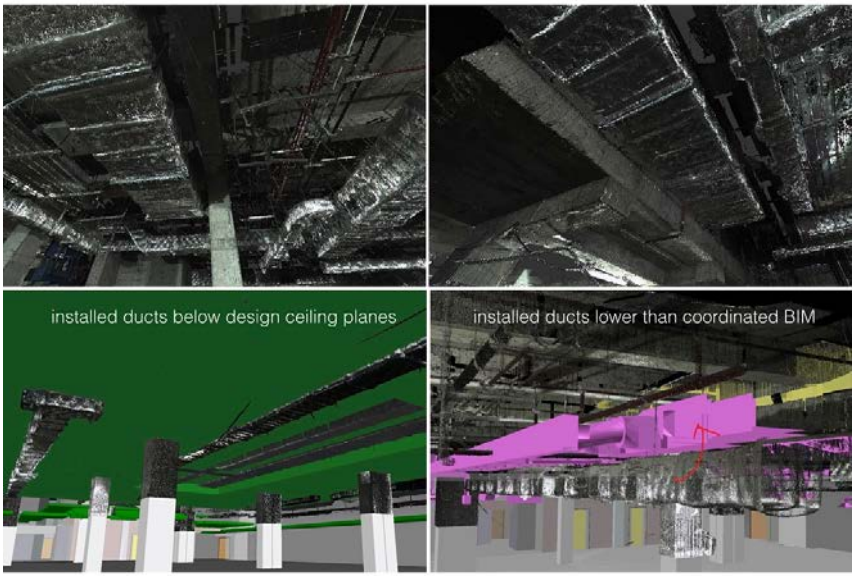

Figure 3 Laser scans of installed ductwork integrated with BIM to review actual vs. planning. Source: (Intelibuild, 2016).

Figure 4 Laser scanned vs. As-built BIM model, Heritage renovation. Source: (Intelibuild, 2016).

3.2.3 Structural Analysis Laser Scanning (As-is Condition)

This density of the scanned point cloud data shown in Figures 6 and 7 allows 3D laser scanners to detect more details of an existing structure depending on an efficient accuracy to allocate structural elements defect and deformation such as cracks and damages.

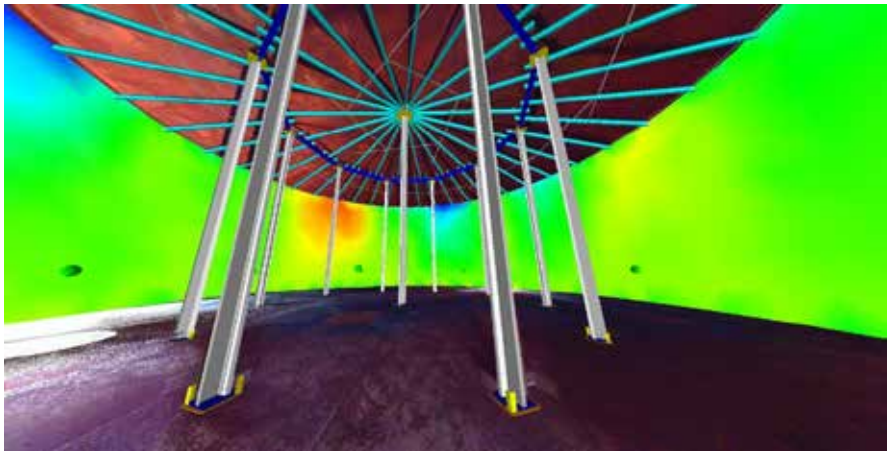

Figure 6 3D model with the layout of the floor, shell, roof, structure, and appurtenances. Source: (TechnoSoft, 2016).

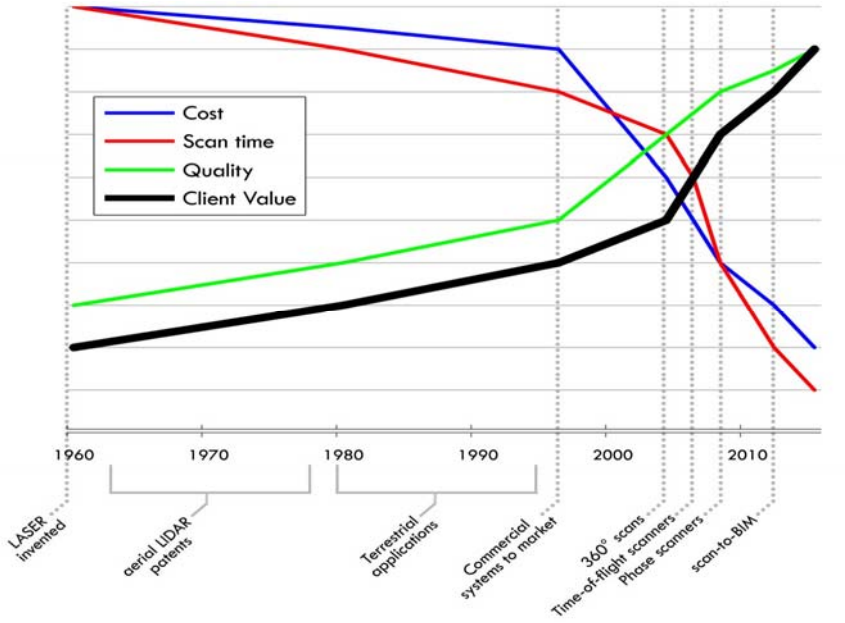

Figure 7 Timeline of 3D scanning development. Source: (Randall, 2013).

The point from detecting distortion by laser scanning techniques is to recognise the amount of the time saved compared to conventional QA/QC checks and site inspection (Kim *et al.*, 2016), which are considered as time-consuming, labour intensive and suffer from shortages in management and systematic registry of the collected data. Therefore, the benefits of Three-Dimensional Laser Scanning could be summarized in the:

- Saved QA/QC Check
- Reduced Time and Effort
- Increased Quality
- Reducing Safety Risks

3.3 Building Information Modeling (BIM)

3.3.1 Integration of BIM

The concept of BIM is not just a 3D modelling application, but it also combines both project activities and applications which significantly affect the project's workflow and delivery processes (Hardin, 2009).

Sackey, Tuuli and Dainty (2014) mentioned that BIM had influenced the way contractors and designers collaborate and work together, as they also defined it as a sociotechnical system, where it includes technical dimension represented in 3D Modeling and social dimension represented in re-engineering process. That an appropriate design and collaborative construction activities empower exchange of data, information creation, resource allocation and technical coordination to work adequately and decrease occasional conflicts, which consume time and effort from the design process and thus classified as intellectual waste.

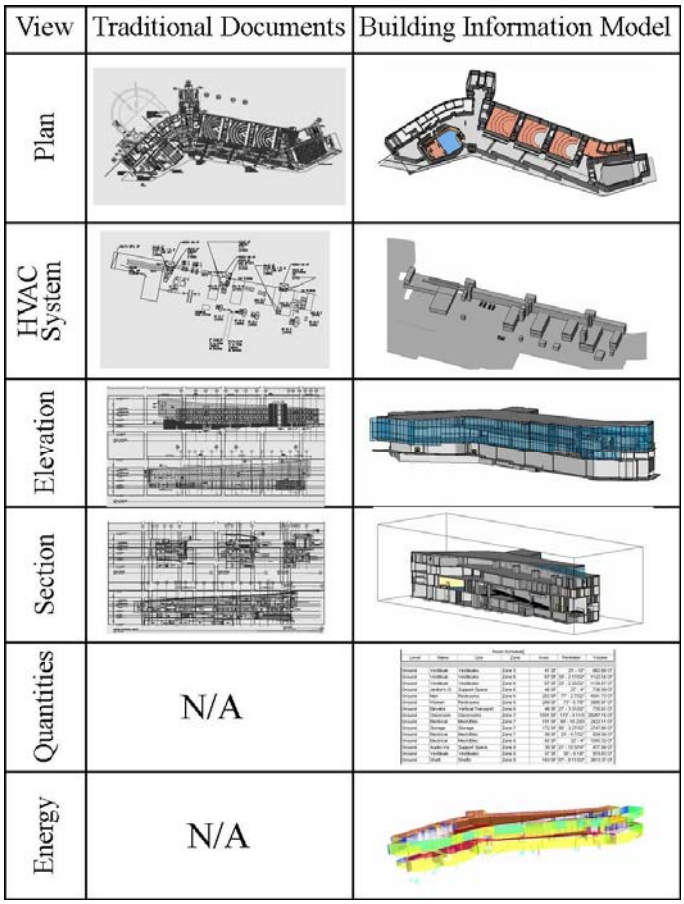

Figure 8 Project documenting comparison between BIM and Traditional Methods. Source (Leicht and Messner, 2007).

3.3.2 The Seven Dimensions of BIM

The following Figure 9 represent the seven dimensions of BIM that enrich BIM's 3D model and make it capable of measuring further aspects of a project during the design phase. These dimensions provide graphical and nongraphical information is a shared digital space between stakeholders, such as time, cost, environment…etc. and will be described in the following as per The B1M (2016), and Impararia (2014) classifications:

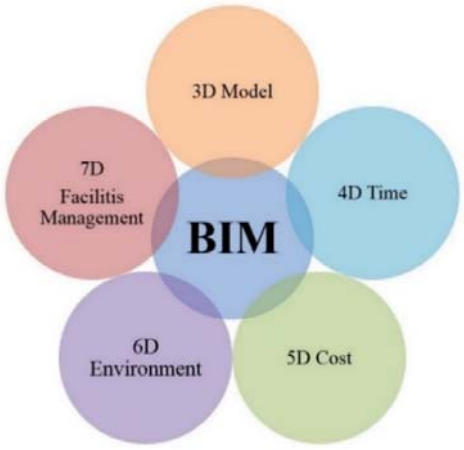

Figure 9 The Seven Dimensions of BIM. Source (Impararia, 2014; TheB1M, 2016).

3.3.3 BIM level of Development (Lod)

LoD is an official language in Construction Industry illustrates the integrity of a digitalized model at a specific point in time. The AIA (American Institute of Architects, 2013) defined it as: "*The Level of Development (LOD) describes the minimum dimensional, spatial, quantitative, qualitative, and other data included in a Model Element to support the Authorized Uses associated with such LOD.*"

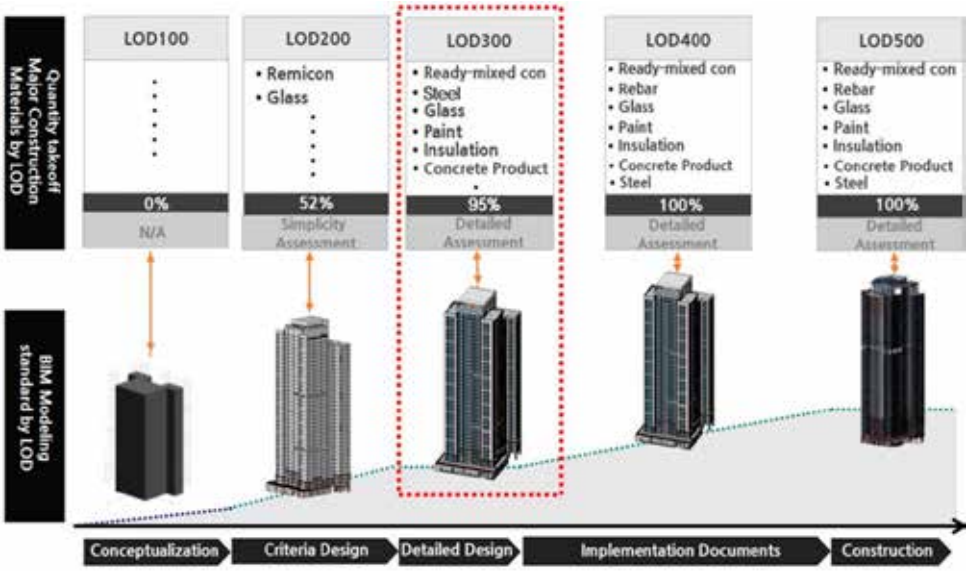

Figure 10 BIM Levels of Development. Source: (Lee et al., 2015).

3.4 BIM Impact through Project Lifecycle

Building Information Modeling (BIM) can create, store, manage, exchange and share building information through interoperability among participants so that this information can be reusable later (Vanlande, Nicolle and Cruz, 2008). This requires to produce digital models and work on their development to be used for simulating various operations during the project lifecycle (Azhar, Hein and Sketo, 2008), such in planning, design and construction.

Table 2 BIM Utilization during Project Design Stage. Source (Azhar, Khalfan and Maqsood, 2012).

Schematic design	Detailed design	Construction Detailing
• Options Analysis (to compare multiple design options) • Photo Montage (to integrate photo realistic images of project with its existing conditions)	• 3D exterior and interior models • Walk-through and fly-through animations • Building performance analyses (e.g. energy modeling) • Structural analysis and design	• 4D phasing and scheduling • Building systems analysis (e.g. clash detections) • Shop or fabrication drawings

Table 3 Use of BIM by Project Stakeholders. Source (Azhar, Khalfan and Maqsood, 2012).

BIM Application	Owners	Designers	Constructors	Facility Managers
Visualization	x	x	x	x
Options analysis	x	x	x	
Sustainability analyses	x	x		
Quantity Survey		x	x	
Cost Estimation	x	x	x	
Site Logistics	x		x	
Phasing and 4D scheduling		x	x	
Constructability analysis		x	x	
Building performance analysis	x	x	x	x
Building management	x			x

Traditionally, the as-built documents are delivered at the end of the project's contract, Huber *et al.* (2011) and Shamki and Al-Hajj (2014) stated that these documents are produced in most cases as as-designed drawings instead of as-built data, which also provide information associated only with 2D drawings. BIM process combines various building properties and systems in one virtual model, as these characteristics are considered as a priority for each of the project partners (Owners, Architects, Suppliers, Engineers, Contractors and Subcontractors), BIM applications contribute to improving collaboration and accuracy compared to traditional methods.

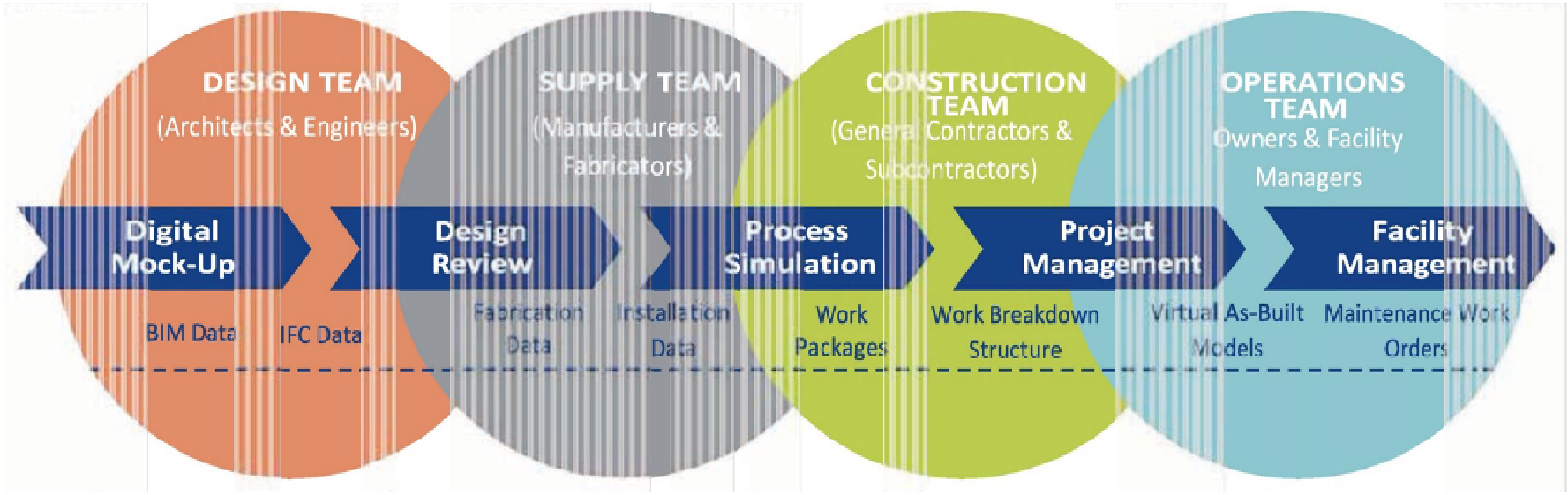

Figure **11** Collaboration of BIM throughout Project Lifecycle (Design, Construction, and Operations). Source (Systèmes, 2014)

3.5 The Need for BIM Cloud-Computing

Despite the benefits provided by BIM implementation, Sarna (2010) recommended upgrading BIM with a more useful technology such as cloud computing. Which provides a faster exchange of data through the cloud thus improve the projects' value and cost (Redmond *et al.*, 2012), and the capability of improving design coordination and for later facility management (Wang and Marquardt, 2013). Further, Tao *et al.* (2011) mentioned four main features of cloud computing stated in the following:

1- It has greater flexibility to access, that users can order the required size of storage or number of servers from the cloud.
2- Economically viable that users will pay only for the number of servers requested. Hence, small businesses can also adapt.
3- Technology's reliability represented in the high availability of cloud services that can overcome faults.
4- Cloud computing applications are easy to utilise (user-friendly) due to the customization which suffices users' demands.

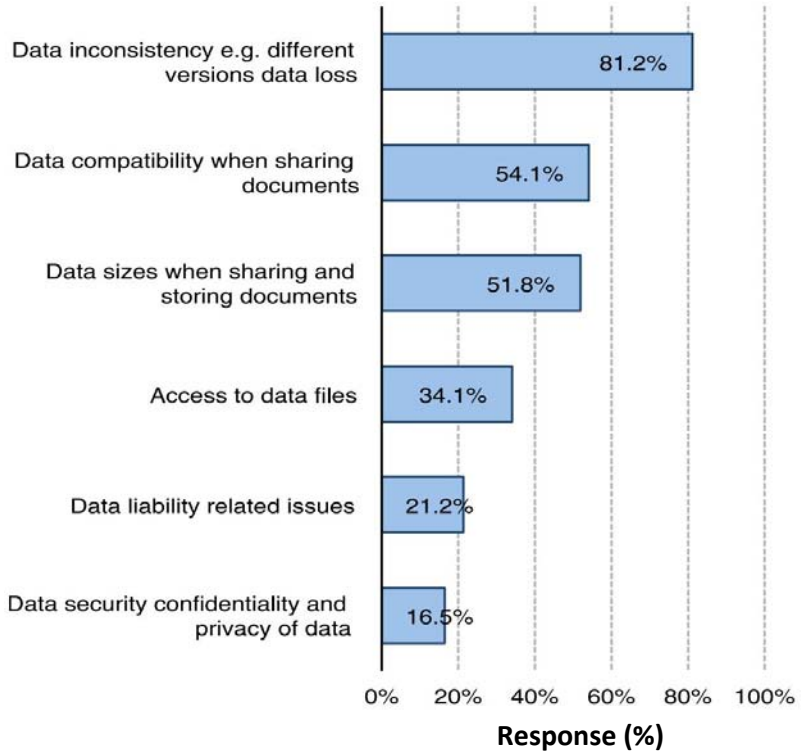

Figure 12 The most common data issues within the construction projects. Source (Alreshidi, Mourshed and Rezgui, 2016).

Furthermore, Xu, Ma and Ding (2014) expressed the increased amount of data flow through the project lifecycle, as complete and detailed lists have been created for all information types required through different stages. Moreover, which require the creation of new groups concerning the classification of BIM information to assist in the management of project information effectively, such information categories are; Design-BIM, Construction-BIM and Operation-BIM represented in Figure 13.

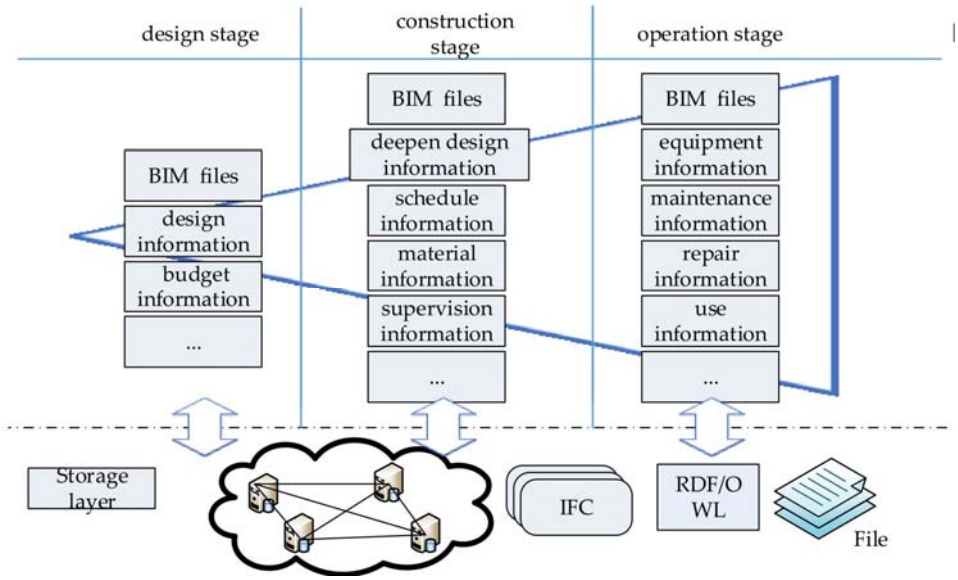

Figure 13 Types of cloud data used through the project lifecycle. Source (Ding and Xu, 2014).

4. Data Collection and Analysis of interviews

4.1 Interviews Results and Analysis

As preparing the analysis, professionals within the UAE construction industry were interviewed, about seven interviews were done based on a semi-structured method which allowed the interviewees to answer in further details, particularly when academic terminologies occurred which needed more clarifications from the questioner's side. Thus, to provide answers based on their knowledge and experience for different theoretical questions. These questions are mentioned and discussed below.

4.1.1 Interviewees' Details

The first eight questions are associated with the interviewees' basic information as illustrated in Table(5.1):

Table 4 Interviewee Basic Information Questions.

1. Interviewee Number
2. Company place of work
3. Current Designation
4. Work Experience in construction industry
5. Work Experience in UAE construction industry
6. Years of experience in dealing with waste management
7. Number of company employees
8. Consultant / Contractor

Figure 14 Q2 response.

Figure 15 Q8 response.

Figure 16 Q3 response.

Figure 17 Q4, Q5 & Q6 response.

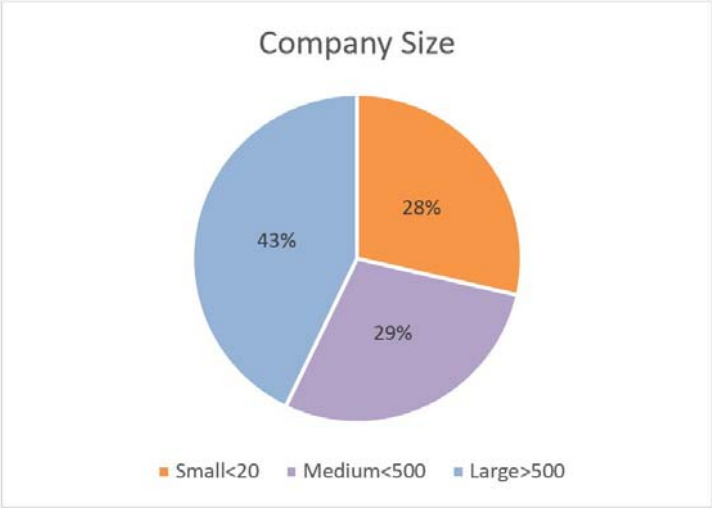

Figure 18 Q7 response.

4.1.2 Time and Intellectual Waste for Consultants and Contractors

Question 1 - What do you know about Time / Intellectual waste?
Response to Q1 - Most of the responders agreed that the concept of "intellectual waste" is related to the mentality of individuals that will affect the time and effort required. Therefore, such waste needs to be planned properly and well managed, especially when it comes to information transfer between participants in the project. Thus, all these aspects will result in reducing deductions of profit made after delivering the project. One of the respondents identified it as the indirect waste of construction projects.

Question 2 - What does intellectual waste mean to you at the briefing stage?
Response to Q2 - This question meant only by consultants as they implement their proposed plan, concept design and gathered client requirements at the briefing stage. Most of the consultants relate data collection process with meeting client's needs, where they consider these demands as the most reliable source if available. Also, they indicated at the difficulty in understanding what the client needs, or at the difficulty in delivering the idea and how the client visualises it. That one of the consultants indicated at the difference between setting the clients' requirements before and after proposing the concept design, as the second process will lead to at least 50% of variations during the design due to the weakness of the client's competence and intervention of other stakeholders who will affect his decision.

Question 3 - What does intellectual waste mean to you during the design stage?
Question 4 - What kind of intellectual waste do you face at construction stage?
Response – Table 4

Table 4 Types of intellectual waste faced by consultants and contractors during different stages of a project

	No.	Intellectual Waste	Consultants					Contractors				
			1	2	3	4	5	1	2	3	4	5
Brief Stage	a	Insufficient data collection		x								
	b	Ineffective information flow			x							
	c	Lack of accuracy in implementing client requirements					x					
	d	Uncertain decision-making by the client				x						
	e	Poor estimations of cost, schedules, efforts…etc										
	f	Unable to determine clients' requirements			x							
	g	Loss of collected information due to physical storage of data				x						
Design Stage	a	Do anything manually if a machine could do it (nearly) as well.				x						x
	b	Unnecessary meetings with participants			x						x	
	c	Lack of clarity on tasks			x						x	
	d	Uncoordinated transfer of information among participants				x						x
	e	Shop Drawing errors and omitted documents (rejected SD) + RFI's				x					x	
	f	Issues in utilized tools for design process (computers, servers…etc.)	x							x		
	g	Inapropriate decision making		x							x	
Construction Stage	a	Inappropriate construction tracking.				x				x		
	b	Lack of Real-time Model navigation.				x						x
	c	Incompetent monitoring to logistics flow										x
	d	Complicated inspections on site		x						x		
	e	Poor scheduling			x						x	
	f	Improper identification of risks			x					x		

4.1.3 Building Information Modeling (BIM)

Question 9 - Do you know anything about (BIM)?
Question 10 - Have you ever utilized (BIM)?
Response -

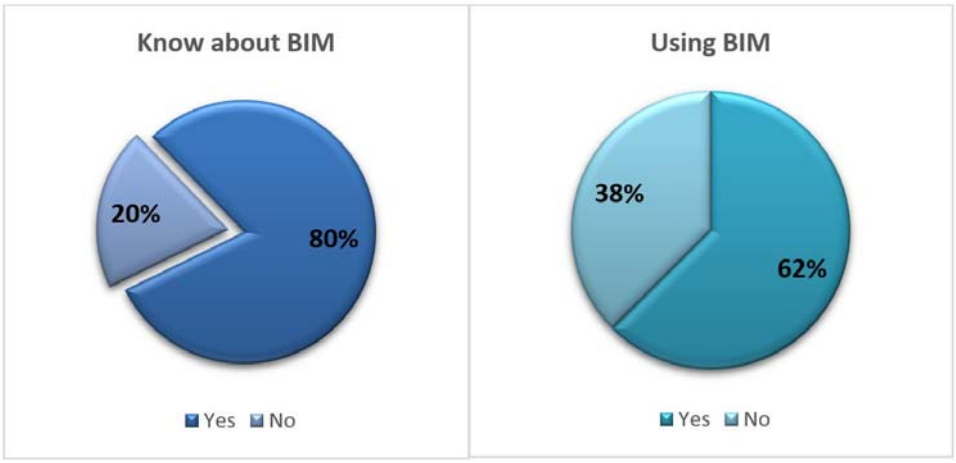

Figure 19 BIM awareness and utilization.

Question 11 - Do you think that BIM adds value to project? If yes, how it is achieved? And at what stage do you feel it adds most value?
Response – In general, all the interviewees agreed that BIM could add value for all stages if it implemented efficiently. That from the beginning of every project, BIM can provide a 3D interactional model, and through 4D and 5D it provides a proper planning for the project could be adopted. One of the interviewees stated that it is necessary to reduce the amount of printed paper especially when it comes to megaprojects. Another interviewee strongly agrees that BIM would add value because its adoption is like doing the right thing from the beginning of any project. This advantage was due to:

- The three-dimensional visualisation of the entire project during design stage,
- Allow participants to recognise how to separate the project, where to start and what requirements to be addressed first, especially in refurbishment projects.
- Also, the identification and allocation of the projects' components can provide and facilitate the overall control on the project during the design stage which will lead to an increased productivity of construction process.

Question 12 & 14 - As a Consultant / Contractor, how would you compare the effects of traditional methods and BIM implementation on the followings: (Figure 20)

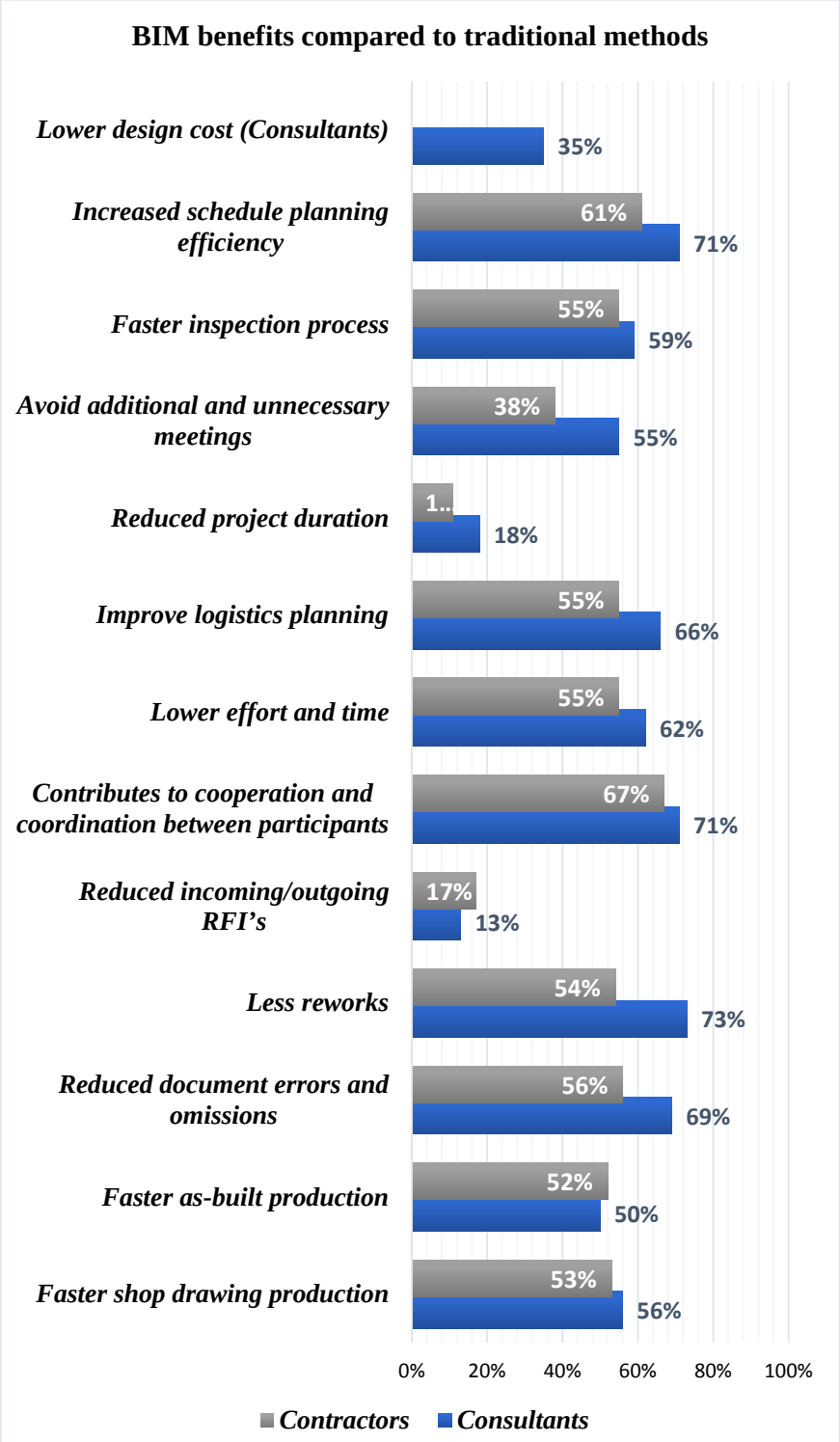

Figure 20 Response to Questions 12 and 14.

4.1.4 Cloud BIM Applications (Consultants and Contractors)

Question 13.1. & 13.1a. Do you know what is Cloud BIM Application?
Response to Questions 13.1 and 13.1a

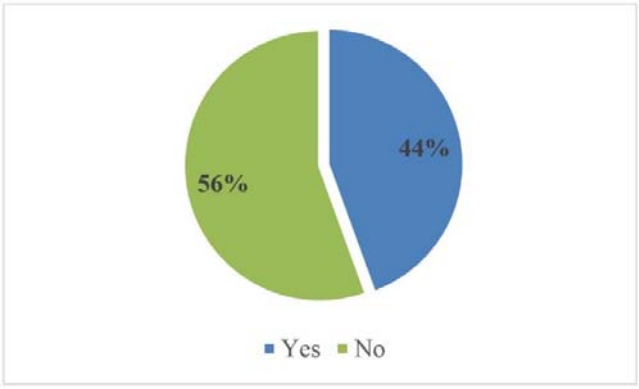

Figure 21 Response to Q13.1 and Q13.1a.

Question 13.2. & 13.2a. If yes, how would you evaluate such technology in terms of:
Response to Question 13.2 and 13.2a:

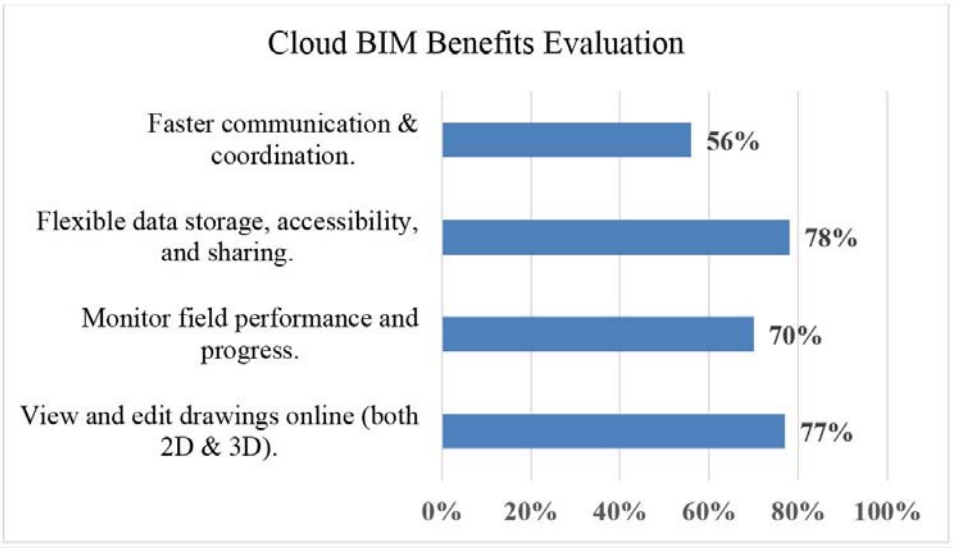

Figure 22 Response to Q13.2 and 13.2a.

4.1.5 Laser Scanning (Contractors)

Question 15.2 - What is the effect on Logistics monitoring? Such as in laser barcoding?
Response – regarding laser barcoding, it is different from 3D laser scanning, which is a series of barcodes linked to structure's components, utilised equipment, documents or locations. Moreover, it helps to differentiate between the installed elements on-site, under production, on delivery or at storage, also, allows the project participant to track different site issues and variations. Recently, new mobile apps were provided which can scan the QR codes instead of using the laser scanner which could be expensive. This type of technology is fully integrated with BIM models and contributes to implementing the planned schedule of the project.

Question 15.3 - In your opinion, what are the other unnecessary processes that could be eliminated through 3D Laser Scanning and BIM?
Response – The most important issues that could be reduced are the humongous amount of printed paper and the elimination of uncertainty of the project tasks. One of the consultants stated: "*In the context of unnecessary processes, in my opinion, I do not think it is a process related as much as it is a communication enhancement during the project lifecycle*".
Many processes could be eliminated through adopting BIM and 3D Laser Scanning during project life cycle such as the off-site activities which contribute to delaying the works on-site, in specific, the case of raising RFIs or any technical issues during construction (see Figure 23).

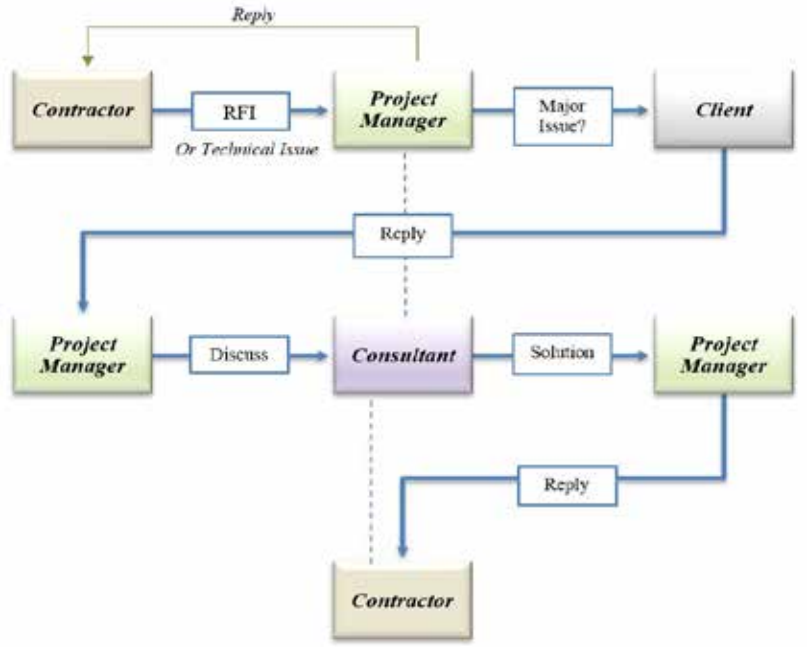

Figure 23 Current data flow between the primary stakeholders in a project.

Question 15.4 - Would you agree that 3D Laser Scanning for as-built carries the following uses? Time, Quality, Cost, Effort, Safety?

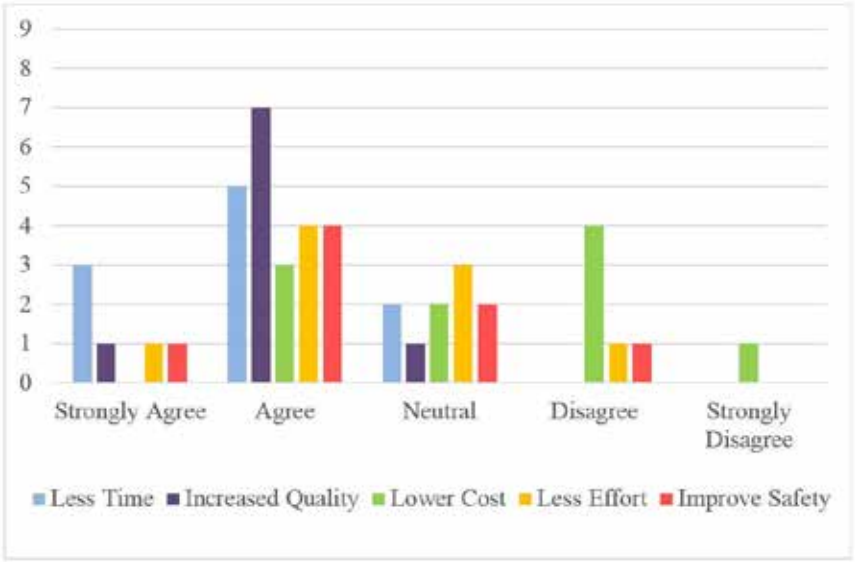

Figure 24 Laser Scanning for As-Built Production.

6. Conclusions and Recommendation

The literature review findings showed that the construction industry is still in the process of development which represented in the provided optimisation efforts to reduce waste as much as possible. The reduction of wastage is not only associated with materials but also with the efficient planning and the required procedures to manage this waste later during the construction phase. This comes because of what the industry suffered from the problems and risks arising from repeated errors and contradictions. The early detection of design errors through BIM utilisation contributes to avoiding reworks during the construction phase and helps to simulate the construction processes before they are implemented through a three-dimensional model, and automatically link them to the project's timetable during the design phase through 4D, 5D…etc. models, which can save more time compared to traditional planning. There are some conditional and necessary actions during the construction stage, which consumes much time and cannot be reduced or disposed of by following the existing procedures. Moreover, it must be drawn to these actions always cause antibiosis between time management and waste management, which imposes a preference for one over the other.

Consultants agreed that BIM has reduced both time and effort required for design stage and assisted in meeting the client's requirements through an interactional 3D model which also facilitated a quick response for RFIs. Contractors stated an advantage of receiving proper estimations and schedule planning from consultants and a disadvantage of having a lower 3D model than the required LoD 300. In the end, BIM implementation in the UAE needs to be more prevalent that individuals should develop their skills to adapt the new management processes provided through BIM.

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Use of LDPE and Steel Slag in Hot Mix Asphalt Concrete, as Sustainable Construction Material

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Abstract

This paper focus on investigating and evaluating mixes of LDPE modified bitumen and steel slag aggregate HMA. Bitumen from Bapco (The Bahrain Petroleum Company) B60/70 is modified by adding different percentages waste LDPE. Processed plastic bags (one form of LDPE) were used as additive to heated bitumen (160 to 170 °C) in different proportions (1%, 3%, 5%, 7%, 9%, 11%, 13% and 15 %) of weight. Three tests were used: softening point test, penetration test, and elastic recovery test according to the BS EN 12591. The most successful modified bitumen mixes were 1%, 3%, and 5%. These were used to produce different HMA samples, which were tested by Marshal Tests. The modified bitumen was added in different contents (3%, 3.5%, 4%, 4.5%, and 5%) of weight of the slag aggregate to the mix. The mixes were tested by marshal test. The results of the modified bitumen show that the increase of the percentage of the LDPE increases its softening point and decreases its penetration values. Further the elastic recovery decreased slowly with the increase of the ratio of the LDPE, but it dropped rapidly when it exceeded 9%. It was noticed that the greater the percentage of LDPE in the binder the greater is its stability. But modified bitumen binder, with LDPE content higher than 3%, are difficult to mix. Finally it was observed that mixes with 1% LDPE modified bitumen at 4.5% binder content in the mix satisfy all requirement.

Keywords: Hot Mix Asphalt (HMA), steel slag aggregate, Low Density Polyethylene (LDPE), GCC, Bahrain, modified bitumen mixes.

1. Introduction

Different reasons motivate for this work. From one side, it is a contribution to solve Bahrain`s shortage of aggregate. Bahrain depends on its aggregate supply on imported material, mainly from UAE, because the native available aggregate in Bahrain is not suitable for construction purposes.

A second motivation is the challenge of safe solid waste management in Bahrain. This challenge is very serious because of the small area of the Kingdom. Waste dump sites in Bahrain are soon reaching their end capacity. Using steel slag waste material as aggregate and waste Light Density Polyethylene (LDPE) material for modification asphalt mixes will contribute to reduce the amount of waste material dumped in the landfills.

A third reason is that the hot mixes of asphalt concrete used in Bahrain and the GCC region, under their extreme weather conditions need to be improved. Asphalt is the most used material in construction of road pavements in Bahrain and the GCC. It is a mixture of aggregate and bitumen, in which bitumen used to bind aggregates. International researches and experiences have shown that modifying bitumen by LDPE improves hot mix asphalt properties and its resistance. Other researches have demonstrate that steel slag can replace aggregate in Hot mix Asphalt (HMA).

"Binder properties are very much related to temperatures. They can behave like a viscous fluid, a viscoelastic solid, or a viscoplastic solid. Depending on the temperature range, the parameters to represent these properties are significantly different." (Linbing Wang, 2011). In the Arabian Gulf Countries such as Bahrain the temperatures are high, which create problems to HMA. "Conventional methods of asphalt refining have their limitations which prompted the introduction of modified binders. In 2005 it is estimated that 20 to 25 percent of the asphalts used in the United States are modified asphalts", (Y. Richard Kim et al., 2009).

According to numerous publications, waste polymer modified bitumen improves the mechanical properties of the mix as compared to conventional mix design (Pei-Hung Yeh et al., 2010). A variety of plastic wastes contain polyethylene can provide improvement of pavement

thermal and mechanical behavior, and increases its Marshall Stability and lower its Flow. Polyethylene has excellent chemical resistance and is not attacked by acids, bases, or salts (it is, however, attacked by strong oxidizing agents). LDPE carry bags waste in asphalt hot mixture improve the stability, flow and voids more than conventional asphalt mixture, (Einas Ibrahim Ali Musa1 et al, 2014). Utilization of low density polyethylene waste in asphalt hot mixture would be beneficial in order to find an alternative solution to reduce environmental pollution.

So, in recent years many investigations have been conducted on asphalt mixtures containing waste materials as additives (Huang, 2007).

"The angular shape, hardness and roughly textured surface give steel slag the characteristics to substitute coarse aggregates in asphalt to deliver the mix stability (resistance to rutting) and skid-resistance"(Huang, 2007). Steel slag also exhibits less susceptibility to abrasion due to its high particle density, allowing it to provide a better skid resistance than natural aggregate. (Wen Haifang et al, 2014)

Slag is a sustainable product that can be recycled and reused multiple times in various construction projects. Using iron and steel furnace slag helps preserve natural resources and reduce greenhouse gases. Environmental tests, studies, and reviews by governmental agencies, the iron and steel industry, and slag processors confirm that iron and steel slag is a safe and valuable resource. In addition to that there are many benefits of using the slag aggregate in the asphalt mixes such as:

- High skid resistance.
- Better durability.
- Superior resistance to rutting.
- Lower whole life costs.
- Sustainable product.
- Reduced carbon emissions.

Slag made during the manufacturing process of crude steel by the electric arc furnace (EAF) process can be an alternative to solve Bahrain`s shortage of aggregate. The origin of the slag in Bahrain is the Steel Factory in Al Hidd area, which was used in this work.

2. Objectives of the Study

Various literature indicate that using polymer modified bitumen in asphalt mixes can bring real benefits to pavement construction and maintenance. It can help to construct long lasting road pavements. Therefore resources can be saved and costs of maintenance and construction can be reduced.

Further, huge amount of LDPE is available as waste. The use of waste LDPE in pavements, contributes to reduce the impact of LDPE waste. In this research waste LDPE as available processible polymer will be used as bitumen modifier. Crushed steel slag has been utilized to replace stone aggregate in the mix. There is many benefits for using steel slag aggregate in the HMA, they result from the properties of the slag aggregate itself. Slag aggregates are highly angular in shape and have rough surface texture. They have high bulk specific gravity and they are moderate in water absorption (less than 3 percent).

Typical physical properties of steel making slag are as follows:

- Specific gravity > 3.2
- Bulk density 1.6 – 1.9 tons per cubic meter
- Water absorption < 3 %

Further processed steel slag has favorable mechanical properties for aggregate use in pavements, including good abrasion resistance, good soundness characteristics, and high bearing strength. Some typical mechanical properties of steel making slag are as follows:

- Los Angeles abrasion (ASTM C131) – 20 %to 25 %
- Sodium sulfate soundness loss (ASTM C88) < 12 %
- Angle of Internal Friction – 40º to 50º
- Hardness 6 to 7 Moh's scale of mineral hardness

In this study the focus is on:

1. Utilization of waste LDPE to modify the bitumen used for road pavement and investigate the bitumen properties.
2. Investigation of asphalt mixes with modified bitumen as binder and steel slag as aggregate.
3. Therefor experiments and tests were performed to investigate:

4. The suitability of slag as aggregate for road pavements in Bahrain,
5. If the mixes meet the standards of the Ministry of Works in Bahrain, and
6. The improvements developed by modifying the asphalt bitumen by adding different percentage of waste LDPE.

3. Methodology

3.1 Modified bitumen

Only bitumen from Bapco (The Bahrain Petroleum Company) B60/70 is used in paving asphalt roads in Bahrain. In the present work, this bitumen is modified by adding different percentages of waste LDPE. Processed plastic bags (one form of LDPE) were used as an additive with heated bitumen (160 to 170 °C) in different proportions (1%, 3%, 5%, 7%, 9%, 11%, 13% and 15 % of weight).

The procedure of modifying the bitumen with the plastic bags was:

1. The plastic bags were cut into small pieces to make it easier to mix with the heated bitumen.
2. The bitumen was heated to reach a temperature of 160 to 170°C, this range of temperature was maintained during the time of mixing.
3. The LDPE was added to the heated bitumen in proper portions to prevent the plastic to conglomerate.
4. Mixing the bitumen with LDPE by using mixing machine for 2-4 hours.
5. The temperature was being checked continuously to keep it stable at the range required.

It was observed that with increasing the percentage of the LDPE in the mix, the mix needs longer time of mixing to be homogenous; especially in cases of high percentage of LDPE such as the 13% and 15% needed more than 6 hours of mixing to get homogenous.

The modified bitumen was tested for:

1. Elastic recovery test according to BS EN 12591,
2. The softening point test (ring and ball) according to BS EN 12591, and
3. The penetration test according to BS ES 12591.

To investigate the performance of different mixes of HMA the marshal test was performed. HMA mixes, using slag aggregate with (1%, 3%, and 5%) modified bitumen, have been tested. The percentages of modified bitumen in the mix have been tested, are: 3%, 3.5%, 4%, 4.5%, and 5%.

3.2 HMA Using Slag Aggregate

Marshal Tests according to the ASTM D1188 were performed on the HMA-samples of LDPE modified bitumen (1, 3, and 5 %) using slag aggregate. Higher LDPE percentages was not considered because the mix became very stiff and difficult to mix. The modified bitumen of 1% and 3% were used to produce HMA of 3%, 3.5%, 4%, 4.5% and 5% total bitumen content. But the 5% modified bitumen was used to produce HMA only of 3.5%, 4%, 4.5% and 5% bitumen content (here the 3% bitumen content has not been done, because its workability is very low and mixing with the aggregate was very difficult).

All HMA samples were tested according to the Marshal Test, to obtain their stability, flow, density, air voids, voids filled with bitumen (VMA) and specific gravity.

Sieve analysis was done to determine the distribution of the aggregate particles according to the Marshal Test standard. The particle size distribution, or gradation, of the constituent aggregate is one of the most influential characteristics in determining how an HMA mixture will perform as pavement material. Aggregate gradation influences almost every important HMA property including stiffness, stability, and durability, workability, fatigue resistant, skid resistant and resistant to moisture damage.

4. The Results

4.1 Softening point

The values of the softening points observed are shown in figure 1 below. It is clear that the increase of LDPE percentage in the bitumen increases the softening point.

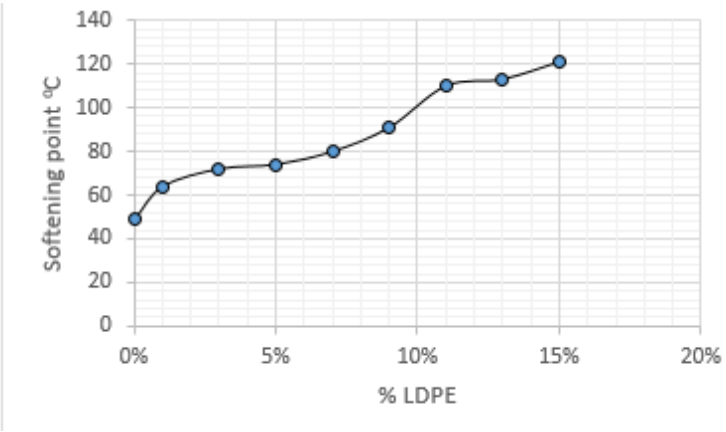

Figure **1** Softening point results.

4.2 Penetration test results

Fig. 4.2 shows the results of the penetration in (mm) of the modified bitumen with different percentages of LDPE. The results show that the increase of LDPE percentage in the bitumen, decreases the penetration.

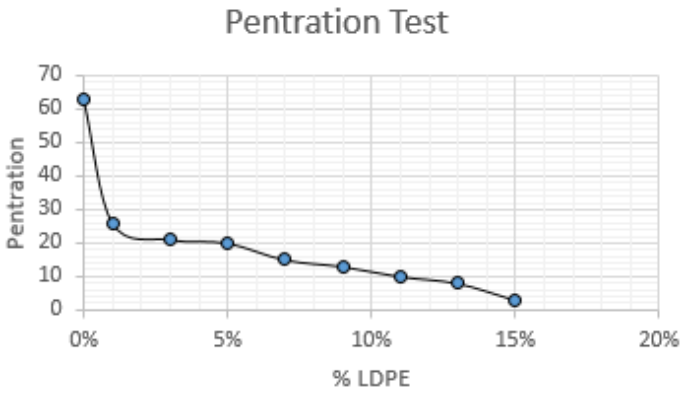

Figure 2 Penetration test results.

4.3 The Elastic recovery test results

Fig. 4.3 shows the results of the elastic recovery test. The red line show the minimum value of the elastic recovery according to the requirement in Germany (no requirement in is available). Fig.4.3 shows that the elastic recovery slightly decreases with the increase of the LDPE content, but it drops rapidly with LDPE content exceeding 9%.

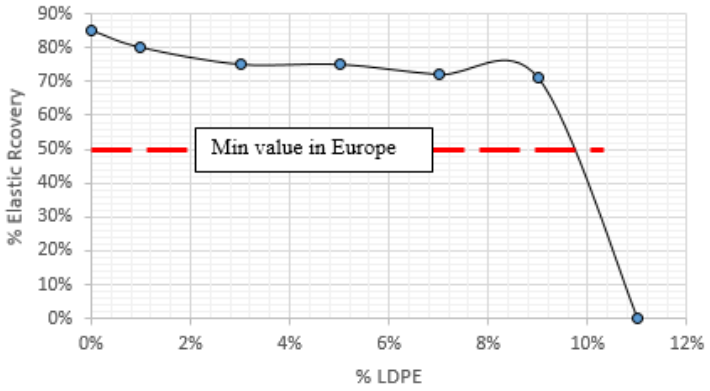

Figure 3 Elastic recovery test results.

4.4 Marshal test

4.4.1. The results of mixes with unmodified bitumen.

In Table 1 and Table 2, the results of the Marshal Test of the mixes with unmodified mixes with Gabbro and with steel slag aggregate are shown.

Table 1 shows the results of marshal test with unmodified bitumen of different content in the mix using Gabbro aggregate.

MIX	DENSITY (MT/m³)	STB (KN)	FLOW (mm)	AIR VOIDS %	VMA %	VFB %
3 %	2.517	12.8	2.7	8.5	15.1	43.8
3.5 %	2.533	12.3	2.5	7	15	53.4
4 %	2.579	14.5	2.7	4.6	13.9	66.7
4.5 %	2.597	13.9	3.3	2.8	13.7	79.8
5 %	2.592	12.6	3.6	2.2	14.4	84.5

Table 2 shows the results of the marshal test with unmodified bitumen of different content in the mix, using steel slag as aggregate.

MIX	DENSITY (MT/m³)	STB (KN)	FLOW (mm)	AIR VOIDS %	VMA %	VFB %
3 %	2.74	16	2.6	9.3	16	41.6
3.5 %	2.77	17.5	2.7	7.6	15.4	50.8
4 %	2.8	17.2	3.1	5.4	15	63.7
4.5 %	2.82	17	3.5	3.8	14.7	74.5
5 %	2.81	16	3.9	3.3	15.4	78.5

4.4.2 Marshal test results of asphalt mix with slag aggregate and LDPE modified bitumen

Marshal test results 1% LDPE modified bitumen:

Table 3 shows the results of the marshal test has been done on asphalt mix using slag aggregate and 1% LDPE modified bitumen.

Table 3 shows the results of the marshal test with 1% LDPE modified bitumen of different content in the mix, using steel slag as aggregate.

MIX	DENSTY (MT/m^3)	STB (kN)	FLOW (mm)	AIR VOIDS %	VMA %	VFB %
3 %	2.787	17.1	3.3	11.2	17.8	37.3
3.5 %	2.815	19	4	9.5	17.4	45.8
4 %	2.847	20.2	2.9	6.7	16.9	60.7
4.5 %	2.882	21.4	2.5	4.8	16.3	70.5
5 %	2.901	21.5	3.2	3.1	16.2	80.7

Marshal test results 3% LDPE modified bitumen

Table 4 shows the results of the marshal test has been done on asphalt mix using slag aggregate and 3% LDPE modified bitumen.

Table 4 Marshal Test results in using 3% LDPE modified bitumen with slag aggregate.

MIX	DENSITY (MT/m^3)	STB kN	FLOW (mm)	AIR VOIDS %	VMA %	VFB %
3 %	2.747	16.4	3.2	12.5	19	34.3
3.5 %	2.792	19.7	4	10.2	18.1	43.7
4 %	2.811	18.7	3.1	8.3	18	54.1
4.5 %	2.822	18.8	3.1	7	18.1	61.2
5 %	2.871	18.7	3.6	4.66	17.1	73.4

Marshal test results 5% LDPE modified bitumen:

Table 5 shows the results of the Marshal Test has been done on asphalt mix using slag aggregate and 5% LDPE modified bitumen. As mentioned the mix of 3% modified binder is neglected, because its stiffness and workability are very high.

Table 5 Marshal Test results in using 5% LDPE modified bitumen with slag aggregate.

MIX	DENSITY (MT/m³)	STB kN	FLOW (mm)	AIR VOIDS %	VMA %	VFB %
3%	-	-	-	-	-	-
3.5%	2.785	24.5	3.1	8.7	18.3	52.2
4%	2.801	24.5	2.8	7.9	18.3	56.8
4.5%	2.82	23.2	3.3	5.4	18.1	70.4
5%	2.858	24.6	2.7	3.7	17.5	78.6

4.5 Comparison between the results

Figures 4 to 9 display all the results and includes the minimum and maximum requirements. Further they show that the 1% LDPE modified bitumen in the mix with 4.5% modified bitumen satisfies all the requirements of the Ministry of work in Bahrain.

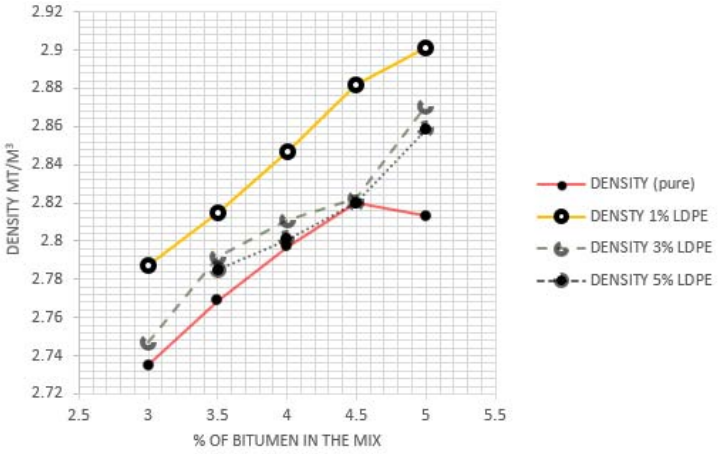

Figure 4 Density vs bitumen content in the mixes.

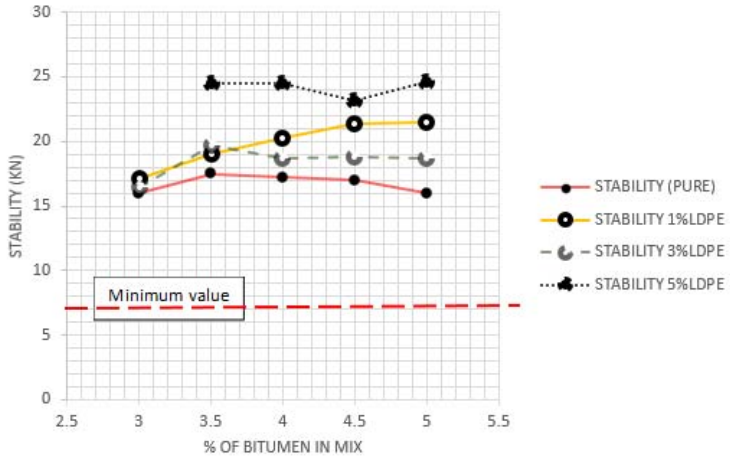

Figure 5 Stability vs bitumen content in the mixes.

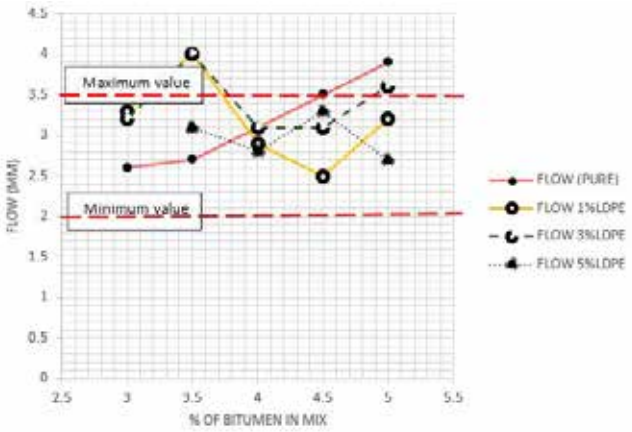

Figure 6 Flow vs bitumen content in the mixes.

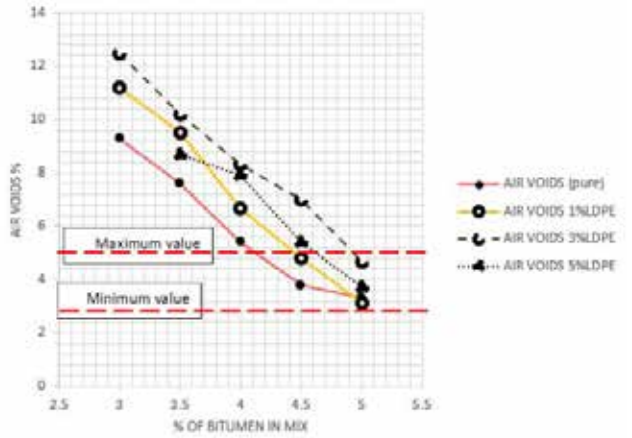

Figure 7 Air voids vs bitumen content in the mixes.

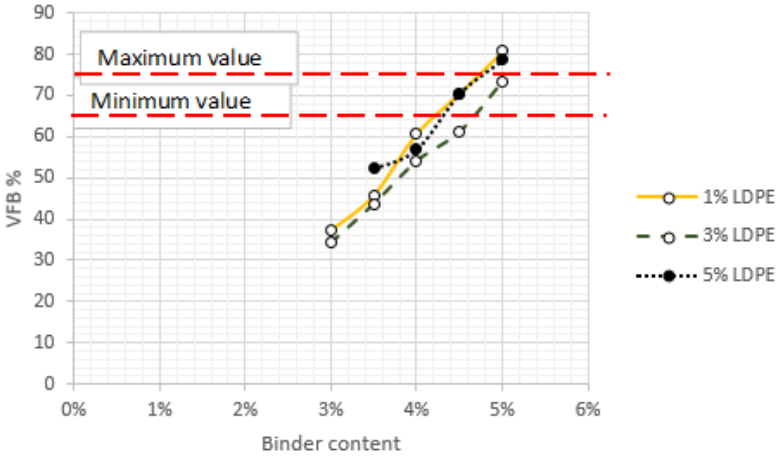

Figure 8 VFB vs bitumen content in the mixes.

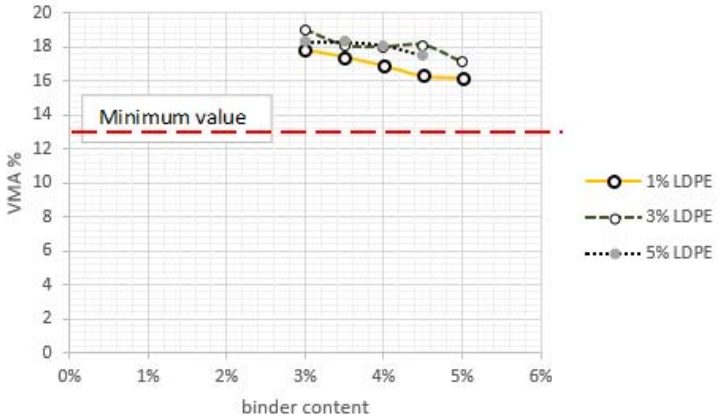

Figure 9 VMA vs bitumen content in the mixes.

5. Conclusions

This study has indicated that waste LDPE improves the properties of the bitumen. The softening point and penetration increased. The elastic recovery slightly decreased with the increase of the LDPE content, and drops rapidly with LDPE content exceeding 9%.

The waste LDPE used in this study was to modify the bituminous binder, subsequently used to improve the behavior of asphalt concrete. Compared to the conventional hot mix asphalt (HMA) the marshal stability increased. Also the addition of waste LDPE decreased the flow of the conventional hot mix asphalt. Further the HMA with 1% waste LDPE modified bitumen that has content 4.5% of binder satisfies all the requirements.

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Public Private Partnership and Sustainable Development in Bahrain

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Abstract

Public Private Partnership was recognized as a very important mechanism for achieving the Sustainable Development Goals (SDGs), and has even become one of its vital Goals, clearly stated in Goal 17: "strengthening the means of implementation and revitalizing the global partnership for Sustainable Development"

A successful sustainable development agenda requires partnerships between governments, the private sector, and civil society, at global, regional, national, and local levels. Public Private Partnership is a successful way to promote the dynamics of Sustainable Development and ensure transparent competition; but it should not be designed to evade national laws and public interest constraints. The problematic of this research is to examine the extent to which Bahrain needs an independent legislation for Public Private Partnership.

The aim of this research is to achieve a successful experience of Public Private Partnership in Bahrain, as a mechanism for meeting its Sustainable Development Agenda 2030. By using the analytical methodology, the concept of Public Private Partnership will be discussed and the differences it implies from the current forms of collaboration between public and private sectors will be specified using the Legislative Decree no.36 of 2002, with respect to Regulating Government Tenders and Purchases. Secondly, the practical advantages and disadvantages of Public Private Partnership will be explored. Finally, the actual need of an independent legislation of Public Private Partnership in Bahrain will be analysed. The findings will be useful for Bahrain's Public Private Partnership, to be coherent with its political, legal, cultural and social environment.

Keywords: Public Private Partnership, Sustainable Development, Administrative Contract, Sovereign Immunity.

1. Introduction

In 2015, United Nations countries adopted the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals and 169 targets. The new Agenda is people-centered, universal, transformative and integrated. It calls for action by all countries for all peoples over the next 15 years in five areas of critical importance: people, planet, prosperity, peace and partnership (United Nations Sustainable Development 2015a).

The Kingdom of Bahrain has taken several steps to adopt the 2030 Sustainable Development Goals (SDGs) after building on its experience and expertise in achieving the Millennium Development Goals ahead of its schedule in 2015 (Kingdom of Bahrain - eGovernment Portal 2017 a).

A successful sustainable development agenda requires partnerships between governments, private sectors and civil societies. These inclusive partnerships, which are built upon principles and values, and shared vision and goals that place people and the planet at the centre, are needed at the global, regional, national and local level. That is why the kingdom of Bahrain has nominated Ministry of Foreign Affairs, Ministry of Finance, Telecommunications Regulatory Authority, Information and eGovernment Authority, and Ministry of Industry, Commerce & Tourism as responsible entities to achieve this goal and monitor its Achievement Levels (Kingdom of Bahrain - eGovernment Portal 2017 b).

The United Nations has defined "strengthening the means of implementation and revitalizing the global partnership for sustainable development" as one of the Sustainable Development Goals (Goal 17) because Public Private Partnership (PPP) is an effective mechanism for achieving the SDGs; actually, it is the best instrument for providing social inclusive development which is one of the key elements of sustainable growth. PPP leads to promote effective public,

public-private and civil society partnerships building on the experience and resourcing strategies of partnerships that mobilize and share knowledge, expertise, technology and financial resources to support the achievement of the sustainable development goals in all countries, particularly the developing countries (United Nations Sustainable Development 2015 b). Public Private Partnership particularity is based upon the principle of risk allocation which distinguish PPP from other traditional forms of collaboration between public and private partners.

2. Research Problem

The problem of this research is to examine the extent to which Bahrain needs an independent legislation for Public Private Partnership.

3. Research Objective

This paper will focus on Public Private Partnership and Sustainable Development in Bahrain. Its problematic is to examine the extent to which Bahrain's need an independent legislation for Public Private Partnership. The aim of this examination is to achieve a successful experience of Public Private Partnership in Bahrain, as a mechanism for meeting its Sustainable Development Agenda 2030.

4. Research Methodology

By using the analytical methodology, the first part of this paper provides a general overview of PPP concept and outlines its definition and forms. The second part summarizes and analyzes the differences between PPP and the other forms of collaboration between public and private sectors according to Bahraini Legislative Decree no.36 of 2002. The third part explores the practical advantages and disadvantages of PPP. The fourth part analyses the actual need of an independent legislation of Public Private Partnership in Bahrain.

5. The Concept of Public Private Partnership

Recent years have witnessed a remarkable increase in cooperation between public and private sectors for the development and operation of environmental and various forms of infrastructure under the designation "Public Private Partnership" which describes a wide variety of arrangements between public and private sectors (Cuthbert & Choudhary 2016) as an alternative and effective method to mobilize additional financial resources and benefits from private sector efficiencies to cover the financial shortages in the public sector (European Commission Directorate-General Regional Policy 2003).

Therefore, it is necessary to find a definition for PPP and put our hands on its types in order to analyze its role in achieving the sustainable development in Bahrain as fowling:

5.1 Definition of Public Private Partnership

Public Private Partnership is a complex concept but it can be simply defined as a long-term global arrangement between public and private sectors based on the principle of risk allocation, to satisfy the public utilities mission.

The principle of risk allocation between public and private sectors is indeed a decisive factor in the success of PPP (Breton & Copé 2004). In this context, the principle of risk allocation is an attempt to guarantee the maximum possible degree of project security by specifying and allocating all project risks, whether foreseen or not anticipated by the risk matrix.

Therefore, principle of risk allocation should be based on a clear determination of the potential risk; the following are some of the key risks which must be managed in PPP:

Construction Risks - potential risks related to construction may include:

- Exceeding the construction period and/or budget.
- Mismatch between the design assumptions and construction practice.
- Abandonment of the project.

Exploitation Risks - Potential risks related to exploitation may include:

- Market Risks - are related to market demand or volume risk, and the cost increase of raw materials.
- Financial risks - are related to fluctuations in exchange rates, interest rate changes, and Cost overrun.

Legal risks - are related to change in the law, increase in taxes, and unilateral modification or termination of the contract.

Political risks - are related to war, revolution, terrorism, labor strikes, and extortion.

Force majeure risk - related to events beyond the control of both parties and which prevents either party from performing its obligations.

The principle of risk allocation is depending on risk matrix for transferring Risks between public and private parties to create a balanced risk sharing. Risk matrix is a table which lists the risks of the project for distributing them between public and private partners. Inside this matrix, there is an exclusive domain of the public partner, such as: risk of soil and risk of unilateral modification or termination of the contract; additionally, there is a shared domain between public and private partners, such as: force majeure risk (Cuthbert & Choudhary 2016).

5.2 Types of Public Private Partnership

There is no standard model of a Public Private Partnership project. Therefore, it can essentially take whatever form that parties desire. Consequently, many forms of PPP exist and are continuously developing to suit project characteristics. However, PPP take a wide range of varying forms include the following (European Commission Directorate-General Regional Policy 2003):

According to the Green Paper, PPP has two distinct forms:

- PPP of a purely contractual nature in which the partnership between the public and the private sector is based solely on contractual links; and
- PPP of an institutional nature, involving cooperation between the public and the private sector within a distinct entity (Commission of the European Communities 2004).

According to the World Bank, Types of Public Private Partnership are classified into (figure1):

Management and Lease Contracts - a private partner takes over the management of a state-owned enterprise for a fixed period. There are two subclasses of management and affermage or lease contracts:

- Management contract: the government pays a private operator to manage the project.
- Affermage or lease contract: the government leases a public facility or land to a private operator for a fee.

Concessions - a private partner takes over the full delivery of services in a specified area, including operation, maintenance, collection, management, and construction and rehabilitation of the system. The public sector owns the project; so, it is responsible for establishing performance standards and ensuring that the concessionaire meets them. The concessions can be classified into the following categories:

- Rehabilitate, Operate, Transfer. (ROT)
- Rehabilitate, Lease or rent, Transfer. (RLT)
- Build, Rehabilitate, Operate, Transfer. (BROT)

Greenfield Projects - a private entity or a public-private joint venture builds and operates a new project for the period specified in the contract. The project may return to the public sector at the end of the concession period. The greenfield projects can be classified into the following categories:

- Build, Lease, Transfer. (BLT)
- Build, Operate, Transfer. (BOT)
- Build, Own, Operate. (BOO)
- Design, Build, Finance, Operate. (DBFO)
- Merchant: A private partner builds a new project in a liberalized market in which the government provides no revenue guarantees. The private developer assumes construction, operating, and market risk for the project.

- Rental: Electricity utilities or governments rent mobile power plants from private sponsors for periods ranging from 1 year to 15 years. A private sponsor places a new facility at its own risk, owns and operates the facility at its own risk during the contract period. The government usually provides revenue guarantees through short-term purchase agreements, such as power purchase agreement for bulk supply facilities.

Joint Ventures: this type of partnership involves cooperation between the public and private sectors, sharing the assets, finances and expertise of their projects. The joint ventures may include contractual arrangements and institutional forms, such as the company with one or more public and private sector partners.

Divestitures: a private entity buys an equity stake in a state-owned enterprise through an asset sale, public offering, or mass privatization program. Divestitures divided into full, or partial divestitures (World Bank Group Public Private Partnership in Infrastructure Resource Center 2016a; Cuthbert & Choudhary 2016; Izaguirre, Hahn, Khuu & Nellis 2003).

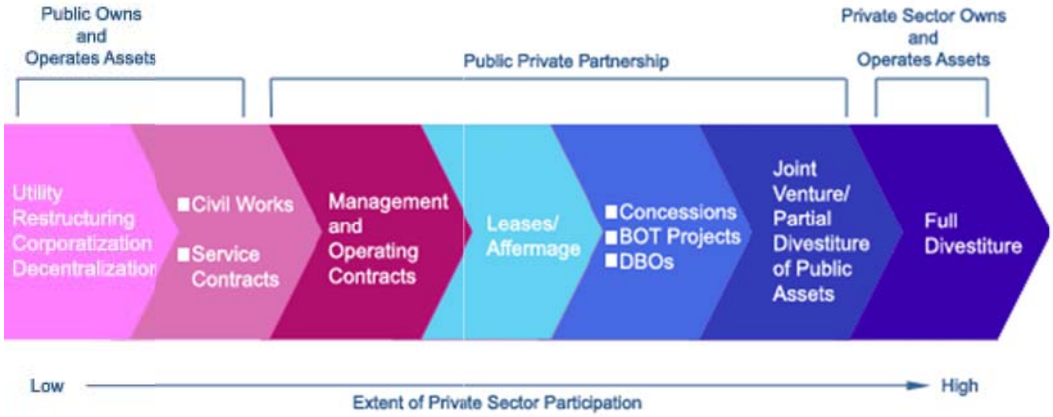

Figure 1 Types of Public-Private Partnership Agreements. Source: World Bank Group Public Private Partnership in Infrastructure Resource Center.

6. Public Private Partnership and Bahraini contracts according to the Legislative Decree no.36 of 2002, with respect to Regulating Government Tenders and Purchases

Bahraini contracts according to the Legislative Decree no.36 of 2002, with respect to Regulating Government Tenders and Purchases classify as administrative contracts. While Government awards contract to private sector parties in both of the current forms of collaboration between public and private sectors (administrative contracts) and PPP projects, the differences between the two methods of collaboration appear as following:

- Government, in administrative contracts, pays private sector parties upon project completion or by its partial phases of achievement, while in PPP, the Private sector arranges financing the project upfront.
- Government is responsible for operation and maintenance in administrative contracts, while in PPP, the Private sector parties are responsible for construction, operation and maintenance for a fixed period.
- Private sector achieves its mission by project completion, while in PPP, private sector regroups costs and makes profit upfront.
- Government, in administrative contract, takes the majority of building and operations risk. While in PPP, Private sector parties are incentivized to achieve standards, otherwise penalized (Cuthbert & Choudhary 2016).

Although there are differences between the two methods of collaboration, PPP contract may be classified as an administrative contract, as a result of satisfying the criteria of administrative

contract "the public partner acts as a public authority with particular privileges and the contract relating to public utilities" (Delcors & Wolf 1977).

7. Advantages and disadvantages of Public Private Partnership

The financial crisis of 2008 renewed the interest in PPP in both developed and developing countries for facing the constraints on public resources and budget deficit. While recognizing the importance of investment in infrastructure to help their economies grow, states governments are increasingly turning to the private sector as an alternative additional source to meet the funding gap (World Bank Group Public Private Partnership in Infrastructure Resource Center 2016 b). However, it should be born in mind that Public Private Partnership does not have the magic solution for countries problems, because practical experience has shown many disadvantages of PPP. Therefore, as with any project, a PPP has both advantages and disadvantages for public partner, private partner, project users, and public utilities as following:

7.1 The advantages and disadvantages of PPP for the Public Partner

7.1.1 Advantages

Public-Private partnerships offer several benefits, such as:

- Great efficiency to reduce budget deficits;
- Re-directing government funds to other important socio-economic areas;
- More competition on market and faster procurement;
- Access to an expertise not available in the public sector, and promote innovation;
- Minimizing development risk by Sharing risks and responsibilities;
- Better compliance with environmental regulations; and
- Improving operating efficiency, cost effectiveness and service performance.

7.1.2 Disadvantages

Public Private Partnership has also some drawbacks, such as:

- Private funding is expansive;
- The bidding process is not perfect, and its costs are likely to be greater than traditional government procurement processes;
- Long-term commitment of the lease payment;
- Creation of a private monopoly;
- Accusation to favorize foreign companies;
- Resistance of final users (when Raising prices);
- Disputes can affect the reputation of the country;
- Government responsibility continues as citizens will continue to hold government accountable for quality of utility services;
- Decrease of employment in the public sector and losing of technical staff and losing of the best managers of the public sector; and
- Limited influence of public authority over the investment. (World Bank Group Public Private Partnership in Infrastructure Resource Center 2016 b; Pârvu & Voicu-Olteanu 2009; Francoz 2010)

7.2 The advantages and disadvantages of PPP for the Private Partner

7.2.1 Advantages

Public Private Partnerships offer several benefits, such as:

- Enhancing private sector participation in government projects;
- Generate cash flows for a long-term period;
- Developing local private sector capabilities through joint ventures, as well as sub-contracting opportunities with large international firms;
- More transparency in the economy;
- Government supports (subsidies, tax and guarantees) ;

- Creates the local standard and a captive market;
- Creation of a market for after sales service, spares (subway, power plants) ;
- Natural hedge to inflation;
- Powerful incentives to perform;
- Shared resources with other projects.

7.2.2 Disadvantages

Public Private Partnership has also some drawbacks, such as:

- PPP procurement procedure is longer and more costly than traditional public procurement;
- Introducing a fully risks appraisal early to determine project feasibility, leads to have unrealistic governmental expectations;
- Lack of skilled teams;
- Profits of the projects can vary depending on the assumed risk, complexity, competitive level, and volume of the project;
- Political and social challenges (like tariff increases , labor transfer, or land resettlement issues);
- Tendency to mistrust private sector;
- High margins of project debt;
- Resistance to high tariffs (demonstrations against price increase);
- Conflict with local partners (World Bank Group Public Private Partnership in Infrastructure Resource Center 2016 b; Pârvu & Voicu-Olteanu 2009; Francoz 2010).

7.3 The advantages and disadvantages of PPP for the Users

7.3.1 Advantages

Public-Private partnerships offer several benefits, such as:

- Creation of a new facilities with better maintenance;
- Social tariffs for low income;
- Lower price for a better quality;
- Less taxes due to less public debt;
- Better compliance with environmental regulation.

7.3.2 Disadvantages

Public Private Partnership has also some drawbacks, such as:

- Creation of a private monopoly can affect the continuity of project;
- Raising prices charged for users of infrastructure;
- Disputes can affect the quality and the accessibility of service (World Bank Group Public Private Partnership in Infrastructure Resource Center 2016b; Pârvu & Voicu-Olteanu 2009; Francoz 2010)

7.4 The advantages and disadvantages of PPP for the Public Utilities

7.4.1 Advantages

Public-Private partnerships offer several benefits, such as:

- Enhance the necessary investments into public sector;
- Guarantee higher quality and timely provision of public Utilities;
- Benefit from private sector expertise and experience in PPP projects implementation;
- Guarantee of the services for a longer-term;
- Decrease of the political interference in economy.

7.4.2 Disadvantages

Public Private Partnership has also some drawbacks, such as:

- Delivered Infrastructure or services could be more expensive;

- Impossibility to anticipate and evaluate all potential events that could influence the future activity;
- Poorer quality of the services, and Limited accessibility to services (World Bank Group Public Private Partnership in Infrastructure Resource Center 2016 b; Pârvu & Voicu-Olteanu 2009; Francoz 2010).

8. Sustainable Development and the Problematic of Public Private Partnership Legislation in Bahrain

Despite the long successful history of collaboration between the public and private sectors to implement energy, infrastructure and other projects in the Gulf Cooperation Council (GCC) region, they have largely done so in the absence of PPP legal frameworks as known in more developed states (Cuthbert & Choudhary 2016).

Recently, the fiscal deficits across the region due to the falling oil prices (figure 2) and the population's growth (Figure 3) have forced the governments in the GCC to step away from their traditional reliance on oil revenues and sovereign reserves, and to search for a new methods of financing projects in order to continue with their ambitious plans for development.

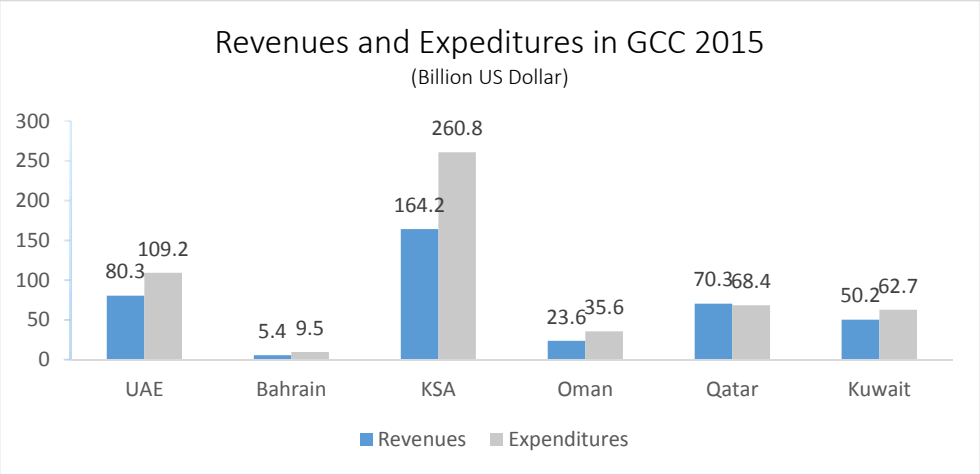

Figure 2 Revenues and expenditures in GCC 2015. Source: GCC Annual Statistical Year Book 2015.

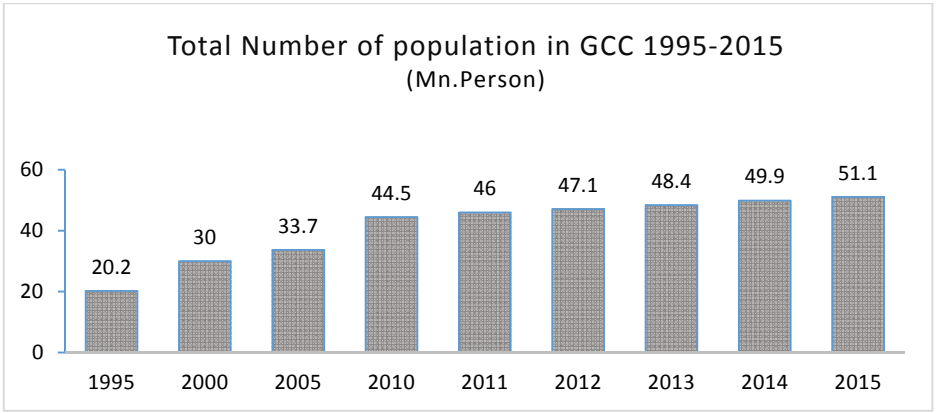

Figure 3 Total Number of Population in GCC 1995-2015. Source: GCC Annual Statistical Year Book 2015.

PPP model was adopted across the GCC; horizontally it treats water and waste projects, power projects, road, rail and airport projects, healthcare projects and education projects, and the

housing projects; while, vertically, it appears in various forms, such as: BOT, DPFO, DBFOT, BOO, Concession, and Joint Venture (Cuthbert & Choudhary 2016) .

In spite of the absence of PPP legislation, Bahrain has adopted PPP program in many projects, such as: Hidd Solar project, Askar Waste-to-Energy project, A-Dur 2 IWPP "The independent water and power" project, Light Rail PPP project and a Housing project (Burbury & Smith 2017). Therefore, the question of the necessity to adopt a comprehensive law governing PPP arises regarding to current situation in Bahrain.

According to Del Nevo, (2016) Bahrain needs to adopt a comprehensive legal and regulatory framework governing PPP because it would be beneficial for developing and implementing a streamlined process, while removing several legal uncertainties related to applicable laws and regulations, legal risks, possibility to override contractual provisions by contracting authority, cancelling the contract totally, or suspending its execution on the ground for public interest; Also the right of contracting authority to modify the terms of the contract by referring to such agreements as administrative contracts; Finally, the sovereign immunity is forced in Bahrain by a statutory prohibition on court enforcement against public property or property owned by the Kingdom.

Del Nevo sees that the presence of a clear provision, which precisely controls the existence and consequences of any such rights (and ensuing indemnification for the investors), would enhance legal certainty of, perhaps, the most important item of concerns for private investors (Del Nevo 2016) .

However, in contrast to earlier allegations, we can affirm that Public Private Partnership does not contradict with administrative contract and sovereign immunity, for the following reasons:

First of all, Public Private Partnership has a distinct mechanism for facing the previous risks relating to the public interest, the administrative contract rules, and the sovereign immunity, which is called risk allocation matrix. So, the previous risks should be allocated and shared between the public and private parties during the negotiation phase.

Secondly, the experience of administrative contract is older and deeper than the experience of Public Private Partnership, for the level which lead us to affirm that the traditional theories of administrative contract balance (***théorie de l'imprévision*** **"**theory of imprevision", ***théorie du fait du prince*** **"**theory of act of administration*", and* ***théorie des sujétions imprévues*** "theory of unforeseen physical difficulties*"*) can recover easily the gap that may occur at the risk allocation matrix. Therefore, those theories play an important role in filling the gap which can occur to the principle of risk allocation during the contract execution because of the impossibility of specifying and evaluating all potential risks of a PPP contract in advance. So, we can affirm that there is a state of harmonization between the principle of risk allocation and the traditional theories of the administrative contract balance (Ruellan & Hugé 2006).

Finally, concerning the matter of sovereign immunity and the prohibition on court enforcement against public property or property owned by the Kingdom. We can affirm that no one can deny the right of each state to have its own property. The state sovereign immunity over its public property should not be challenged, especially that national ownership is emphasized throughout the 2030 Agenda for Sustainable Development which confirms that SDGs are: "applicable to all, taking into account different national realities, capacities and levels of development and respecting national policies and priorities. These are universal goals and targets which involve the entire world, developed and developing countries alike" (Sustainable development knowledge platform 2015).

The previous allegations cannot support the adoption of a comprehensive law for PPP. The adoption of PPP legislation in Bahrain should come as a result of actual legal needs and after a thorough and comprehensive study to be coherent with the Bahraini political, cultural, and social environment. Especially that the World Bank affirms the ability of applying PPP through various legislations and regulatory frameworks such as: Concession Law or General Procurement Law as the case of Bahrain, without requiring a specific PPP law or framework (figure 4).

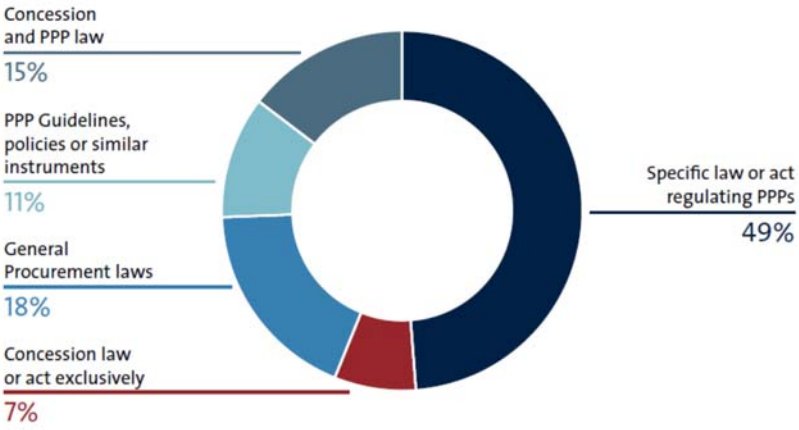

Figure 4 Type of PPP regulatory framework adopted. Source: Benchmarking PPP Procurement 2017..

9. Conclusion

Although Public Private Partnership is considered as the cornerstone for achieving the 2030 SDGs Agenda, as a result of its ability to deliver project financing and realization, there are multitude forms of PPP; each type of PPP has its strengths and weaknesses. So, the selection of each type must occur according to project nature, needs, and the ability of PPP type to deliver clear advantages and benefits.

The dissemination of legal awareness concerning PPP projects is more important than issuing PPP legislation. Therefore, creating the right environment for investment and guaranteeing the rights of the investor, the rights of the State and the most important rights of the citizen (user) is the key to the success of a fair partnership that benefits everyone. The Trust between PPP parties must occur through negotiation of project tasks, common SWOT analysis that helps in risk allocation.

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Section 3

Energy

Evaluating Critical Success Factors for Implementing Renewable Energy Strategies in the Dominican Republic

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Abstract

Global awareness and commitment, in regards to climate change, access to water and renewable energy deployment has risen in the last decade. However, many countries are still locked in unsustainable practices, specifically in regards to energy, this results in damaging consequences not just for the country but the world. Case in point of the Dominican Republic (DR), an island with an immense renewable energy potential, a growing economy and the financial aid of many international entities. Regardless of all this, "the business as usual" decision for the energy strategies is based on fossil foil. As a result, thousands of people are still without energy, the infrastructure itself is unreliable, and the cost of fossil fuel is 8% of the country's GDP. In addition to, blackouts, the expensive tariff for users and unstable energy grid. Therefore, this paper discusses and critically evaluate critical success factors for implementing renewable energy strategies in the DR.

For this purpose, an extensive literature review was done, along with interviews with the key actors in the renewable energy market of the DR. This resulted in the evaluation of the energy infrastructure by obtaining a clear view of the situation. Future work will involve creating a framework for implementation of renewables.

Keywords: Critical success factors, Sustainable goals, successful implementation.

1. Introduction

Behavioural changes, as well as an increase in renewable energy knowledge and investment, are the key to enhancing the adoption of more sustainable practices worldwide. However, this increase is detained by unsustainable practices, especially in the energy area. As many developing countries (Low-middle economy countries) are still locked in the "business as usual" of fossil fuel for power generation; Case in point of the Dominican Republic (DR), a country with high sustainable goals yet it has locked its energy sector on fossil fuel. Despite the fact, that the fossil fuel energy generates several critical issues to the nation: Fossil fuel imports are susceptible to the unstable oil prices, and with around 85% of the energy in the country coming from Fossil fuel, this results in a high cost to the country of around 8% of the GDP, making the countries trade market unbalanced and contributing to the pollution and global climate change, which of the region the DR is the greatest CO2 polluter. In addition, the energy sector in the DR suffers from blackouts due to inadequacy of fossil fuel power generating plants and the high cost of the tariff a long with technical and non-technical issues that have plague the country for years. The paradoxical matter is that the DR has a renewable energy potential to not only supply its energy demand but to aid in supplying energy to neighbouring countries.

Some of the challenges that the DR faces are related to three specific areas: Government, Private sector and the end user. Better coordination between the involved actors would result in a successful implementation of renewable energy strategies. For this coordination and implementation, is where Critical Success Factors (CSFs) should be used.

CSFs are an x-number of the main areas where an organisation, institution, department, project and so on, must achieve an efficient performance to realise its mission, vision and goals. CSFs can be derived from a literature and organisational document review. However, Parker (2010) defines CSFs as an information analysis to a project's (Organization, Institution and more) ability to exploit its strengths and weaknesses, therefore implying an interlinking of the CSFs and the current strengths and the current barriers of the project. Also, CSFs provide a vital instrument for measuring the performance goals of a project. Also, CSFs can be obtained from the analysis of interviews with the principal management personnel about their specific position (business or project related) and the barriers encountered in reaching the goals and objectives

of the specific project, department or organisation that the interviewers belong. It is a combination of this two methods that this paper is based on. CSFs indirectly affect the renewable energy strategies, as their effect is on the asserted goals of the project and as a way to enable the success of the project mission. CSFs will also aid in increasing the efficiency of the generation, transmission, and distribution of renewable energy (RE) in the power sector of the DR. This transformation to RE must be an essential priority in the country.

In this evolving environment characterised by increasing electricity demand, the pipeline of new power generation projects is key for the sustainability of not just the country but of the world. The foremost objective of the research is to find and fill potential gaps in the existing research that might result in conclusions that will formulate an efficient CSFs and ultimately a Framework for the successful implementation of Renewables. This paper provides a summary of main energy resources in the Dominican Republic. Section three is focussed on the methodology used in this analysis. While section two will present the description of the case study of the DR with its sustainable goals and renewable energy potential. Furthermore, section four focuses on CSFs in a general manner and the un-unique and unique CSFs of the DR. Finally section five contains the conclusions that have been reached during the analysis.

2. Energy Description of the Dominican Republic

The DR is one of the largest islands in the Caribbean and possesses one of the most diverse and fastest growing economies in the region. Also, its energy consumption is increasing rapidly, at an average of one percent per year. However, the country relies heavily on fossil fuel, which needs to be imported and accounts for nearly 82% of the energy generated and supplied; at present this importation of fossil fuel represents 6% to 8% of the annual GDP (6,722.22 USD per capita) spent, this is not considering the 2% that represents the energy subsidies that the government injects into the electricity tariff to stabilised the rates for consumers (IRENA, 2016). Contradictory, the DR also has one of the highest renewable energy potential in the region (66% of energy capacity approximately 1.44 gigawatts just on on-shore wind and hydro power). However, despite all the challenges the DR has committed to several sustainable goals, as can be seen on the Table 1.

Table 1 Sustainable goals of the DR. Source: IRENA (2016).

Sl. No	Sustainable Energy Goals of the DR
1	Reduction of Greenhouse Gas emissions by 25% by 2030
2	Reduce fossil fuel import dependency
3	Reduce the local and global impacts of fossil fuel combustion on the environment
4	Increase renewable energy in the power generation mix by 25% by 2025 (Law 57-072)
5	Rural Electrification program with off-grid renewable projects
6	Blackout reduction programme

In regards, to the first sustainable goal the Dominican Republic has the highest CO2 emissions of not only the Caribbean region but of several Latin American countries. With a 0.79 gigatons per GWh in 2002 and 0.81 gigatons per GWh in 2011, having a 0.2% increase per unit of generated electricity.

The energy strategies are key for increasing the share of renewables and achieving all sustainable goals. Currently, the majority of power generation plants in the DR are primarily based on hydrocarbons, and this fossil fuel plants are very inefficient**.** On average in the DR the efficiency of fuel oil generation in 26.6% and coal steam is 28% this is extremely low and inefficient. However, the energy market is still working under the obsolete hydrocarbon laws. (Konold et al. 2015)

In recent years the sector has experienced a flourishing in renewable energy projects. However, very few of the projects are realised. In addition, the sector, and specifically the law 57-072 that rules renewable energy along with the Energy Distribution law, have gone through a series of reforms to ensure, secure and lower the cost of electricity supply to consumers, as the electricity sector is one of the highest in cost in the region, without the subsidies $1 billion USD

that the authorities of the country infuse into the tariff. These reforms have introduced some policies such as the cut to the tax incentives, which the law 57-072 initially had, by more than half, along with the feed in tariff energy method establish. These new policies have reduced the investment and interest in renewables (IRENA, 2016).

A part from the legal challenges the DR face technical and non-technical issues, especially with the grid. Some of the issues are: (a) very high distribution losses at approximately 32% in 2014. (b) Subsidise electricity prices by the government ($1 Billion USD annually), which results in an inadequate investment of funds, cutting the investment into grid capacity upgrades. This lack of grid optimisation leads to hours long blackouts. Among the non-technical challenges the major one is Electricity theft as it is not adequately addressed because of the limited regulatory capacity and implementation. Also the fear of threats from the population illegally connected. These non-technical issues account for approximately 12% of the DR electricity losses. Other technical issues are (a) inefficiencies at generation plants and substations, (b) inefficient and overloaded transmission lines. These technical and non-technical challenges contribute roughly to a loss of around $100 million USD annually (Konold *et al* 2015) in the electricity sector's creating a deficit for the country and government.

The DR possesses a strong RE potential across the wind, solar, hydro and much more. Also, this potential is spread all over the country and can meet almost completely the current power demand with the RE. In regards to local wind potential, the DR possess from 100-10000 MW with approximately 79 potential areas of high winds. In solar the DR shows incredible solar potential with a GHI that ranges from 5 to 7 kilowatt-hours per square meter per day (kWh/m2 /day) throughout most of the country and approaches eight kWh/m2 /day in some regions. The hydropower in the DR is almost at maximum capacity, as already 90% of the water sources have been utilises, meaning that any new hydropower plant would impact on a minimal scale the energy supply and demands. Also, the hydropower plants in existence only operate for short hours (4-6) a day because of water regulations that prioritise water for drinking, agriculture and then electricity. Regardless of this, the government continues to invest greatly in the area ($1.6Billion USD from 2010-2015), showing the business as usual thinking.

The Future Expansion of the electricity capacity in the DR has been planned since 2012 with the proposed addition of 2,069.5MW of energy by 2018. However of this 2,069.5MW renewable energy (RE) only represents 219MW around 10.58% of the whole energy expansion. (IRENA 2016 and Konold et al. 2015) This is an example of the unsustainable practices and thinking of the government; with the current approval and construction of the Punta Catalina Power Central that shall be coal generated, the government has efficiently locked the energy market in the DR into a fuel dependency that might probably raise the cost of electricity for consumers, and that disregards the energy goals that have been set.

The country has significant additional renewable energy potential to go beyond the projected 66%. However, for the country to reach 66% and beyond a restructuring of the current strategies is needed. The first step is to study the projects that have been implemented successfully in the DR and analyse the CSFs, to guide the country into a more sustainable future.

3. Research Methodology

Given the complexity of renewable energy (RE) issues and the paucity of comparable research in the area, a qualitative research methodology has been adopted. As Willis (2008) explains the qualitative research will aid in understanding the underlying drivers, challenges and knowledge of renewables in the DR. The data utilised in this study will be based on current scientific literature review, project documentation and interviews with the principal actors of the renewable energy in the DR; with the purpose of achieving the aims and objectives of this research. Also, a CSFs analysis has been completed. With the purpose, to identify the key areas unique and un-unique to successfully implement a renewable energy project in the DR. As Esteves (2005), Ali et al. (2008), Parker (2010) and Hsiang-Yung (2012), have described CSFs analysis can be carried out based solely on literature and documentation review or on interviews; as CSFs are a number(s) of key areas that define the performance and success of a project. For this paper literature review, documentation review and interviews are analysed and reported, to obtain a profound understanding of the current situation and challenges in the DR. It is imperative to understand the characteristics of CSFs; some of the key features are: CSF hierarchy, types, uniqueness, and stability over time. For this research, a focus on the kinds and uniqueness has been done.

The fact that the decisions for the energy infrastructure need to be decisive for a country to developed RE as this involves difficult trade offs, it was critical to gather the most current and high-quality data. As Donastorg et al. (2016) explain the use of the literature review is an essential tool for the summarising of the current knowledge by also including the analysis and synthesis of empirical cases studies. For that purpose and in-depth literature review of current research in the area has been done on the DR along with the successful implementation of renewable energy projects in the country, as to survey, synthesises and critically analyses the information. This method of collection will ensure that the scope of research will add, and not duplicate any previous research in different areas of the DR renewable energy sector and the Caribbean region. These documents were used as relevant references for the research and provided vital information about various areas of the RE situation in DR; however, a comprehensive overview of the different stakeholders, business perspective and PESTLE (Political-Economic-Social-Technological-Legal-Environmental) analysis regarding the energy strategies in the country was lacking.

Primary data was collected through Semi-structured interviews, and purposive sampling technique was used to select interviewees. This technique was chosen as the quantity of knowledgeable personnel in the area of renewable in the DR is very limited, for this very reason the identities of the interviewed has been coded as Energy interview # (EI#), to comply with the anonymity that was agreed upon, as can be seen in Table 2, along with a summarized profile of the interviewed in Table 3.

Table 2 Classification of Interviewees for CSFs for the implementation of RE projects in DR.

Participants	No. of interviwees
CEO's	7
Directors	11
Managers	7
Total	**25**

The interviews were conducted in a face-to-face format lasting for 20-160 minute. A total of 25 professionals were interviewed from the private, public and government areas of the renewable energy sector in the DR. All the interviews were transcribed verbatim.

Table 3 Description of critical criteria of interviewees.

Interviews	Detail Desired Criteria
Senior Experts Representatives	• Experience in the RE area (Technological, generation, Legal, financial, public and private sector) • Knowledge in RE subjects • At least five years of experience in RE area

For this research to make feasible proposals for assertive actions, it was imperative to understand the drivers, challenges and CSFs of all stakeholders—governmental and nongovernmental—that are critical to transforming the energy sector to RE as a reality. The semi-structured questionnaire was created, with open questions and providing the interviewer with time to explain or explore particular areas, to procure in-depth information of the drivers, challenges and knowledge from the main actors. The interviews were recorded, transcribed and supplemented with field notes as appropriate. The unit of analysis adopted for this study was the energy industry, and the embedded unit of assessment was the 'individual employee'.

Once the data was collected analysis of such data was completed. Of all the possible CSFs obtaining from the research, six essential were revealed and can be seen in section four of this paper. Once the CSFs where identity, the need to introduce them into the project hierarchy, as can be seen in Figure. 1. The purpose of CSFs is not just to be identified but to be introduced into the project and methods on how to measure them (Key Performance Indicators) created and evaluated during the life cycle of the renewable energy project.

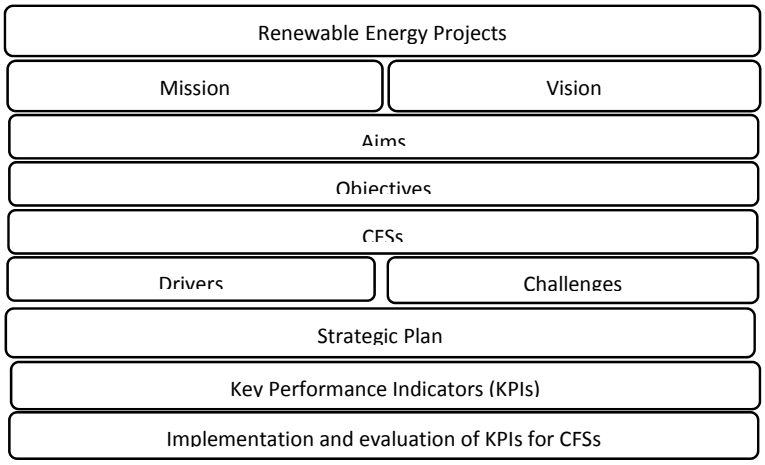

Figure 1 Renewable Energy Project Process. Source: Parmenter (2008), Esteves (2005) and Parker (2010).

The RE potential benefits, in a financial, environmental and social aspects for the DR provoke the question of why Sustainable practices, especially RE, have not become the business as usual for the country.

4. Critical Success Factors

As stated CSFs are a limited and defined a number of fields that, if implemented correctly, will ensure a successful completion of the goals and mission of the organisation or project (Parker, 2010). Many researchers (Baharuddin *et al*., 2008. Esteves, 2005., and Hsiang-Yung, 2012) defined these factors as key subjects where measures and tasks must be correctly implemented to ensure favourable results, this area is essential if the goals of the project are to be achieved. These particular areas must receive continuous and meticulous attention.

Hsiang-Yung (2012) focused the research at the renewable industry level and proposed that CSFs be common across the organisations within the energy sector. This CSFs are non-unique at an industry-level, this means that these particular factors are relevant for any company in the renewable energy project. However, Parker (2010) explains that CSFs might differ from project to project depending on the hierarchy of the CSFs. This would re-established concepts from 1979 of CSFs and would reintroduce the notions of managerial-level CSFs and organizationally unique CSFs. A thorough discussion of several researchers (Parker, 2010, Esteves, 2008 and Bahariddin et al. 2008)the tiered nature of CSFs, can be divided into four specific levels: industry, organisational, department, and individual. Now, this classification is based on the industry or environment analysed. Stainforth and Staunton (1996) restore five different levels of CSFs based on the different departments or roles in a project and how each contributes to achieving the mission of the project: (a)the structure of the specific project (industry/project CSFs) (b) competitive approach, project importance, and physical location (strategy/approach CSFs) (c) the current social-political-economical-technological-climate change environment (environmental CSFs) (d) challenges/barriers to implementing the project (temporal CSFs) leadership and knowledge management (management CSFs).

A renewable project CSFs may contain any or all of these types. Analysing and understanding the different types of CSF helps the projects professional recognise whether the CSFs are common or unique and how they may continue or evolve; no organisation can manage to create and implement a strategy that does not provide acceptable care to the primary factors which are the cause of success in the project.

As Stainforth and Staunton (1996) described the CSFs for implementing renewable technologies, however, the focus of the research, in this case, was on simply implementing the technology and did not take into account the challenges and drivers needed for the whole project. In this paper, the focus has been on the entire project and its key actors in the DR specifically, as this country is usually used as a testing ground for companies, since it is one of

the largest and fastest growing economies, investors and organizations will usually set the base of operations in the country or do a trial and error of the projects in country. The thought behind this is that if it works in the DR, it will work for the rest of the region. In this way, the DR becomes a mirror of the area.

In the case of the DR, after conducting the interview's and analysing the data the key CSFs were determined as can be seen in Table 4.

Table 4 CSFs for implementing RE business strategies in the DR.

CSFs	Percentage of interviewees Cited (N=25)	Possible Measures
Creation of financial tools for renewable energy projects	84%	Reports on: RE loans, Incentives, Cooperatives, Interest rates
Coordination between the different stakeholders	80%	Knowledge management reports and logs
Knowledge creation and exploitation related to RE business	75%	RE education and training, RE higher education curriculum
Implementation of the legal Framework	72%	Implementation committee, Surveys, incentives tracker, disclosure of incentives reports
Update and provide access to the grid	64%	Reports on rate of change of energy line connections and private connection forms
Transparency in the legal and financial tools available	60%	Reports and logs of open source publications of documentations, public auctions of agreements

5. Conclusions and Recommendations

As can be deduced from the research each CSFs augments the possibilities of success. However, this is not a 100% guarantee that the project will, in fact, succeed; as cases where some but not all of the CSFs have been present, and the project has failed, and on the contrary, others have succeeded again with some but not all of the CSFs. The important pieces of any project most be taken into account, and the more CSFs identified, and measures for them that have been correctly implemented the higher the possibility of success.

CSFs reveal areas that must be monitored over time. In the case of the DR these areas are quite broad: (a) Correct implementation of the legal Framework, as 72% of the key actors highlighted the country has sufficient laws. However, it is in the implementation of the renewable and energy legislation that the actors find insufficient. For this purpose, a re-check of the laws and how and who implements them is needed by the government in cooperation with the private sector (most affected by this CSFs) (b) Creation of financial tools for renewable energy projects. An 84% of the actors explain that the tools or funds for large renewable energy projects do not exist in the DR; 90% of the successful projects in the country have been self-financed or internationally finance (International aid organisations) (c) Coordination between the different actors. The discombobulation of the system to obtain a project and then the communication between all the players involved leaves many gaps that have been unfullfil, and that creates a state of confusion and generate a perceived risk for a renewable energy project that deters many investors and organisations to invest in renewables in the country. The same can be said of (d) Transparency in the legal and financial tools available. The interviews reveal that the lack of proper transparency in the financial instruments (banks) and on the legal aspects (PPA) creates, again, a perceived risk, that does not actually exist, but the uncertainty of the process for obtaining the project and the funds diminishes the importance and need of renewables in the country. Another of the general CSFs is (e) Update and provide access to the grid. This particular CSFs is the cost of more than 20% of a project additional or expensive cost of any project in the DR, as the lines as not suitable for renewable injection in a large scale, the owners of project

most see fit to suitable them and this presents a sure method to fail if not taken into account. This establishes that with the right legal and financial framework and technical solutions, the DR can be a key country in the region attracting significant investment in renewable energy.

Interviews and literature and document review lead to strategic conversations and to uncovering the potential success areas of future renewable energy projects for which an organisation can measure and monitor to ensure success. This CSFs, although they produce tangible results, also provide processes that help a project, institution and hopefully the country establish strong ways of thinking, communicating, and making decisions in regards to renewable energy.

The CSFs and KPIs will aid stakeholders, specially decision makers, to make the best decision to develop RE in the DR at the same time, will promote developers and investors into increasing the RE projects and economy in the country. This help will showcase to the government and the public that it is in the country's best interest to invest in RE.

Some of the areas that should be further research are the diversification of the electricity generation portfolio, wind and solar are especially feasible and should be fundamental in the country's energy mix. This diversification could be essential to reduce the country dependence on fuel imports and improve the energy supply security considering the fast-growing energy demand. The decentralisation of the grid, as currently 80-88% of the country is connected to one grid, yet the unreliability and instability of the grid still cause several blackouts and grey-outs in the country.

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Application of Supervised Learning Methods to Better Predict Building Energy Performance

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Abstract

Building energy consumption is shaped by a variety of factors which prompts a challenge of accurately predicting the building energy performance. Research findings disclosed a significant gap between the building's predicted and actual energy performance. One of the key factors behind this gap is the occupant's behavior during operation which includes a set of dependent and independent parameters generating a greater level of uncertainties. To accurately estimate the energy performance, we need to quantify the impact of any observed parameters and further detect its correlation with other parameters. Human behaviors are complex and quantifying the impact of all its interconnected parameters can be error prone and costly.

To minimize the performance gap, more scalable and accurate prediction approaches, such as supervised machine learning methods, should be considered.

This paper is devoted to investigate the most commonly used supervised learning methods which, when intertwined with conventional building energy performance prediction model, could potentially provide more accurate and reliable estimates. The paper will pinpoint the best use of each studied method in the relation to energy prediction in general and occupant's behavior in specific and how it can be implemented to better predict building energy performance.

Keywords: Energy performance, Supervised Machine Learning, Energy prediction, Occupants' behavior, Performance gap.

1. Introduction

Building energy performance has been a central topic among researchers since buildings are one of the main contributors in the energy consumption. There has been a significant increase in building energy consumption during the last decade (Shabani and Zavalani, 2017), in which Buildings account for 40% of total energy consumption (Buratti et al., 2014b) and the electrical consumption of the residential and commercial buildings alone reach a staggering 60% of the total electricity consumption (UNEP, 2016). Reducing the building energy consumption is a global concern that has been researched extensively.

The Energy Performance of Building Directive established a legislation that promotes building energy performance and reduction of CO2 emissions. The objective is to reduce energy consumption in building in Europe by 20 % by the year 2020 (EPBD, 2010). There is a weighty potential for the building sector to reduce the energy consumption and perform better by applying more feasible and effective design and operational solutions (UNEP, 2016). Those solutions for buildings can be projected by means of modeling and predicting in order to attain better energy performance and effectively utilize the energy use in buildings. Thus, it is imperative to predict the energy usage in building to achieve energy conservation and to explore different scenarios that can assist in choosing the most effective building use (Huang et al., 2014).

It's agreed on that building energy modeling plays an important role in predicting building energy performance. Modeling tools offers the potential to analyze the energy usage patterns and predict consumption (Huang et al., 2014). Nonetheless, having the model to obtaining reliable results always require time and accuracy (Buratti et al., 2014a). There's a significant gap between the actual and predicted energy performance defined as the "energy performance gap". De Wilde (2014) noted that one of the obvious causes of mismatch between the prediction and actual measurements is within the modeling and simulation stage, as this stage is a fundamental constituent of prediction. When inadequate tools or methods are used, inaccurate

prediction will be obtained, and consequently a performance gap as an end result (CarbonTrust, 2011, Menezes et al., 2012).

Nevertheless, even if the modeling stage was performed correctly, the prediction remains a complex process accompanied by fundamental uncertainties resulting from the various factors that affects the energy consumption (Menezes et al., 2012). This high obscurity in predicting the energy performance or controlling it, is accounted to a number of variables and parameters that contributes directly and indirectly to the building energy use, such as building design, construction and operation, building technologies, weather conditions, and most importantly occupants and their behaviors (De Wilde, 2014). Figure 1 provides an overview of the parameters affecting the building energy use, which undoubtedly complicate the energy usage prediction, while Figure provides an overview on the parameters affecting occupant behavior and in return the building energy use.

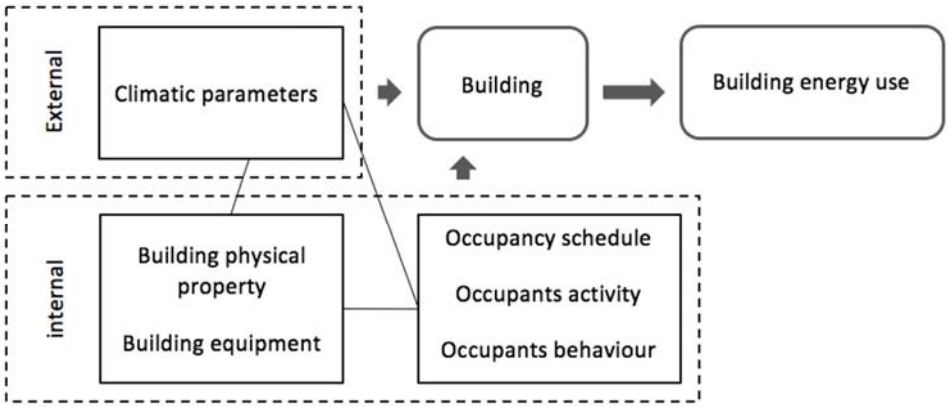

Figure 1 Parameters influencing building energy use.

When talking about the factors affecting performance gap, research has disclosed that occupant's behavior is one of the main contributors of this gap (Menezes et al., 2012, Haldi and Robinson, 2008). Predicting building energy performance whilst comprehending the human behavior is a complicated procedure, as human behavior is stochastic (Yan and Malkawi, 2013). There is a need to find alternative methods to perform such predictions that do not limit the typical occupants' behavior but instead offer suggestions, consent changes and are able to learn from the observation and interaction between the occupants and the building.

As the prediction relates and define patterns of the occupant behavior, the learning will increase, till it is reckoned as truthful. This may be achieved by employing supervised learning techniques.

For the reliable prediction of building energy performance, various models and modeling techniques were put under investigation showing a discrepancy in the success rates (Zhao and Magoulès, 2012, Crawley et al., 2008, Li et al., 2014, Swan and Ugursal, 2009, Magoulès and Zhao, 2016, Wang and Srinivasan, 2017). Buildings showed that its operation and energy consumption have a nonlinear dependency on exogenous variables (Huang et al., 2014). That being said, supervised machine learning techniques and algorithms have been extensively explored as modeling techniques as they are capable of mapping nonlinear dependencies between variables. Moreover, as evidenced in many research domains, supervised machine learning techniques and algorithms has been an adjunct to many advances related to domains such as criminology, financial trading and fraud detection. Machine learning has the capacity to solve complicated problems and aids in providing more accurate predictions (Najafabadi et al., 2015).

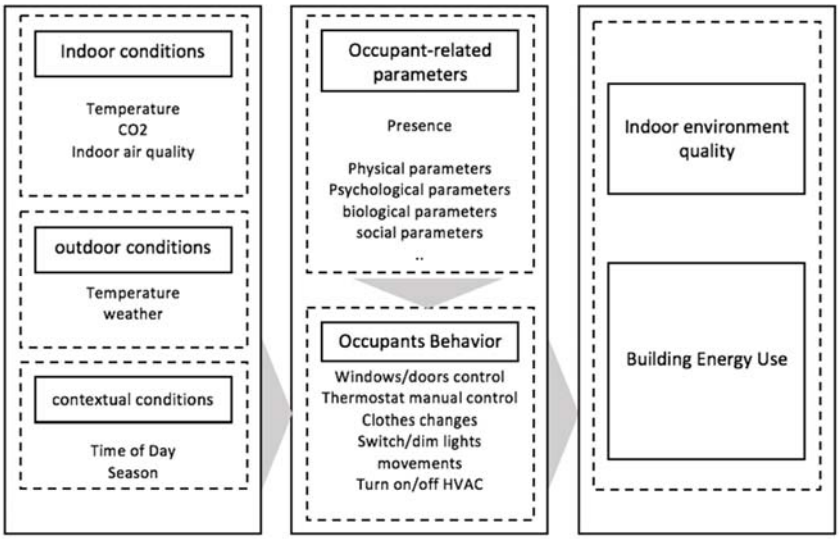

Figure 2 Effect of occupant behavior on building energy performance.

As suggestions on how to bridge the gap is an ongoing concern in the research industry, Literature substantiated occupant behavior must be considered and explored (D'Oca et al., 2015). In this paper, the most common supervised learning methods are reviewed in terms of their capability in predicting building energy performance. By exploring supervised machine learning methods and techniques, new approaches can be employed to predict building energy performance with further consideration of occupant's behavior developed inputs into building energy model.

2. Methods

As artificial intelligence based modeling approaches, including supervised machine learning approaches, ought to be known for their scalability, ease of use and adaptability to seek accurate and reliable predictions in an optimal time frame (Wang and Srinivasan, 2017), those modeling techniques have attracted researchers attention to investigate modern solutions for energy performance prediction in general and occupancy behavior prediction in specific. This brings in the necessity to carry out an in-depth literature review for building energy prediction by means of supervised machine learning, and discuss recent development and implication towards incorporating occupant's behavior in the prediction model.

The research at first provides a background about the challenge of modeling occupant's behavior. This is followed by a background of the common used supervised machine learning techniques and algorithms covered in this paper, which are linear regression, Bayesian networks, artificial neural networks, support vector regression and decision trees. Then, a detailed literature review is conducted for recent research development carried in the past decade (2007-2017). Research papers related to our topic are identified, scoped and reviewed paving the road to an elaborated review of the application, benefits and limitations of the studied supervised machine learning techniques.

In short, this paper sets the road for providing better understanding of the use of supervised machine learning techniques for the prediction of building energy use.

The following sections are organized as follows:

Section III provides an overview to the problem which is modeling occupant behavior section IV defines and establishes an understanding of the common supervised machine learning methods and a brief description of their principles; Section V presents a review of the application of supervised machine learning in the field of building energy analysis in which advantages and limitations of each method will be presented. Section VII offers concluding considerations, and covers the future directions of supervised machine learning approaches for predicting energy performance and occupant's behaviors.

3. The Dilemma of occupant's behavior

Occupants behavior have a significant impact on the building energy use, not only their presence, schedule and number affect the energy use, but also the ability to control lighting, set points, shadings, doors and windows operation, and building equipments (van Dronkelaar et al., 2016).

A number of researches were dedicated to unveil the substantial effect of occupant's behavior on the energy use. Azar and Menassa (2012) studied the impact of the parameters related to occupant behavior in office building energy simulation. Moreover, a study on housing stock in Mediterranean area, showed that building physical factors and occupant parameters caused 48.7% of variation in electricity consumption (Mora et al., 2015). Parys et al. (2010) demonstrated that energy use differs robustly as occupants' behavior vary with a standard deviation up to 10% on the energy consumption linked with occupant behavior.

Although many research findings have disclosed that occupant's behavior is one of the main contributor of the energy performance gap (Menezes et al., 2012, Haldi and Robinson, 2008, De Wilde, 2014, Azar and Menassa, 2012), it's unfortunate that the occupant's behavior contribution is somehow overlooked and not copiously included in the building energy use prediction. When predicting building energy use, the majority of current used energy simulation tools provides bigger attention for the physical parameters which includes building characteristics, schedules, weather condition(Crawley et al., 2001, Zhang et al., 2008, Yan et al., 2008). On the other hand, the relationship between occupants and the building, and the effect of occupant's behavior on the building energy use are seldom addressed (Jia et al., 2017). In most cases, The occupant behavior is considered deterministic or static and doesn't get full account while simulating energy use (Fabi et al., 2011, D'Oca et al., 2014).

Ahn and Park (2016) mentioned that modeling humans by means of empirical, experimental, and numerical approach is not easy since occupant behavior is accompanied by lots of uncertainties affecting its prediction. Also, There's a necessity to acknowledge the difference in occupant's behavior that are affected by personal, physical, physiological, biological, social and cultural parameters and how these parameters can contribute differently on the energy use (van Dronkelaar et al., 2016). Peng et al. (Peng et al., 2012) has defined the relationship between the occupants and buildings as presented in

Figure shedding the light on the main points formulating this relationship which are: behavioral ideologies, occupants feelings, and the influence on occupants behavior on the use of energy.

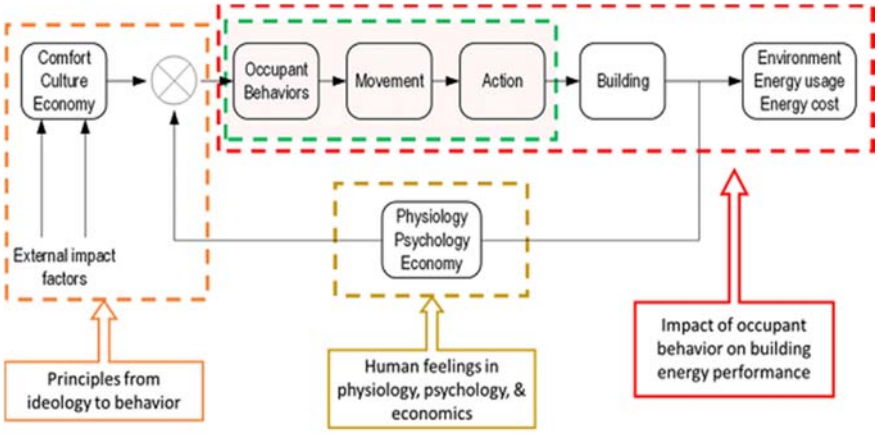

Figure 3 Relationship between occupants and buildings (Peng et al., 2012).

It is imperative to understand that occupant behavior modeling is much more detailed and complex than occupancy detection. It is also important to distinctively differentiate between occupancy (presence of occupants, schedule and number of occupants) and occupants behavior, as more often those two terminologies gets mixed up (Jia et al., 2017). Moreover, it's critical to capture the dynamic and interdependent complexion of occupant behavior when modeling.

4. Supervised machine learning techniques and algorithms

More reliable modeling techniques should be approached for predicting building energy consumption. Those techniques must ensure consideration of occupancy, occupants behavior (passive and active), and the interaction between occupants themselves as well as the building. When those considerations are met, more accurate and truthful models will provide decision makers with a better approach to conserve energy by revising design consideration through exploring different alternative solutions.

Supervised machine learning is the formulation of algorithms capable to generate patterns and general hypotheses by means of externally supplied input to provide prediction of forthcoming outputs (Singh et al., 2016). In simple terms, supervised machine learning requires a set of input parameter and an output parameter, which with the use of selected algorithm can learn to map function that allows the prediction of the output once a new input data is introduced (Figure 4).

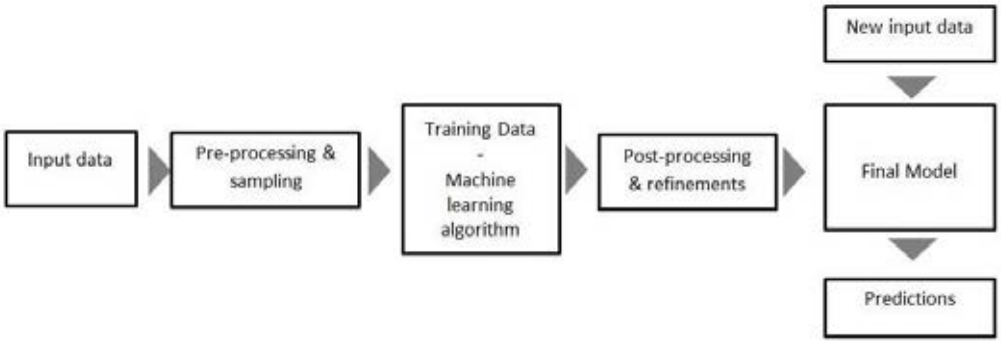

Figure 4 Supervised machine learning process.

Overall, Supervised learning approaches have proven to be efficient in the prediction of building energy consumption (Zhao and Magoulès, 2012). When compared to the conventional modeling techniques, the supervised machine learning approaches brought up more advantages in terms of requiring less time and effort, as there's no prerequisite to define explicitly the relationship between input parameters and the output (Huang et al., 2014).

4.1 Background on selected supervised machine learning methods

A brief background of the selected supervised machine learning techniques is provided. The studied techniques are: Bayesian network, linear regression, decision tree, support vector machine and artificial neural network.

4.1.1 Linear Regression

Linear regression is a well-known machine learning technique frequently used for prediction and forecasting models. Linear regression tends to be a popular technique because of its easiness of application and understanding of the model parameters. The regression is used to set an equation, derived from the input data, for predicting the value of the output as a linear function (Tso and Yau, 2007).

4.1.2 Bayesian Networks 'BN'

Bayesian networks are graphical models demonstrating probabilistic relationships among set of random variables (Tong and Koller, 2001).
According to Darwiche (2009), Bayesian networks involves the following components:
a) The structure of the network defined as a directed acyclic graph, in which the random variables are presented by nodes, while dependencies among variables are represented by directed edges directed edges.
b) Conditional probability distributions assigned for the variables.

4.1.3 Decision Trees 'DT'

Decision trees are considered hierarchical model consisting of a set of decision rules that recursively arranges the input parameters into homogeneous zones (Myles et al., 2004). The decision tree can be a regression or classification tree. Its purpose is to provide a prediction by defining a set of decision rules based on the input parameters. Decision trees deals with interaction between parameters and provides high efficiency with low computational effort (Singh et al., 2016).

4.1.4 Support Vector Machine 'SVM'

Support vector machine is one of the latest supervised learning methods. It is established on the basis of statistical learning theory and structural risk minimization principle (Vapnik and Vapnik, 1998). although SVM is considered to be complex, it's highly accurate and can deal with high dimensional data (Singh et al., 2016).

4.1.5 Artificial Neural Networks 'ANN'

Neural networks are nonlinear statistical learning techniques resembling the biological neural configuration; they consist of three layers made up of interconnected neurons: input, hidden and output layer. The ANN is defined by the interconnection between the neurons belonging to different layers, the weight of this interconnection derived from the learning process, and the activation function converting the weighted input of the neuron to the output activation (Wang and Srinivasan, 2017). ANN is employed as a random function approximation tool that can capture complex relationships between inputs and outputs and model dynamic problems. As such, ANN provides ease of use in modeling problems that are difficult to explain (Singh et al., 2016).

5. Review of application and discussion

In this section, a review of the application of the selected supervised machine learning approaches in predicting building energy performance is presented. Table 1 presents the reviewed methods, the input needed and their application.

Bayesian network has been employed to predict building energy performance and occupant related parameters in a number of researches. Petzold et al. (2005) predicted occupants' presence and the amount of time spent at a specific location by means of a dynamic Bayesian network predictor. The research showed that the accuracy for predicting the occupant location reached up to 90 %, while predicting the duration reached 87%. This was compared to the performance of neural network predictor which proven to have same level of accuracy. In Walt Disney World Resort in Florida, a Bayesian network been developed to predict the energy consumption for a food service building and 3 retail shops The input parameters included operation schedule, historical energy data, weather data, building-related data, and other needed inputs were estimated. The results showed that Bayesian network is an applicable network to predict energy consumption on large scale and can deal with missing data (Tarlow et al., 2009).More over Bayesian network used hourly energy consumption in residential property, it was proposed to predict occupant's behavior. The network was trained to learn occupant's preferences and behavior trends to predict their consumption needs such as light intensity, desired temperature, and plug load and to provide system tuning when there is a change in the occupant's behavior(Hawarah et al., 2010).

Table 1 Application of supervised machine learning methods.

Method	References	Application	Input data
Linear regression	(Li and Huang, 2013) (Yiu and Wang, 2007) (Zhao et al., 2013)	Cooling load prediction HVAC load prediction Occupancy schedule	climatic data, historical data, operation schedule
Support vector regression	(Dong et al., 2005) (Zhao and Magoulès, 2010) (Li et al., 2009)	Prediction of total energy consumption Cooling loads prediction	historical data, monthly utility bills and weather data
Artificial neural network	(Vintan et al., 2006) (Yokoyama et al., 2009, Li et al., 2009, Li and Huang, 2013) (Aydinalp et al., 2004) (Zheng et al., 2008) (Karatasou et al., 2006)	Occupancy movement Cooling load prediction Heating loads prediction Human activity clustering Total energy use	climatic data, time, equipment properties, operational schedule, domestic hot water and heating system properties, historical energy consumption patterns, occupants characteristics
Decision tree	(Nguyen and Aiello, 2013) (Yu et al., 2010) (Tso and Yau, 2007)	Total energy prediction Electricity prediction	Climatic data, building characteristics, utility bills
Bayesian network	(Petzold et al., 2005) (Hawarah et al., 2010) (Tarlow et al., 2009)	Occupants movement Occupants behavioral patterns Energy consumption estimation	climatic data, building characteristics, occupancy schedules, historical data

Linear regression, which is known for its ease of use, has been successfully employed to predict building energy performance. Electrical consumption, HVAC performance and total building energy use is predicted (Li and Huang, 2013, Yiu and Wang, 2007). Moreover, Zhao et al. (2013) used linear regression to predict occupancy schedule in an office building. The results disclosed practicability for the model in predicting occupancy schedule.

SVM is considered to be a modern supervised machine learning methods (Shabani and Zavalani, 2017). SVM have been used extensively for predicting building energy performance, as it is capable to deal with nonlinear regression problems. Dong et al. (2005) used support vector regression for the prediction of energy consumption for four commercial buildings in Singapore. The input parameters included historical data, monthly utility bills and weather data. The prediction reached accuracy within 4%. Li et al. (2009) compared SVM to other modeling approaches in terms of predicting cooling energy loads for an office building in china. The results proved that SVM predictions are accurate when compared to back propagation neural network and radial basis function neural network. Also, by means of large energy consumption data sets, an SVM model is developed to predict energy consumption. Findings emphasized on the benefits of SVM modeling for large datasets (Zhao and Magoulès, 2010). SVM predictions showed higher accuracy when compared to many supervised machine learning approaches such as ANN, decision trees and statistical approaches (Shabani and Zavalani, 2017).

Artificial neural networks have been employed in many researchers to predict building energy performance due to its ability to handle complex and nonlinear problems. ANN managed to predict occupancy movements (Vintan et al., 2006), cooling loads (Yokoyama et al., 2009, Li et al., 2009, Li and Huang, 2013), heating loads (Aydinalp et al., 2004), daily human activity clustering (Zheng et al., 2008), total energy use (Karatasou et al., 2006). Overall the performance of ANN was satisfactory as the results show that ANN has noteworthy accuracy in prediction.

Decision trees has been applied in the recent years for prediction energy consumption in buildings (Nguyen and Aiello, 2013). A decision tree model was used to predict the annual energy demand level (Yu et al., 2010). By using decision tree, a classification of the factors influencing the energy consumption were derived. Moreover, Decision tree model was used in different buildings to predict electricity consumption(Tso and Yau, 2007). The decision tree model proved to require less input data and have better performance when compared to neural networks.

The table below compares the selected methods in terms of input and training quantity requirements and states the benefits and limitations of each studied method.

Table 2 Comparison of the reviewed methods.

Method	Input Data Requirement	Training Data Requirement	Benefits	Limitations
Linear regression	Low	High	Wide application opportunity as output is interpreted as probability. Capable of dealing with nonlinearity.	Entails large sample size.
Support vector regression	Low	High	Capable of dealing with nonlinearity. High accuracy and flexibility.	Complex process dependent on the selection of parameters.
Artificial neural network	Low	High	Ability to handle complex and dynamic relationships as well as irrelevant input data and parameter independencies.	Complications in terms of interpretation of the output.
Decision tree	Low	High	Deals with interactions among variables. Provides high quality performance.	Incapable of managing complex interactions. Difficulty in processing high dimensional data.
Bayesian network	Medium	Medium	Deals with relationships between various input parameters.	Performance dependent on data. Difficulty in processing high dimensional data.

6. Conclusion and future scope

The means presented in the research industry to model building energy performance are diverse. Current research presents a wide range of complex models in an attempt to model the occupants' stochastic behavior. However, there's a narrow employment of such models in building energy simulation software. According to Gaetani et al. (2016), up till now, research has not offered recommendations to support the choice of a modeling technique with respect to occupant behavior in terms of simulation and prediction. This paper reviewed the most commonly used supervised machine learning methods for energy performance predictions and their use in predicting occupant's behavior in an attempt to identify the variations between the discussed models, as well as their benefits and limitations. The paper concludes that each supervised machine learning method has its own constraints and conditional requirements. Also the selection of method differs according to the input data available and application needs. The research deduces machine learning approaches, when selected properly, could provide

more accurate predictions and eventually support the simulation phase by providing more accurate predictions with an intent to minimize the energy performance gap.

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A Review of Geothermal Energy Resources for Electricity Generation in Oman

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Abstract

Oman, like other Arab gulf countries, depends on oil and gas to produce electricity. However, these resources are not guaranteed to last forever and constitute one of the energy security issues in the country. Oman's oil and gas reserves are comparatively low to other Gulf Cooperation Council (GCC) member countries. This article explores the potential of using geothermal energy resources for electricity generation in Oman. Geothermal energy is counted as a type of renewable energy, which means the availability is not affected by the lack of source and the increasing price of fossil oil. The review of geothermal energy shows that cost of electricity generation and greenhouses gases emission is comparatively lower than other form of renewable energy resources. Different types of geothermal plants are discussed with a reference of required temperature for operation of these plants. The binary cycle geothermal power plants are used for low temperature applications (85–175 °C). The temperature of 55 bore holes in Oman is more than 100^0 C which can be used in binary geothermal plants for electricity generation. The maximum temperature (173.68^0 C) is at PDO well "Makarem-I" located in the northern part of Oman. There is opportunity for Oman to adopt renewable energy resources and explore the potential of geothermal in more detail. This will help the country to reduce the dependency on oil and gas and compete in the region towards adopting renewable resources.

Key Words: Energy, Natural Resources, Renewable Energy, Fossil Fuels.

1. Introduction

Oman's economy is heavily reliant on oil and gas revenues, which accounted for about 84% in 2014 of the country's export earnings and 47.2% of its gross domestic product (CBO, 2015, NCSI, 2015). All of Oman's domestic energy consumption is supplied by natural gas and oil, reflecting the country's relative abundance of oil and natural gas reserves. In 2011, oil accounted for 71% of Oman's total primary energy consumption, and natural gas made up the remaining 29%. With the exception of 2009, Oman's petroleum consumption rose steadily over the past decade, reaching 154,000 barrels/day in 2013. This further has a significant contribution towards greenhouses gases.

Oman, like other Arab gulf countries, depends on oil and gas to produce electricity. However, these resources are not guaranteed to last forever, and are one of the energy security issues in the country. Some of the gulf countries have diversified their energy resources for example, the Emirates has considered nuclear and renewable energy as part of their electric generation and Qatar aims to generate 20% of its energy from renewables by 2024 with 1800MW of installed green capacity by 2020. As for Oman, the progress of renewable energy development is at a slow pace as currently the electricity generation is still dependent on oil and gas. Omani Vision 2020 seeks to reduce dependence on oil, diversify the economy and create new employment opportunities for all citizens. Omani Vision 2020 also stresses on the promotion of technology transfer and the increased use of natural and renewable resources, with due regard to the social and natural environment, which gives priority to the main key aspects (NCSI, 2008).

In the last two decades energy consumption in the Gulf Cooperation Council (GCC) member countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arab and United Arab Emirates) has increased rapidly. In 2013, the average electricity consumption in GCC countries was approximately 12370.91 kWh per year per capita while in China this value was 3762.07 (WB, 2016). GCC countries electricity consumption is more than double of the consumption per capita in United

Kingdom, which is 5407.29 kWh. In 2013, the electricity consumption per capita in Oman was 5981.45 kWh. The main reasons for the high consumption rate of electricity in GCC countries is high temperature in summer and secondly the cost of electricity is very low compared to other countries. The low cost of electricity for both domestic and industrial users in GCC countries don't encourage them to avoid the excessive use of electricity. In Oman, the electricity consumption is comparatively low than other GCC countries as Oman is somehow beyond in terms of infrastructures development and industrialization.

Umar and Wamuziri (2016) explore the potential of wind and solar energy in Oman and found that there is a huge opportunity to use these resources. This article provides a review of the geothermal energy resources in Oman by considering the temperature data from the Petroleum Development, Oman (PDO). Geothermal is derived from the Greek word; geo means earth, and thermal means heat, and it can be interpreted as a geothermal heat or energy produced from the earth. The temperatures of the 55 bore holes are more than 100^0 C which can be used for the electricity generation through binary geothermal energy power plant.

2. Geothermal Energy and Power Plants

2.1 Geothermal Energy

Geothermal energy is counted as a type of renewable energy, which means the availability is not affected by the lack of source and the increasing price of fossil oil. The energy contained in the geothermal fluid is water of which can be in vapor phase, liquid or both as a mixture. The fluid is usually located at a more than 1km depth below the earth's surface. The energy (hot water) comes from the radioactive decay energy from the center of the earth where the temperature can reach 6650 °C, and this energy moves to the earth's surface by conduction and convection (DiPippo, 2007, Gehringer and Loksha, 2012). It is estimated that the energy flowed from this activities reaches up to 42 million MW. Geothermal energy occurs due to three important elements in a specific location within the earth: source of heat, water and permeable layer (Dickson and Fanelli, 2013). The water comes from the rain or melting snow into the earth and trapped in impermeable layer and forming geothermal source, as shown in Figure 1 (Muffler and Cataldi, 1978). Geo-thermal energy can supply the need of the world's energy consumption for100,000 years (Sofyan, 2012).

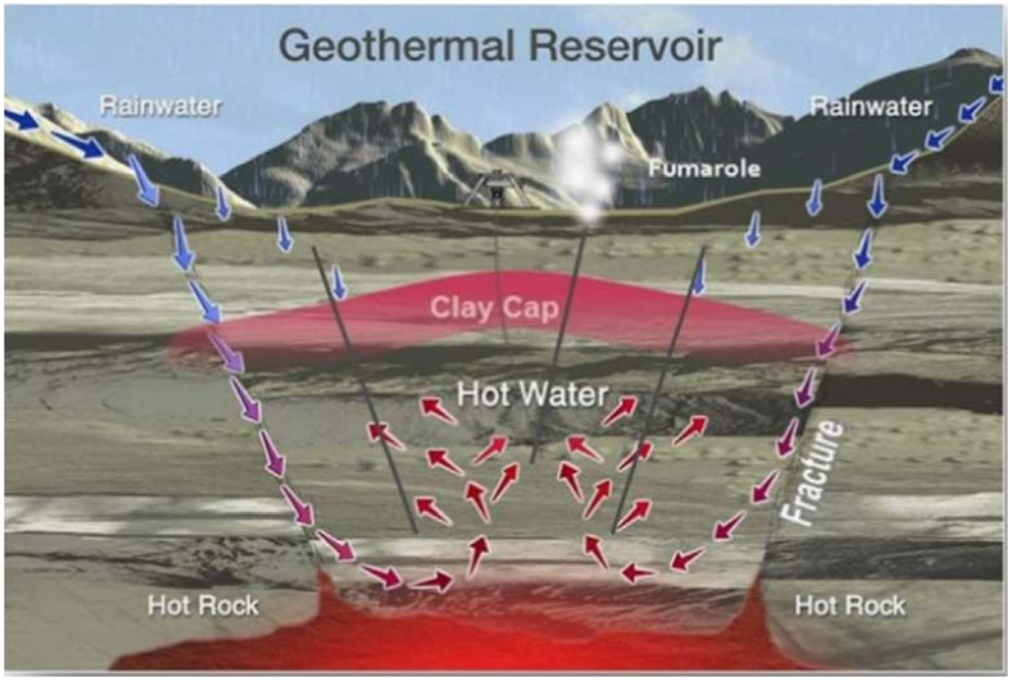

Figure 1 The Schematic of Geothermal (Ngangkham et al 2012).

Based on the fluid temperature, the enthalpy of geothermal energy can be classified into low, medium and high .Although sometimes classifying it can be confusing, it can be known by at least two variables to determine its thermodynamic state of the water (Lee 2001). Geothermal classification is still not standardized; some classifications separate geothermal in five categories based on its characteristics of reservoir. In order to provide the geothermal categories, table 1 can be used as the reference to obtain the five categories of geothermal such as hot water systems, two phase, liquid dominated systems, low enthalpy systems, two phase, liquid dominated, medium enthalpy system, two phase, liquid dominated high enthalpy system and two phase, vapor dominated systems (Eylem Kaya and O'Sullivan Michael 2011). Lower temperature (120–200 °C) requires pumping. They are common in extensional terrains, where heating takes place via deep circulation along faults, such as in the Western US and Turkey. Water passes through a heat exchanger in a Rankine cycle binary plant. The water vaporizes an organic working fluid that drives a turbine. These binary plants originated in the Soviet Union in the late 1960s and predominate in new US plants. Binary plants have no emissions. Heat pumps extract energy from shallow sources at 10–20 °C in 43 countries for use in space heating and cooling. Home heating is the fastest-growing means of exploiting geothermal energy, with global annual growth rate of 30% in 2005 and 20% in 2012.

Table 2 Categories of geothermal systems (Eylem Kaya and O'Sullivan Michael 2011).

Category **Hot-water**		**Temperature (T)**	**Production enthalpy (h)**
		T < 220˚C	h < 943 kJ/kg
Two-phase, liquid-dominated	Low-enthalpy	220˚C < T < 250˚C	943 kJ/kg < h < 1100 kJ/kg
	Medium-enthalpy	250˚C < T < 300˚C	1100 kJ/kg < h < 1500 kJ/kg
	High-enthalpy	250˚C < T < 330˚C	1500 kJ/kg < h < 2600 kJ/kg
Two-phase, vapour-dominated		250˚C < T < 330˚C	2600 kJ/kg < h < 2800 kJ/kg

2.2 Geothermal Power Plants

According to Mehmood et al (2016) Geothermal resources are available in three temperature ranges: (a) Low Temperature, (b) Moderate Temperature, and (c) High Temperature. Temperature greater than 150 °C is high temperature while, temperature more than 90 °C and less than 150 °C is moderate temperature and temperature lower than 90 °C considered as low temperature. For different ranges of temperature, separate geothermal plants are used for electric power generation. Geothermal energy used as power generation is usually referred as geothermal power plant and the power plants are environmental friendly, renewable and sustainable due to the characteristics of the energy source (Duffield and Sass, 2003; Jennejohn and Blodgett, 2012). CO2 emissions from coal fired power plants is12 times greater than the geothermal power plant, while the CO_2 emission from gas power plants produces 6 times larger than geothermal power plant (Nasruddin et al 2016). In addition, the area required for geothermal power plant is smaller than the area required by conventional power plant (Risch 2012). Another advantage of geothermal power plant is the ability to sustain base load electricity, since the energy produced does not fluctuate against the weather or season, hence continuous electricity production is possible Edrisi and Michael 2013; EPRI, 2010).

There are three types of geothermal power plants in use today, namely dry steam, flash steam and binary cycle. The dry type or direct steam power plant (figure 2) is the typical geothermal plant with steam vapor dominated (dry-steam). Dry steam generated from several production wells are circulated by pipes to the turbine. The high temperature and pressure steam rotates the turbine. This approach to utilize geothermal energy is restricted because dry-steam hydro thermal resources are very rare.

In flash steam power plant, hydrothermal fluids above 182 °C can be used to make electricity. Fluid is sprayed into a tank held at a much lower pressure than the fluid, causing some of the fluid to rapidly vaporize, or "flash", also termed as "Wet Steam Power Plant". The vapour then drives a turbine, which drives a generator. If any liquid remains in the tank, it can be flashed

again in a second tank to extract even more energy. Flash power plants can be categorized in single flash and multiple flash plants. Hot water is collected in a vessel and as water pumps to the generator water is released from hot geothermal reservoir and abrupt change in pressure force some water to be converted in to steam. The steam rotates the turbine and finally electrical output received by generator that is operated by turbine action as presented in figure 3.

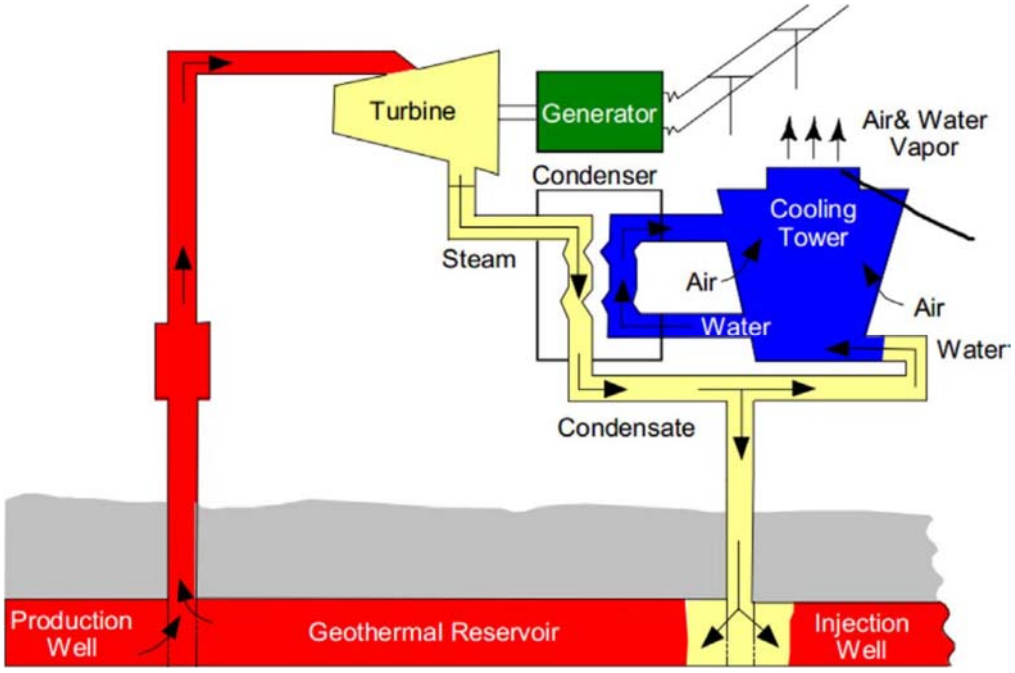

Figure 2 Dry or Direct Steam Power Plant (GSE, 2011; Kagel, 2009; Lund, 2009).

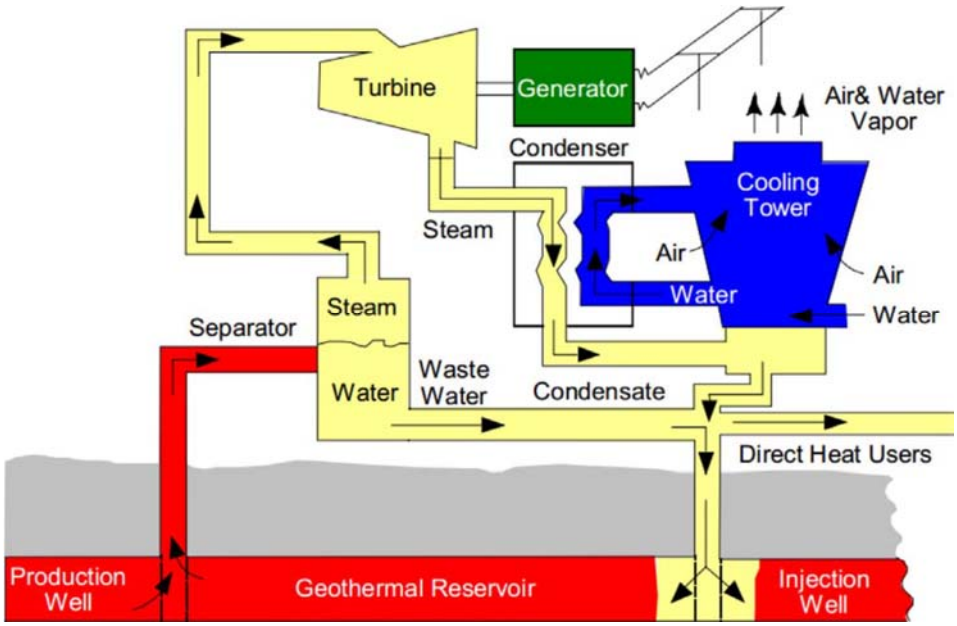

Figure 3 Flash Steam Geothermal Power Plant (GSE, 2011; Kagel, 2009; Lund, 2009).

Binary Cycle Geothermal Power Plants are used for low temperature applications. The hot water heat up another fluid having low Boiling Point (BP) organic compound, fluid like butane

(BP=-0.5) by heat exchanger. Steam of that fluid is used to rotate the turbine and further turbine operate generator for electrical output. Two fluids in binary cycle power plant are:

a) Geothermal Fluid (Extracted from geothermal reservoir).
b) Working Fluid (Low boiling Point).

Geothermal fluid transfer its energy to working fluid using heat exchanger and working fluid is converted in to steam. The steam operates the turbine; steam is then condensed and prepared for the next cycle. Geothermal fluid is sent back to reservoir for maintaining internal temperature of the geothermal reservoir. Furthermore, binary cycle plant operated at temperature 85–175 °C. The temperature has very less carbon emission (Kose, 2007). The typical structure of the Binary Cycle Geothermal Power Plant is shown in figure 4.

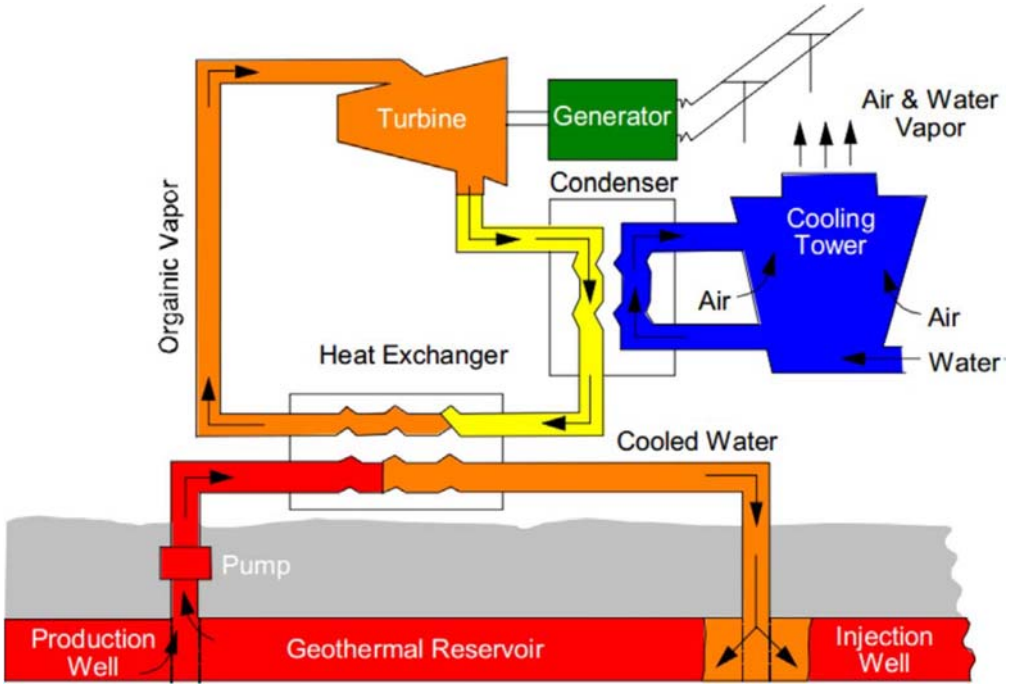

Figure 4 Binary Cycle Geothermal Power Plant (GSE, 2011; Kagel, 2009; Lund, 2009).

Research conducted by Shevenell (2012) on Nevada geothermal wells reported that geothermal projects cost might be expected to range from $835,000 to $3.4 million per MW if the drilling of well will be successful. Similarly, drilling costs per MW were estimated using all drilled wells (successful or not) and indicate costs could range from $341,000 to $1.1 million per MW. A typical breakdown of costs of completing a geothermal power production facility from beginning to end has been presented by GEA (2005) and Hance (2005) as shown in figure 5. Although the data presented here is more than 10 years older, however it helps to understand the cost of different stages of a geothermal power project. It is needed to note that the percentage of such cost may vary from country to country.

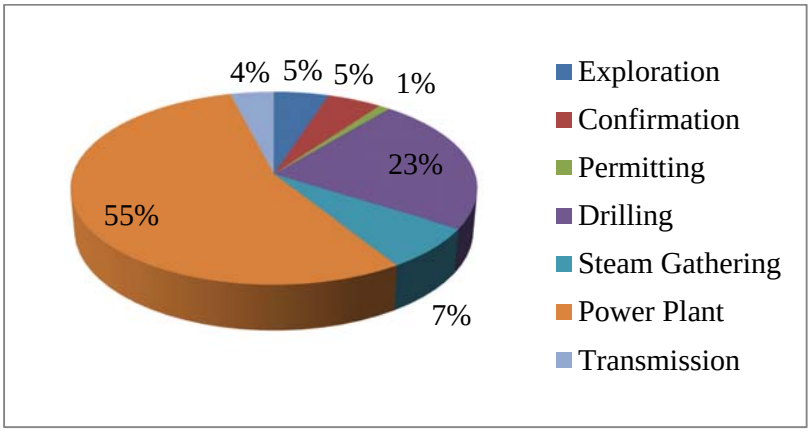

Figure 5 Typical cost breakdown of geothermal power projects (Hance 2005).

3. Geothermal Resources in Oman

The underground fluid temperature is the key element and need to be considered to evaluate the potential of geothermal energy for electricity generation and other uses. Knowing the temperature will further help to use the appropriate geothermal plant for energy generation. The Oman hot water springs is one of the main prediction which justify that the lower temperature of the fluid could be comparatively high than the temperature of the water of these springs. According to the Oman Water Society (OWS, 2016), there are more than more than 360 water springs; most of which are in Musandam, Muscat and Dhofar Governorates and are non-traditional sources for fresh water. 23 springs are classified as hot water springs which are very famous for tourism and natural therapy. For instance the temperature of the spring at Al Kasfah (figure 6), located in Wilayt Ar Rustaq in Al Batinah South Governorate is 45 degree Celsius (MOT, 2016). To further explore the potential of underground temperature and to see the possibility of using geothermal energy in Oman, it was necessary to examine the fluid temperature at certain depth in Oman. Such exploration required boring to obtain sample from earth and examine to temperature and as such involve huge cost. The geothermal gradient can be used to estimate the depth of the desired temperature, however as the thickness of the crust varies around the world therefore using an average value of geothermal gradient (25°C/km) would not give an accurate results.

Figure 6 Al Kasfah Spring in Oman (MOT, 2016).

The only organization which conducts underground exploration in Oman is the Petroleum Development of Oman (PDO). The main purpose of PDO exploration is to search for new oil and gas reserve, however, measurement of sample temperature at certain depth is part of such exploration. PDO operates over 5000 well drillings in more than 120 oil fields in Oman. PDO is producing 7 barrels of well water per barrel of crude oil (5 to 6 million barrels of water a day). Most of the produced well water is re-injected in the same or new wells. The average temperature of the well water was estimated to 86° C (AERO, 2008). The latest data obtained from PDO show significant temperature (table 2) at different location of Oman, which could be used for energy generation. The 55 bore holes which have a temperature of more than 100° C are located in block 6 as shown in figure 7.

Table 2 Temperature of 55 Bore holes (Temperature above 100^0 C).

Well Name	**Temperature (°C)**	**Well Name**	**Temperature (°C)**
ABU THAYLAH	102.70	YIBAL IV	131.10
AL BASHAIR	157.00	ZALZALA	107.10
AL FAISAL	116.51	AL HUSAIN	125.00
AL NOOR	101.40	AL HUWAISAH I	126.40
AMBRAH	100.92	AL HUWAISAH II	110.00
ASEEL	100.48	AL HUWAISAH III	114.00
ASFOOR	117.74	AL HUWAISAH IV	124.00
BARIK	124.38	DHULAIMA I	104.00
DAFIQ	103.00	DHULAIMA II	157.80
FAAL	120.74	FAHUD	130.00
FAHUD SOUTH EAST	163.00	FUSHAIGHA	110.00
FAHUD SOUTH	106.60	HASIRA I	103.30
FAYROUZ	101.63	HASIRA II	103.00
INAAM	153.84	LEKHWAIR I	101.70
KHAZZAN I	157.65	LEKHWAIR II	160.00
KHAZZAN II	145.74	LEKHWAIR III	147.00
LAHAN	129.64	SAIH NIHAYDA	111.00
MABROUK I	121.10	SAIH RAWL I	100.60
MABROUK II	114.40	SAIH RAWL Ii	133.00
MAKAREM I	173.68	SHUWAIQI	118.90
MAKAREM II	170.00		
MUSALLIM	147.54		
NIBRAS	142.84		
QARN NIHAYDA	110.00		
QASHOOB	115.40		
RABAB	117.00		
SABEEL	114.00		
SAKHIYA	107.33		
SUWAIHAT	106.40		
TIBR	140.13		
YIBAL I	137.20		
YIBAL II	123.00		
YIBAL III	111.00		

Figure 7 Location of Boreholes with Temperature more than 100° C.

Considering the temperature data of different bore holes in table 2, the binary cycle geothermal power plant which operate at a temperature of 85 – 175° C, can be used for power generation. According to Parada (2013), the binary power plants are 44% of the world total geothermal power plants. A comparison of cost for electricity generation using different renewable sources is shown is figure 9. It is clear that the cost of electricity generation from geothermal binary plant is comparatively low than solar, hydro, wind and nuclear. Electricity generation costs for a 50 MW geothermal binary plant is $ 92 per megawatt hour (GEA, 2016). Such comparison provides a guideline to adopt an appropriate source of renewable energy in Oman. The maintenance of binary cycle power plants is highly influenced by different factors such as: the nature of the geothermal fluid used in the primary loop, the nature of the working fluid, the technology and location of the plant, climate and weather. Corrosion and scaling are the most common problems in binary power plants (Parada, 2013).

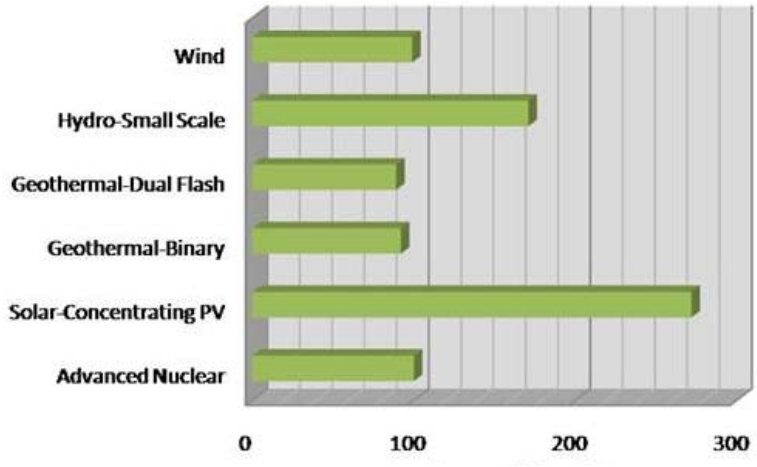

Figure 8 Electricity Generation Cost in US $ per 50 MWh from Different Renewable Energy Resources (GEA, 2016).

4. Conclusion

The temperature data obtained from PDO of 55 bore holes indicates that there is potential of utilization geothermal energy resources in Oman. Considering the temperature of these bore holes, the binary geothermal plant can be used to produces electricity. Energy production cost of binary geothermal is low compared to solar and wind. The initial cost of the geothermal project is high while the success of drilling is the main contributing factor. The maintenance of binary cycle power plants is highly influenced by different factors including the nature of the geothermal fluid, the technology and location of the plant, climate and weather. Other issues with binary geothermal plants are corrosion and scaling. In GCC region, Emirates is has set the target to produces 25% of power by renewable sources by 2030 and Qatar aims to generate 20% of its energy from renewables by 2024. Emirates have recently started the feasibility study on the use of geothermal resources. There is an opportunity for Oman to consider geothermal energy resources and to reduce the dependency on oil and gas. This research is exploratory in nature and considers the temperature data for the potential use of geothermal resources in Oman. The data presented in this article is from the PDO, keeping in mind that the main focus of PDO is on the oil and gas resources. The depth of required temperature to use the geothermal resources will be a factor that will contributes towards the cost and needs to be considered during the feasibility study. While planning for using geothermal resources, Lund (2009) suggest that several environmental impacts including emission of harmful gases, noise pollution, water use and quality, land use, and impacts on natural phenomena, wildlife and vegetation needs to be considered.

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The Potential of Biomass for Electricity Generation in Oman

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Abstract

Oman, like other Arab gulf countries, depends on oil and gas to produce electricity. However, these resources are not guaranteed to last forever and constitute one of the energy security issues in the country. This article explores the potential of using biomass energy resources for electricity generation in Oman. Energy from biomass resources is counted as a type of renewable energy, which means the availability is not affected by the lack of source and the increasing price of fossil oil. The review of biomass energy shows that waste from different sources such as wood and woody plants and their wastes, agricultural crops and residues, municipal solid organic wastes, animal wastes, sewage, waste from organic industrial processing and food processing, and aquatic plants and algae can be used for electricity generation. The biomass from animal manure and wastewater are reported with its potential for electricity generation. The results show that a total of 2651.81 GWh per year electricity can be produced from animal manure and wastewater which corresponds to 10% of the total electricity consumption in Oman. Although there is potential to use biomass for a sustainable electricity generation, however several environmental, social and technological factors associated with biomass energy need to be considered before adopting such resources.

Keywords: Energy, Sustainability, Waste management & disposal, Renewable energy

1. Introduction

Energy is essential to economic and social development and improved quality of life in all countries. Problems with conventional energy are that it produces greenhouse gases which affect climate and can't sustain for long time. It is essential to tackle these problems by moving towards sustainable energy. Oman's economy is heavily reliant on oil and gas revenues, which accounted for about 84% in 2014 of the country's export earnings and 47.2% of its gross domestic product (CBO, 2015, NCSI, 2015). All of Oman's domestic energy consumption is supplied by natural gas and oil, reflecting the country's relative abundance of oil and natural gas reserves. In 2011, oil accounted for 71% of Oman's total primary energy consumption, and natural gas made up the remaining 29%. With the exception of 2009, Oman's petroleum consumption rose steadily over the past decade, reaching 154,000 barrels/day in 2013. This further has a significant contribution towards greenhouses gases.

Oman, like other Arab gulf countries, depends on oil and gas to produce electricity. However, these resources are not guaranteed to last forever, and are one of the energy security issues in the country. Some of the gulf countries have diversified their energy resources for example, the Emirates has considered nuclear and renewable energy as part of their electric generation and Qatar aims to generate 20% of its energy from renewables by 2024 with 1800MW of installed green capacity by 2020. As for Oman, the progress of renewable energy development is at a slow pace as currently the electricity generation is still dependent on oil and gas. Omani Vision 2020 seeks to reduce dependence on oil, diversify the economy and create new employment opportunities for all citizens. Omani Vision 2020 also stresses on the promotion of technology transfer and the increased use of natural and renewable resources, with due regard to the social and natural environment, which gives priority to the main key aspects (NCSI, 2008).

In the last two decades energy consumption in the Gulf Cooperation Council (GCC) member countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arab and United Arab Emirates) has increased rapidly. In 2013, the average electricity consumption in GCC countries was approximately 12370.91 kWh per year per capita while in China this value was 3762.07 (WB, 2016). GCC countries electricity consumption is more than double of the consumption per capita in United

Kingdom, which is 5407.29 kWh. In 2013, the electricity consumption per capita in Oman was 5981.45 kWh. The main reasons for the high consumption rate of electricity in GCC countries is high temperature in summer and secondly the cost of electricity is very low compared to other countries. The low cost of electricity for both domestic and industrial users in GCC countries don't encourage them to avoid the excessive use of electricity. In Oman, the electricity consumption is comparatively low than other GCC countries as Oman is somehow beyond in terms of infrastructures development and industrialization.

Umar and Wamuziri (2016) explore the potential of wind and solar energy in Oman and found that there is a huge opportunity to use these resources. Since ancient times biomass has played an important role in the society, and is nowadays used as fuel in a wide range of applications, such as cooking, heating and power generation. Biomass can be converted into electric power through several methods. Heat is used to thermos chemically convert biomass into a fuel oil which is then burned like petroleum to generate electricity. Biomass can also be burned directly to produce steam for electricity production or manufacturing processes. One alternative for producing electricity from biomass in a gas turbine is direct combustion of biomass as a primary energy source. Biomass is burned directly to produce steam, the steam turns a turbine which derives a generator thus electricity is generated. The aim of this paper is to make an assessment of the potential in biomass resources available in Oman and discuss this potential with respect to the expected long-term sustainable energy needs of the country. It is estimated that Oman can produce 2604.44 GWh from animal manure and 47.37 GWh from wastewater treatment.

2. Literature Review

In September 2015, the 193 United Nation (UN) member states adopted the new Sustainable Development Goals (SDGs) consisting of 17 goals, supported by 169 targets and underpinned by 230 global indicators. Access to affordable, reliable, sustainable and modern energy for all is one of the UN sustainable goals set for achievement by 2030 (UN SDGs, 2015). Energy from solar, wind, geothermal, biomass, waves and tidal are some of the sustainable resources of the energy adopted in different regions. In the year 2010, renewable energy sources accounted for an estimated 16.7% of global final energy consumption, while traditional biomass accounted for 8.5% of total energy consumption globally (EUI, 2013). It is projected that electricity generation from different renewable resources will be more than 10 trillion kilowatt-hours by 2040 (EIA, 2016). Biomass resources include wood and woody plants and their wastes, agricultural crops and residues, municipal solid organic wastes, animal wastes, sewage, waste from organic industrial processing and food processing, and aquatic plants and algae. The use of biomass to produce electricity has steadily increased by an average of 13 TWh per year between 2000 and 2008. Biomass based electricity has maintained its market share of total global generation over the last 20 years, at approximately 2% (Strezov. and Evans, 2010). Statistics from International Energy Agency indicates that a total of 370 TWh of bioenergy electricity was produced in 2012, which corresponds to 1.5% of world electricity generation (IEA, 2016).

A recent conducted by Hamamre et al. (2017), on sustainable-renewable energy resources for Jordan shows that Jordan has an annual power potential 847.39 GWh from different types biomass. In the last decade, many new biomass power plants have been built and the development of new technologies for biomass-based power generation is going on. Figure 1 shows the integrated biomass gas turbine/steam combined cycle power plant (Alidrisi, and Demirbas, 2016).

There are three primary technology categories (Pyrolysis, Gasification and Direct combustion) used for the combustion based conversion of biomass into electricity. Each category has undergone significant development and therefore has many different methods available. A simple biomass electric generation system is made up of several key components. For a steam cycle, this includes a combination of the following items:
(i) fuel storage and handling equipment, (ii) gasfier, (iii) combustor/furnace, (iv) boiler, (v) pumps, (vi) fans (vii) steam turbine, (viii) generator, (ix) condenser, (x) cooling tower, (xi) exhaust/emissions controls, and (xii) system controls (automated).

The generation of electricity from biomass faces various environmental, technological and social challenges. Electricity price, efficiencies, greenhouse gas emissions, availability and limitations for biomass produced electricity are currently favourable, when compared with the other energy generation options, however, significant attention must be given to reducing the

land and water use and, the social impacts of biomass power generation before sustainability can be achieved (Evans et al. 2010).

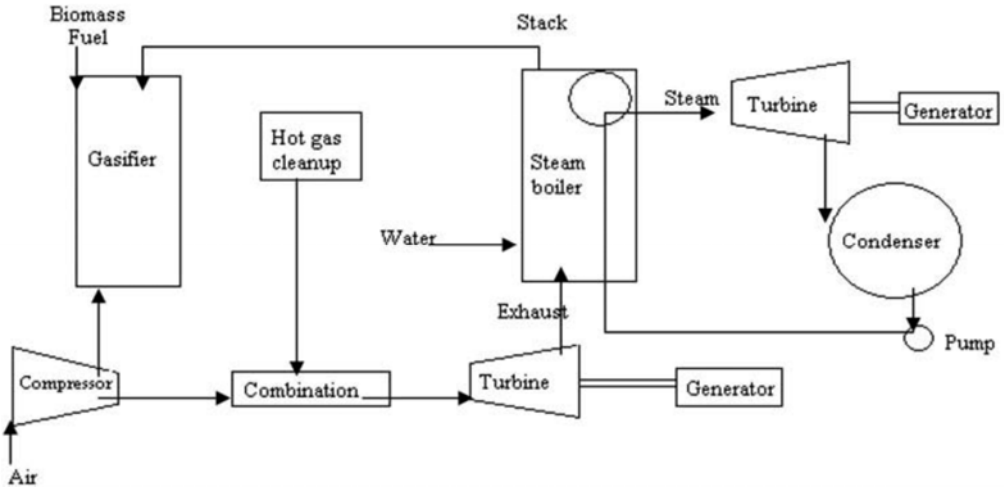

Figure 1 Integrated biomass gas turbine/steam combined cycle power plant (Alidrisi, and Demirbas, 2016)

3. Biomass Energy Potential in Oman

Although biomass from different sources are available in Oman, however the two of them i.e., animal waste and waste from water treatment are discussed here.

3.1 Biomass Energy from Animal Manure

Oman is endowed with its rich biodiversity as it has not only diversified traditional agriculture involving almost all types of animal and crop species but also vast rangelands especially in Dhofar having various pasture species, the source of feeding large number of animals. Oman has wide diversity of animal genetic resources which are indigenous and known to be in the Sultanate since time immemorial. These constitute cattle, sheep and goats, poultry and camels. For the number of different animals the Ministry of Fisheries and Agriculture in Oman is used. The total number of animals in 2014 stood at 547,713 for cows, 273,203 (camels), 311,1569 (goats), and 102,6395 (sheep) respectively (MAF, 2014). Table 1 show the number of different types of animal in different regions of Oman.

Table 1 Number of Animals in Different Regions of Oman (MAF, 2014)

Region	Cows	Camels	Goats	Sheep
Muscat	5492	525	77809	23258
Dhofar	207891	151571	283689	15105
Musandam	333	21	127985	13399
Al Buraimi	5890	4395	85019	39792
Al Dakhilia	18063	11537	229180	59573
Al Batinah North	67119	11003	351717	136996
Al Batinah South	23113	9114	157379	51388
Al Sharqiyah South	9260	20375	312986	78575
Al Sharqiyah North	8431	24592	250356	76129
Al Dhahirah	13914	6938	169548	65135
Al Wusta	1	20810	104245	22237
Imported	188206	12322	961656	444808
Total	**547713**	**273203**	**3111569**	**1026395**

According to Monteiro et al. (2011) the Manure or the total solids (TS) are estimated per year for different types of animal considering the average value of 5.5 kg/day for cows, 4.16 kg/day for camels, and 0.5 kg/per day for goats and sheep. The volatile solid (VS) in each category is obtained by multiplying 0.75 to total solid as shown in table 2. An average value for the weight of each type of animal is considered for this calculation.

Table 2 Calculation of Total Volatile Solids from Manure of Different Animal

Types of Animals	**Cows (250 kg)**	**Camels (250 kg)**	**Goats (25 kg)**	**Sheep (30 kg)**
Total number	**547713**	**273203**	**3111569**	**1026395**
Manure - Total Solids (TS) tonnes / year per animal	5.5 x 30 x 12 / 1000 = **1.98**	4.16 x 30 x 12 / 1000 = **1.50**	0.5 x 30 x 12 / 1000 = **0.18**	0.5 x 30 x 12 / 1000 = **0.18**
Total TS tonnes / year	1.98 x 547713 = **1084471.74**	1.5 x 273203 = **409804.5**	0.18 x 3111569 = **560082.43**	0.18 x 1026395 = **184751.10**
VS (Volatile Solids) tonnes / year	0.75 x 1084471.74 = **813353.80**	0.75 x 409804.5 = **307353.37**	0.75 x 560082.43 = **420061.82**	0.75 x 184751.10 = **138563.32**
Total VS tonnes / year	**1679332.32**			

Research conducted by Monteiro et al (2011) shows that biogas production is 0.33 m^3/kg from animal Volatile Solids. Widyastuti et al (2013) reported that 4.7 kWh of electricity could be produced by 1 m^3 biogas. Thus the potential of biogas production and electricity generation per year from animal manure listed in table 2 is as under:
Biogas production = 1679332.32 x 1000 x 0.33 **= 554179665.6 m^3 / year**
Electricity Production = 554179665.6 x 4.7 **= 2604644428.32 kWh or 2604.44 GWh**

3.2 Biomass Energy from Wastewater Treatment (Sludge)

Responsibility for Oman's wastewater sector is divided among five entities with each having a different geographic jurisdiction. They are:

a) Haya Water oversees wastewater services in the Muscat governorate.
b) Salalah Sanitary Drainage Services Company (SSDSC) looks after Salalah city, and some part of the Dhofar governorate.
c) Dhofar Municipality has responsibility for the rest of the Dhofar region.
d) Sohar Development Office within Muscat Municipality looks after the Sohar province.
e) The Regional Municipalities & Water Resources Ministry has responsibility for the rest of Oman.

In addition to the wastewater treatment plants and networks owned and operated by the five public entities, hundreds of smaller plants are also owned by the private sector. The total wastewater treatment capacity in 2008 was 105,990 m^3/ day (figure 2) and it was estimated that 230,000 m^3/ day (MEED, 2008). Thus the total capacity for wastewater treatment by the end of 2016 is estimated 335,990 m^3/ day.

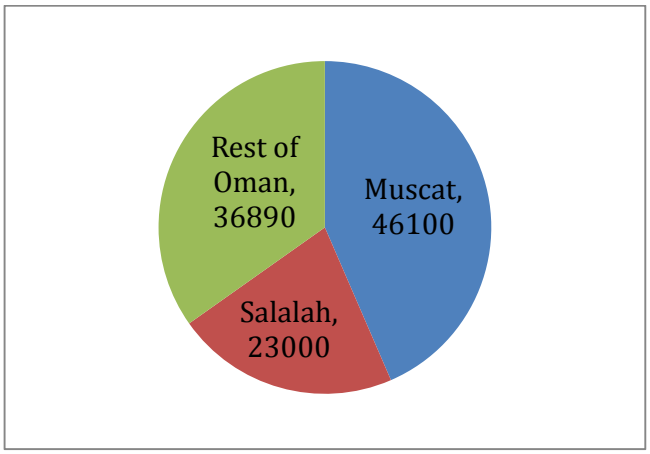

Figure 2 Capacity of Wastewater Treatment (m^3/ day) in Oman (2008).

Typical primary and secondary wastewater treatment produces a total of about 1.95 lbs (0.94 kg) of dry solids per 1,000 gal (3.78 m^3) of wastewater treated (Metcalf and Eddy, 1991). Thus the quantity of sludge for one m^3 can be translated as 0.25 kg. Under optimum digestion conditions, biogas yield of 315 – 400 m^3/tones organic dry matter can be expected (Hanjie, 2010). A simple principle is that one third of the solid matter in the sludge can be transformed into biogas which is equivalent to about 50% of the organic matter (IEA Bioenergy, 2015). Using this criterion, the electricity production from wastewater in Oman can be 47.37 GWh as shown below.

Amount of treated wastewater = 335,990 m^3/ day
Production of sludge from treated wastewater = 0.25 x 335,990 = 83997.5 m^3/ day
Biogas Production from sludge = 83997.5 x 1/3 = 27999.16 m^3/ day
Biogas Production per year = 27999.16 x 30 x 12 = 10079697.6 m^3/ year
Electricity Production per year (4.7 kWh / 1 m^3) = 10079697.6 x 4.7 = 47374578.72 kWh or **= 47.37 GWh**

The total electricity production from animal manure and wastewater treatment is about 2651.81 GWh. Statistics from National Centre for Statistic and Information (NCSI, 2016) indicates that the total population of Oman at the end of 216 was 4,548,856 and electricity consumption is 5981.45 kWh. Thus the total electricity demand in Oman is around 27208.75 GWh. The waste from two sources (animal and wastewater) consider in this article can constitute up to 10% of the total electricity requirement in the country. Considering the use of biomass from other sources will not only increase the electricity production but will a more sustainable waste management.

The generation of electricity from biomass faces various environmental, technological and social challenges. Electricity price, efficiencies, greenhouse gas emissions, availability and limitations for biomass produced electricity needs, to be compared with the other energy generation options. Apart from this, significant attention must be given to reducing the land and water use and, the social impacts of biomass power generation before sustainability can be achieved (Evans et al 2014). The cost of electricity production from biomass is cheaper than photovoltaics, approximately equal with geothermal but more expensive than wind and hydro (Evans et al 2009).

The production of biogas from different waste is the key to enhance the electricity production. The research work conducted by Palaniswamy et al (2016) on production of biogas from kitchen waste mixed with the cow manure using an artificial neural network. The results of their research show that the highest biogas performance level of 375 ml/g volatile solids on the 25th day of digestion was achieved by a substrate profile of 80% food waste and 20% cow dung at a temperature range of 30–40°C.

4. Conclusion

Oman like other gulf countries produces electricity from oil and gas resources which are no longer lasting and sustainable. Oil and gas reserve of Oman are low compared to other GCC

countries, therefore it is essential for the country to move towards sustainable energy resources. Different research studies show that Oman can utilize the renewable energy resources from solar, wind and geothermal for electricity generation. This article provides an assessment of using biomass from two sources (animal manure and wastewater) for electricity generation. Biogas production from selected animal manure (cow, camel, goats and sheep) is estimated up to 554179665.6 m^3 / year which can produce 2604.44 GWh electricity. The treated wastewater is estimates as 335,990 m^3/ day which have an electricity generation capacity of 47.37 GWh. There are several environmental, social and technological factors associated with electricity generation from biomass need to be considered before adopting such resources. Different research has shown that electricity generation from biomass is expensive from some form of renewable energy resources. Further research needs to be conducted to evaluate the total quantity of biomass from all sources in Oman and corresponding electricity production. A full feasibility need to be carried out to evaluate to cost effective sources for electricity generation among different available renewable energy resources in Oman.

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Solar Systems Efficiency, Optimum Tilt Angle and Useful Electricity Output for Bahrain and GCC Countries

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Abstract

The electricity generation by solar systems is widely used nowadays and it can be a sustainable investment for Bahrain and GCC countries as high solar potential is available. In this paper the real solar efficiency estimation is attempted according to the geographical location and the environmental conditions, as the amount of atmospheric dust and humidity and the high climate average temperatures in most of the calendar year. In addition an extended investigation is presented concerning the tilt angle values, the estimated panels' temperature, the purity of the horizon influence, the effectiveness of the most popular types of panels and the performance reduction factors types and values according to the climate conditions and requirements. The efficiency and useful electricity generation are estimated annually and certain parameters are highlighted and defined as the SCT conditions for the panels seems not to be a good performance indicator for this region, while NOCT should be considered as well. It is concluded that as GCC countries and Bahrain are exposed to a peak insolation of approximately 7 kWh/m^2/day with average daily sunshine more than 10 hours, if certain instructions and considerations are followed, the solar systems application can be a sustainable solution for electricity generation for Bahrain and GCC although the efficiency drops to 11% for single-crystalline type of panels.

Keywords: panels' efficiency, GCC countries, performance reduction factors, NOCT.

1. Introduction

The main operation and performance of the renewable solar energy sources is based on the sun existence and the energy of solar irradiance, which reaches the earth. The sun provides the earth continuously large amounts of energy, which we utilize by a variety of ways. In recent decades, after the decline in stocks of oil and the environmental impact of traditional energy sources, the international community is trying to use more soft power based on utilization of energy provided by the sun.

The renewable resources of energy development seem to be more necessary than ever as the electricity consumption is growing rapidly. The European Union's energy consumption is expected to grow by 0.7% to an annual rate up to 2030 (Europe APE, 2014). Also in the world petroleum congress had been held in Moscow, they said through the report titled «BP Statistical Review of World Energy 2014» that renewable energy sources accounted for over 5% of global electricity generation for the year 2013, while the share of photovoltaic systems was 33% (Giakoumelos, 2013).

The Gulf Cooperation Council (GCC) Countries intent to invest even more to the renewable resources of energy to the near future, although the oil and gas production is still in a high level. The six GCC countries of Saudi Arabia, United Arab Emirates, Kuwait, Qatar, Oman and Bahrain cover their energy needs through the oil and gas production (Abdmouleh, 2015), while the electricity consumption in each country is comparatively high, mainly due to the air-conditioning function demand. The geographical coordinates - location of the GCC countries provide them a high solar potential and good solar energy exposure. Several projects have been developed in this area and it seems that the necessary conditions exist in order to invest in this type of renewable source. Many researchers have noticed the particularities of this area and

they have studied the parameters of the solar energy systems applications, since long, as Patlitsianas (Paltitsianas, 2006), who tries to set the appropriate conditions of this type of projects according to the available companies, the policies and the cost. As Alnaser (Alnaser, 2011) present the current situation in renewable energy projects in the region, it seems that the relating projects exceed 600MW, where Kingdom of Bahrain has its significant role.

Concerning the U.A.E. region, various research works have been done, as Chaar (Chaar, 2010), who focus on the solar radiation in Abu Dhabi, or Islam (Islam, 2009), who present a measurement technique for the solar radiation in the same region and relating results with acceptable convergence. The data which are presented by Makri (Makri, 2013) prove that the electricity demand in U.A.E. has been increased significantly, while the high economic development of the country led also to CO2 emissions high precedence and the solar energy projects can be an effective solution due to the irradiation values in this country. Similar studies have been developed for Oman (Albadi, 2011), Libya (Fathi, 2007), Algeria (Benatiallah, 2007) or North Africa (Tsikalakis, 2011), showing according to the particular parameters that the solar energy exploitation can be beneficial and sustainable for these countries as well.

The Kingdom of Bahrain is always open in the renewable resources of energy development following the GCC countries vision as some solar systems applications have been already developed in the country (Mokri, 2013) in the last decade (Alnaser, 1995), (Alnaser, 1989).

1.1 Aim and Objectives

In the present paper we study the necessary requirements, constrains, parameters and estimations for an efficient usage and installation of photovoltaic systems in GCC countries and especially in Bahrain. Although the parameters set can be applied for any PV applications, this study is recommended mainly for cases with limited available area as in buildings. The solar systems efficiency in this geographical location is calculated in real numbers indicating the reasons of the drop and the value of the drop difference. The optimum tilt angle, the azimuth, the orientation and the tracking system effectiveness are presented. Current data have been used regarding the Bahrain weather and climate, as air humidity, dust precedence in the atmospheric air, average annual and monthly temperatures, purity of horizon and solar irradiance values, in order to identify the most appropriate proposal for solar systems development to this region. We based on recent studies in this field and extend their findings in order to present efficient solar energy solutions for this region (Alnaser, 1985), (Alnaser, 1995), (Sadah, 1990).

2. Data and Theoretical Methodology

Solar energy has several positive aspects such as, reduction of greenhouse gases, increased energy independence, job opportunities and improved quality of life. Although the solar energy applications based on sun existence and simple physics properties, the efficient photovoltaic' s systems development and installation is a complicated study due to the demand of making the appropriate choices according to the geographical location, in order to achieve the highest panels' efficiency.

2.1 GCC countries and solar energy projects in Bahrain

The Arab Gulf has already begun important efforts to use the solar energy for electricity production and it seems that according to several studies can be an efficient and sustainable solution for the near future. As it is expected due to the known climate conditions and it is depicted in the solar radiation map of the Arab Gulf (Figure 1), the Gulf Area is annually exposed to a significant amount of irradiance from the sun, with a range between 1400-1700 kWh/m^2/year (Dashti, 2015). Furthermore, viewing the global solar radiation in GCC countries, it is shown in the graph below that the peak daily irradiance in Kuwait reaches over 8KWh/m2

in June, followed by the UAE at about 7.5 kWh/m2 in May, while KSA and Bahrain are exposed to a peak irradiance of approximately 7 kWh/m2 (Kim, 2013).

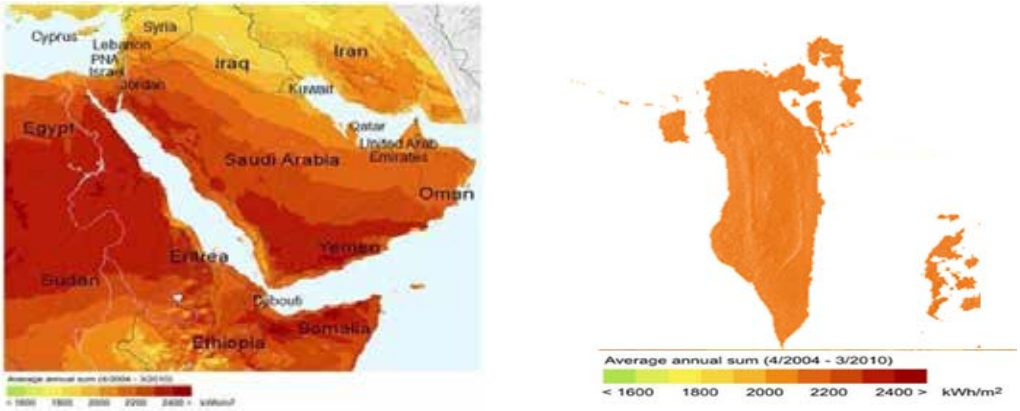


Figure 1 Solar radiation in Middle East countries (Kim, 2013) and solar potential in Bahrain (Modi, 2016).

In Bahrain the annual average temperatures is about 30 °C to 32 °C and presents a very high solar capacity of 2,300 KWh / m^2 The country has already started to invest in the exploitation of solar energy in recent years and it seems that a lot of progress may follow as Bahrain and the Gulf Cooperation Council countries (GCC) have some of the highest levels of solar radiation in the world (Figure 2).

The County makes the first steps to exploit renewable energy sources and various proposals have been submitted by the academic and industrial sector. Today in Bahrain have been completed the procedures for installing a pilot system for the production of electricity. The project is based on the installation of PV systems that will produce 5MW per year, and it will be installed in three different areas; in Awali 1,6 MW, in the refinery park of BAPCO 3 MW, and in the University of Bahrain campus 0,5 MW (Kloosterman, 2014). This project will provide more than 8,000 MWh of electricity, which is attributable of high savings as 67.000 MCF (thousand cubic feet) of gas and 6,900 metric tons of carbon dioxide each year (Solar Green Energy, 2016). Also in the Al Door area, an area of approximately 12 hectares, has decided to be installed a hybrid system consisting by PV of power 3 MW, and wind power equal to 2 MW. In the Juffair district the lamps for lighting have been replaced by LED lamps and it can decrease the electricity consumption in this road by 25% (Figure 2). In 2013, in Hidd area they have installed solar lighting where the electricity reduction has been followed in order to draw in reliable conclusions (Alternative Energy, 2016). In 2008, the building of the World Trade Centre have been adapted and the three wind turbines can achieve a total power output of 0,66 MW, or 11% to 15% of the total capacity building needs (EWA, 2014).

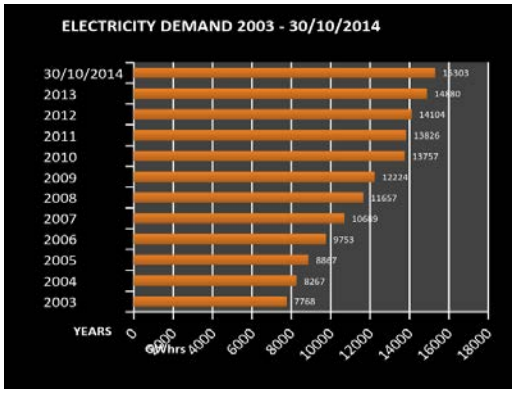


Figure 2 Electricity demand in Bahrain.

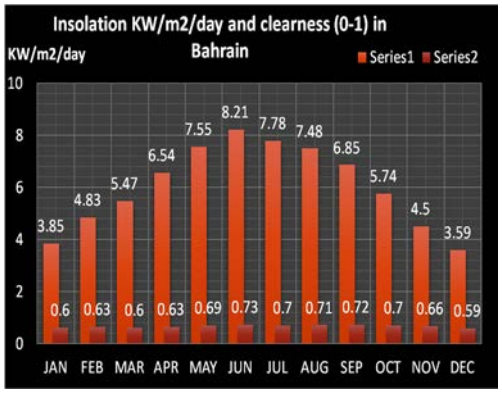


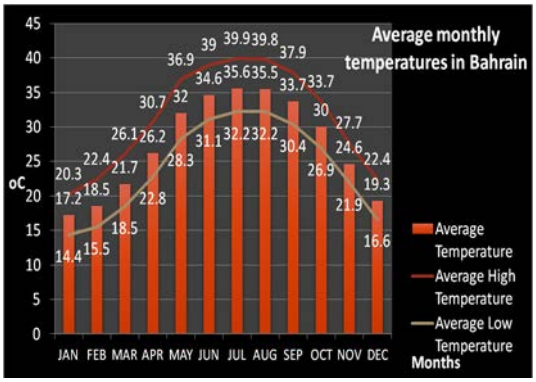
Figure 3 Solar insolation in Bahrain.

The Kingdom of Bahrain has a continuous population growth mainly from economic immigrants, thus is observed a corresponding continuous increase in demand for electricity (Figure 2). Bahrain and particularly its capital, Manama has latitude 26 ° 12'36 "N and longitude 50 ° 34'48" E as geographical coordinates. According to the NASA Langley Research Centre Atmospheric Science Data Centre the intensity of solar radiation is between 3.59 $\frac{KW}{m^2}/day$ and 8.21$\frac{KW}{m^2}/day$, while the purity of the horizon on a scale from 0 to 1 varies between 0.59 to 0.73 (Sun earth tools, 2016), as it is shown in Figure 3.

The average monthly temperatures in Bahrain in a year are divided into two categories. In the first category mild temperatures are included ranging from an average of 14,4 ^{0}C to 30,7 ^{0}C from November to April and in the second one is comprised of the average temperatures from 26,9^{0}C up to 40^{0}C, which are usually developed among May to October (Fig. 4) (Martin, 2012). In the winter season as well as in the autumn months, the average daily of sunshine range is 7.13 hours to 10.05 hours, while in the spring and summer months the average of sunshine range is 7.20 hours to 10.12 hours approximately (Fig. 4) (Sun earth tools, 2016).

3. Results

Considering the above data, it seems that the solar energy potential in GCC countries is high and photovoltaic systems installation can be profitable if necessary requirements are followed according to fundamental parameters in order to maximize the panel's efficiency. The following estimation has been considered for Bahrain territory but these can be applied for all GCC countries due to certain similarities. It is recommended to be followed for solar panels' installation where the land area is limited, as in buildings.



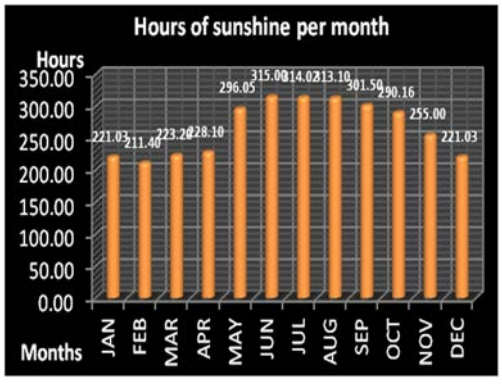


Figure 4 Average higher and lower monthly temperature and sunshine hours in Bahrain.

3.1 Types of PV Panels for Bahrain and GCC

The most common solar panels types which are widely used in most of the commercial applications are single crystalline and polycrystalline types. In order to make the appropriate choice, we will assume the following parameters and criteria: efficiency in real conditions, heat resistance, durability, the availability in the market and cost. In general the single crystalline panels operate with higher efficiency than the other type in SCT conditions. According to the literature an average value for their single-crystalline efficiency can be 15-20% at STC while for the polycrystalline 12-15% (Lumby, 2012).

As we have seen by the above graphs, the GCC region is characterized by high temperatures all year. Due to this factor, panels efficiency drop is developed when the total temperature of the cell is higher than 25°C. This factor seems to be higher at the polycrystalline panels (approximately experimental values 0.45% to 0.5%). In some experiments, single-crystalline panels have performed in a very good efficiency rate even in 50°C surface temperatures. Finally, if we assume the same characteristics and quality, the cost is 5-7% higher in single-crystalline panels, which seems not to be so important disadvantage due to the longer life of the product and the less demand in regular maintenance. For this reason, in this paper we choose single-crystalline panels. It is worth to be mentioned that both of the panels' types have been used in GCC countries with good power production and efficiency in most of the times according to the project and what is more important to be considered. Sometimes the current availability in the market is important as well.

3.2 Orientation and Installation Geometrical Parameters

The efficiency of the certain panels is not only depended on their type or the solar irradiance but also to the certain inclination angle which can be modified or the orientation. Major role for these selections play the geographical coordinates and determine the optimum location and inclination for each application. As we have already mentioned, in order to achieve the maximum electricity production by the solar panels, the solar irradiance incidence angle to the panel has to be as close as possible to 90 deg. This can be arranged according to the tilt angle as well as the azimuth angle of the panel. If we want to install photovoltaic systems in Bahrain or in a GCC country, as we are at the north hemisphere, the optimum inclination angle of the panel should be equal to the geographical latitude and the azimuth angle equal to approximately zero (0) with south direction (Figure 5a).

As the location geographical coordinates for Bahrain are latitude 26 ° 12'36 "N and longitude 50 ° 34'48" E, the optimum tilt angle for the panels should be equal to 26 deg while the ideal azimuth equal to zero with south orientation.

However sometimes, due to the specific location characteristics, maybe it is not possible to follow and apply the above values. In such cases we may follow the below rules shown in figure 5b.

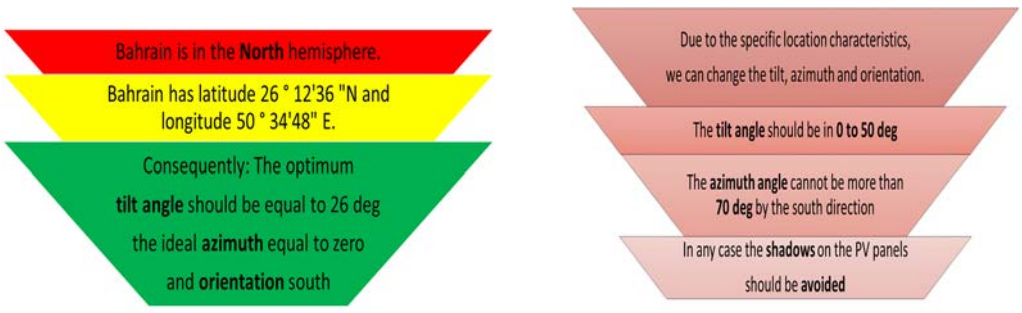


Figure 5 Proposed values for tilt angle, azimuth and orientation for Bahrain.

It is worth mentioning that the possible shading on the solar panels has negative impact to the panel's efficiency and these have to be avoided through the initial installation study, even for the possible future shading.

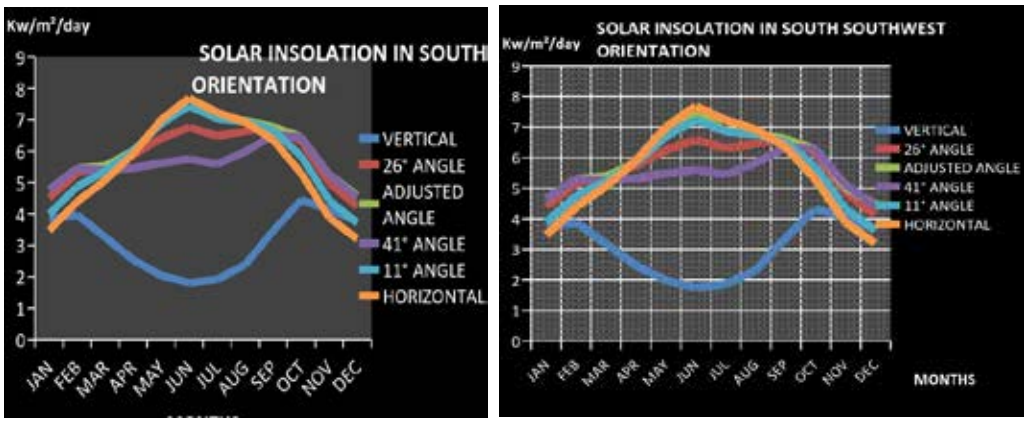


Figure 6 Solar Insolation in Bahrain for various tilt angles in south and southeast orientation.

By these figures it can be easily seen, that if a tracking system is possible to be mounted and adjusted to the solar panels, we will be able to achieve maximum values of the panels' efficiency during all the year. However if not, the optimum tilt angle is 26 deg as the maximum average performance is developed (Figure 6).

3.3 Tracking System

If the desired solar applications will be installed in buildings for residential purposes the photovoltaic modules are usually mounted on the structure to keep them oriented in the desired direction. The mounting system for solar structure can be fixed (the most common design used) or dynamic (tracking system which is rarely used).

The fixed mounted designs keep the rows of modules at a fixed angle of orientation (azimuth) and at a fixed tilt. As explained above, the location of the sun varies during the course of the day and during the course year. Using the fixed mounting system will not collect the maximum sunlight from the sun because the module should be perpendicular to the sun to collect the maximum amount of energy. For this purpose a tracking system can be used (Zoltenergy, 2010), (Alnaser, 2007).

A fixed tracking system can be finally used according to the type of application and surrounding areas because they are simpler, cheaper and have lower maintenance requirements compared to tracking systems. Adjusting the arrays manually two to four times per year would be costly. However, if the solar system is installed in building the tracking system application is not recommended as the structure of tracking systems contain more parts (especially moving parts), and hence require more maintenance. Some of the moving parts would fail eventually and the initial capital costs would be higher (extra component). Furthermore, the tracking systems require more land (space between the PV modules) to avoid shade compared to fixed types where less number of modules can be fixed for structures with tracking systems if the land area is fixed, and hence less energy would be produced (Landis, 1997).

3.4 STC and NOCT

Standard test conditions (STC) are the usual normal laboratory conditions which all the solar panels manufacturers use in order to perform the panels' tests. In this way, the comparison in

various panels' parameters is easy performed and the selection process is easier. By the other hand the efficiency which is measured is not applicable for all areas as the conditions are set without taking into consideration the geographical location or other climate parameters. According to the SCT conditions an irradiance of 1000 Watts per square meters is considered, the light spectrum as 1.5G while the temperature of the cell is taken as 25o C. By the other hand the Nominal Operation Cell Temperature (NOCT) is defined as the temperature reached by open circuited cells in a module when irradiance of 800W/m2 is applied, the air temperature is 20 oC and the wind velocity 1m/s (Figure 7).

As we have already mentioned, the panel's efficiency is decreased according to the cell's temperature and it is influenced as well by various climate conditions. Due to this reason the NOCT indications are more reliable for the GCC region as the high cell temperature development is certain during their operation. Better indication can be given under NOCT to the engineers that they want to choose the type and the manufacturer of the panel.

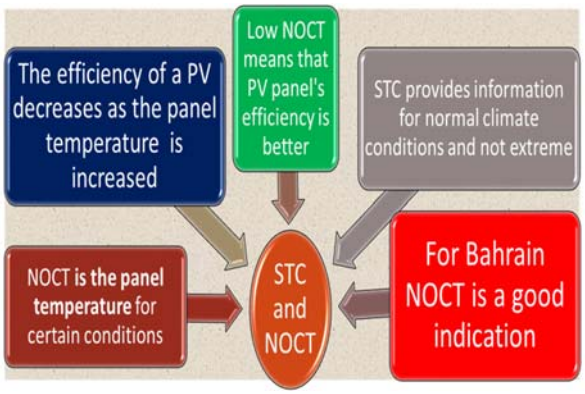


Figure 7 SCT vs NOCT.

3.5 Efficiency and Electricity Production

The efficiency calculation for the PV panels is a challenging procedure as the SCT estimation is only an approach to the maximum one and various environmental parameters have to be considered according to the geographical location of each are or country. In the following section an analytical approach is attempted according to certain determined values of the efficiency parameters according to Bahrain geographical coordinates.

The daily temperature range is wide, from 14oC to 40oC for Bahrain. The efficiency will present an important drop from the SCT values, especially if the temperature is more than 35oC and that is why this parameter has to be considered if we estimate the approximated real panels' efficiency value.

In addition, one of the important issues and maybe one of the major concerns about the solar panels development in the GCC and Middle East region is the existence of high precedence of atmospheric dust. This dust has several effects on the panels operation such as the decrease of the amount of sunlight reaching their surface or the reduction of the transmission of the solar radiation. The calculation differences according to the experimental or analytical calculations that are presented are sometimes high as in Alamoud's approach (Alamoud, 1993), who claims that the reduction in the efficiency may reach 20%.

In order to estimate the efficiency of a solar panel the panel's power and the solar radiation have to be considered, as we can see below:

$$n = \frac{P}{SR*A} \qquad (1)$$

where P is the panel's power, SR the solar radiation and A the panel's area (Gaglia, 2010).

The extracted value by the above formula is ideal and it cannot be reached in real conditions due to various environmental and climate parameters. If we want to estimate an approximate difference drop due to the developing temperature on the panel's surface during operation, the below formula can be used:

$$\Delta n = C_{temp}(25 - T_{mod}) * n \qquad (2)$$

where Δn is the efficiency drop, C_{temp} the temperature coefficient which is given for each panel by the manufacturer, T_{mod} is the panel's temperature in real conditions n the efficiency of the panel in SCT conditions (maximum possible efficiency value) (Alnaser, 2007).

As we have already assumed that a good panel type choice for Bahrain is the single-crystalline ones, the usual C_{temp} value is equal to 0.45% and the T_{mod} ids given by:

$$T_{mod} = Monthly\ Ave.Temp. + 28℃ \qquad (3)$$

The panel's temperature is estimated for each month, which means that the efficiency of the panels is not a constant value. The relating average temperature values are presented in Table 1.

As we have already mentioned. The efficiency of the panels in SCT is provided by the manufacturer and for the specific type of panels is usually 15-20% (average value equal to 17.5%) according to the brand and quality of cells.

Table 1 Average monthly temperature and solar irradiance for Bahrain (Bahrain climate, 2016).

Months	Av. Temp (^{0} C)	Sunshine h/day	Av. Solar Irradiance KW/m^2/day	Average Solar Irr. KW/m^2/day South Orientation and 26^0 tilt angle	Average Solar Irradiance KW/m^2/day Southeast orientation, azimuth 20^0 and 26^0 tilt angle
Jan	17,2	7,13	3,85	4,50	4,39
Feb	18,5	7,55	4,83	5,30	5,17
Mar	21,7	7,20	5,47	5,52	5,38
Apr	26,2	7,59	6,54	5,88	5,73
May	32	9,55	7,55	6,41	6,25
Jun	34,6	10,50	8,21	6,76	6,59
Jul	35,6	10,12	7,78	6,48	6,32
Aug	35,5	10,10	7,48	6,63	6,46
Sep	33,7	10,05	6,85	6,78	6,61
Oct	30	9,36	5,74	6,31	6,15
Nov	24,6	8,50	4,50	4,98	4,86
Dec	19,3	7,13	3,59	4,24	4,13

The real efficiency due to the panel temperature and other various conditions can be finally depicted by the below formula according to the relating coefficient:

$$n_{real} = (n - \Delta n) * C_{tot} \qquad (4)$$

where C_{tot} is the total dimensionless coefficient of losses due to the local environment and other operational conditions and it is calculated for Bahrain as below (Galanou, 2010), (Gagglia, 2010):

$$C_{tot} = Co_1.Co_2.Co_3.Co_4.C_{O_5}.C_{O_6} \qquad (5)$$

where:
Co_1: Coefficient of dust = 0.9
Co_2: Coefficient of inhomogeneity panels = 0.98
Co_3: Coefficient of panels connecting cables = 0.98
Co_4: Coefficient of energy transfer losses from the output PV system to consumption = 0.92
Co_5: Coefficient of inverter efficiency = 0.96
C_{O_6} : Coefficient of aging=0.90

Applying this formula we have already considered the most important environmental conditions and we approach a more realistic efficiency values for the GCC territory. However the selection of the coefficient values can vary according to more specific indications if these are provided.

For a typical solar single-crystalline panel operating in Bahrain an approximated estimation has been attempted concerning the relating variables and values and it is presented to the following Table 2:

Table 2 Efficiency and relating variables approach for PV Panels Operation in Bahrain.

Variable	Value
Efficiency STC (n)	17.5%
A	1.70 m^2
C_{temp}	0.45%
T_{mod}	45.20℃
C_{tot}	0.69
Co_1	0.9
Co_2	0.98
Co_3	0.98
Co_4	0.92
Co_5	0.96
Co_6	0.90
Δn	1.22
H_d	4.5 KWh/m^2
$(n - \Delta n)$	16.28%
n_r	11.18%
E_{total}	7.52 KWh/day
E_p	1.17 KWh/day

It can be seen that the efficiency drop is highly influenced by the certain environmental and climate conditions as the drop is from 17.25% to 11.18%.

4. Conclusions

The photovoltaic system applications and development in Bahrain and GCC countries has been addressed in this paper trying to estimate and define the appropriate parameters for the installation and estimate the approximated efficiency according to various reduction factors. By the above analysis, it seems that the solar systems applications can be beneficial enough for these countries as in this region, as the solar potential is high and the solar irradiance receive very high values in most of the time of the year, in comparison with the other countries. There are several proposals concerning the panels' types and although none of these can be excluded, the single-crystalline (mono-crystalline) ones seem to be more efficient in this region according to the location and specific characteristics. The dust precedence and humidity inside the

atmosphere as well as the high cells surface temperature which is developed in most of the time of the year during operation have to be considered. Both of the factors have as results to reduce the real efficiency of the panels up to even 37% and reduce in addition their life span, reduction which is usual in most of the countries for various other reasons. For this reason also the NOCT indication can provide more useful data rather than SCT for GCC countries as the SCT conditions are based on 25oC cell temperature only. Due to the high dust precedence in the atmospheric air, a periodically cleaning system is necessary to be included to the photovoltaic system. By the above estimations it seems that the solar systems applications can be quite beneficial for Bahrain and GCC countries, offering a sustainable solution for the power generation and facing the high demand for electricity consumption simultaneously. These can be durable and efficient enough, if certain local and operational parameters are considered through the installation analysis and implementation.

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Water Food and Energy Sustainability Nexus

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Abstract

Climate change and social changes such as population growth and urbanization represent a stress on earth's natural resources and a challenge to sustainability. Water, food and energy are the most needed resources to sustain life on earth. The three strategic resources are highly interwoven in a way that researchers and policy makers should take into consideration the connections "nexus" between them for proper findings, planning and decision making. This paper demonstrates the water-food-energy (WFE) nexus with a special focus on Arab countries.

Keywords: Water Security, Food Security, Energy Security, Nexus approach, Sustainability.

1. Introduction

In 2050, with a forecast 9.2 billion people sharing the planet, it is expected there will be a 70% increase in demand for food and a 40% rise in demand for energy. Yet by 2030, the world should confront a water supply shortage of about 40%. Therefore, our economy cannot run on the same finite energy, water and food resources far into the future. (UNESCAP 2013)

Of all natural resources, energy, water and food are most needed to sustain life on earth. These three strategic resources share many comparable characteristics: billions of people without access to them; they are rapidly growing global demand; all face resource constraints; all three are 'global goods' 'involving international trade with global implications; each have different regional availability and variations in supply and demand; and all operate in heavily regulated markets (Bazilian et al 2011). Moreover, global water cycles, carbon energy cycle, food production, and climate change are inseparably linked. Because of these reasons, they present deep security issues as they are fundamental to the functioning of society. (UNESCAP 2013)

The three resources are tightly interconnected, forming a policy nexus. A macro argument is in order here. Food production is the largest user of water globally. It is responsible for 80-9% of consumptive water use from surface- and ground-water. Water is required for separating and handling petroleum derivatives and to generate power from different sources; about 8% of global water withdrawal is used to generate electricity. Energy, in turn, is needed to transport and fertilize crops. Food production and supply chains are responsible for around 30% of total global energy demand. Crops can themselves be used to produce biofuels (UNESCAP 2013). Such interlinkages are convincing governments, the private segment, groups, the scholarly world and different partners to investigate coordinated answers for facilitating the weights and figure improvement pathways considering feasible and productive utilization of restricted assets.

This paper first addresses the water, energy and food security issues; highlighting the trends and challenges of each. The paper then demonstrates the nexus approach; explaining its origin, meaning and boundaries. Afterwards, different levels of the nexus are presented in the form of problems/challenges and their recommended solutions, a special focus has been made on the Arab countries.

2. Water, Energy and Food Security

Water, food, and energy security are differently characterized. This investigation will utilize definitions as gave by worldwide associations working in water, vitality, and sustenance since they have been talked about and settled upon by countless from the global improvement group.

2.1 Water security

A working meaning of water security by the United Nations is expressed as: "the limit of a populace to defend supportable access to satisfactory amounts of an adequate quality water for managing employment, human prosperity, and financial advancement, for guaranteeing insurance against water-borne contamination and water-related catastrophes, and for saving environments in an atmosphere of peace and political steadiness" (UNU, 2013).

In the year 2000, the Global Water Partnership introduced the concept of Integrated Water Resources Management (IWRM) which influenced reforms in the water sector. IWRM is defined as: "…a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems." (Global Water Partnership, 2000)

The World Economic Forum (2011, p. 1) broadens the definition of water security by couching it within a wider political economy and trade context: "Water security is the gossamer that links together the web of food, energy, climate, economic growth, and human security challenges that the world economy faces over the next two decades." (UNESCAP 2013)

IWRM tries to engage all sectors from a water management perspective, the nexus approach on the other hand treats water, energy and food security as equally important. (UNESCAP 2013)

2.1.1 Water Trends

Water, particularly fresh water is one of the world's most scarce vital resources with only 12% of the world's population uses 85% of its fresh water (Badran, 2017). Figure 1 shows the renewable internal freshwater resources per capita, by region.

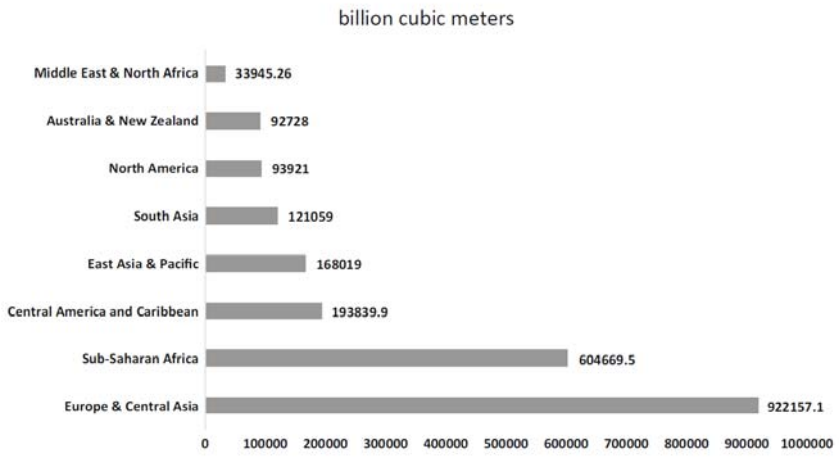

Figure 1 Renewable internal freshwater resources per capita, by region 2014 (FAO 2017).

Already one-third of the world population is living in water-scarce or water-short areas. There are 13 Arab countries among the world's most water-scarce nations, and water availability in 8 Arab countries is less than 200 m^3/capita/year, less than half of the UN-designated water-severe country (UN severe water scarcity below 500 m^3/capita/year) (Badran 2017)

The Arab region has 5% of the world population and occupies 10% of Earth space, with only 1% of world water resources. This is why the Arab region shares 50% of the world desalination capacity and is expected to double by 2020. Agriculture consumes 87% of available water resources, (the highest) as compared to 70% of the world average. The industrial sector consumes 7% and domestic use 6% (Badran et al 2017).

AFED (Arab environment: Food security) in 2014 forecasts the per capita distribution averages for some countries of the Arab region for 2050 as follows (Waterbury 2017):

Table 1 Arab Water Resources.

Iraq	1077 m^3
Lebanon	962
Morocco	739
Sudan	709
Syria	508
Egypt	464
Jordan	94
Libya	81
KSA	53

The total Arab water resources is 371.8 billion m^3 distributed as follows: 41% Mashreq Arab States, 23.4% Maghreb Arab States, 31% Nile Arab States, and 4.6% Arab Peninsula (Gulf States) (Badran et al 2017). While the resources percentage by source are shown in Figure 2.

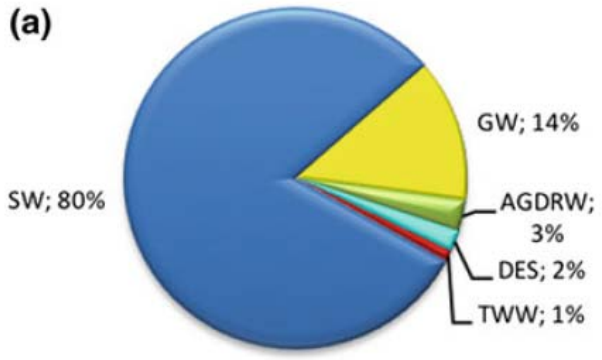

Figure 2 Water resources (SW surface water, GW groundwater, AGDRW reuse agriculture drainage water, DES desalinated water, TWW treated wastewater) (Al-Zubari 2017).

The Arab region covers an area of over 13 million square kilometers, with almost 90% of it is either arid or extremely arid with very little precipitation, extremely high evaporation and almost no vegetation cover. Most of the countries in the Middle East are essentially arid and receive very little rainfall (250–400 mm annually), and the expected drop from such limited amounts can be especially disastrous to domestic, agricultural, and industrial diversity (Badran et al 2017).

Several countries are "mining" renewable water resources at unsustainable rates. Ground water levels are falling precipitously as withdrawals far exceed annual re-charge from rain fall and snow melt (which are themselves falling). The over-pumping of aquifers and the proliferation of private, unlicensed and unmonitored wells is increasingly recognized as a major threat to sustainable agriculture in the region (Waterbury 2017)

It is estimated that about 60% of the region's surface water originates in sources outside its borders, principally in the Nile and the Tigris-Euphrates basins. Global warming will probably reduce run-off in the Tigris-Euphrates basins by as much as 25%. The impact of global warming on the Nile watershed is less certain (Waterbury 2017). Table 2 shows the water dependency ratio of some Arab countries.

Table 2 Water dependency ratio in the Arab Region (source UNDP 2013).

Country	Water dependency ratio (%)	Country	Water dependency ratio (%)
Kuwait	100.0	Qatar	3.4
Egypt	96.9	Palestine	3.0
Bahrain	96.6	Lebanon	0.8
Mauritania	96.5	Morocco	0.0
Sudan and South Sudan	76.9	Djibouti	0.0
Syria	72.4	Oman	0.0
Iraq	60.8	Yemen	0.0
Somalia	59.2	Saudi Arabia	0.0
Jordan	27.2	Libya	0.0
Tunisia	8.7	UAE	0.0
Algeria	3.6	Comoros	0.0

Note: The water dependency ratio refers to surface water only. Many of the countries with zero water dependency ratio share transboundary groundwater aquifers with other countries.

Water security is entering in the Arab locale, a standout amongst the most influenced by water shortage on the planet. The nexus approach plans to encourage the accomplishment of SDG-6 on guaranteeing accessibility and supportable administration of water and sanitation for all. The issue of water is additionally reflected in other SDGs, (for example, 3, 11, 12 and 15). The WFE security nexus takes into consideration execution concentrated on applying and building upon lessons gained from incorporated water assets administration (IWRM) standards and apparatuses.

2.2 Energy security

The United Nations Advisory Group on Energy and Climate Change (2010) defines energy security as: “access to clean, reliable and affordable energy services for cooking and heating, lighting, communications and productive uses.” (UNESCAP 2013)

Fueled by concerns over global warming, recent security thinking extends the traditional focus on energy security as mainly the questions of availability, accessibility and affordability to encompass newer concerns such as efficiency and sustainability (or environmental stewardship). This re-definition is gaining ever more prominence on contemporary policy agendas. (UNESCAP 2013)

The Global Vitality Office characterizes vitality security as: "the continuous accessibility of vitality sources at a moderate value" (IEA, n.d.). While there is no single meaning of the idea of vitality security, it has advanced from a tight connection to the steady supply of oil items to coordinate other vitality sources, and additionally the basic measurement of supportability.

2.2.1 Energy Trends

The world energy consumption projection as predicted in the EIA (US Energy Information Administration) international energy outlook 2017 is shown in Figure 3. Energy consumption in non-OECD countries increases 41% between 2015 and 2040 in contrast to a 9% increase in OECD countries (EIA 2017)

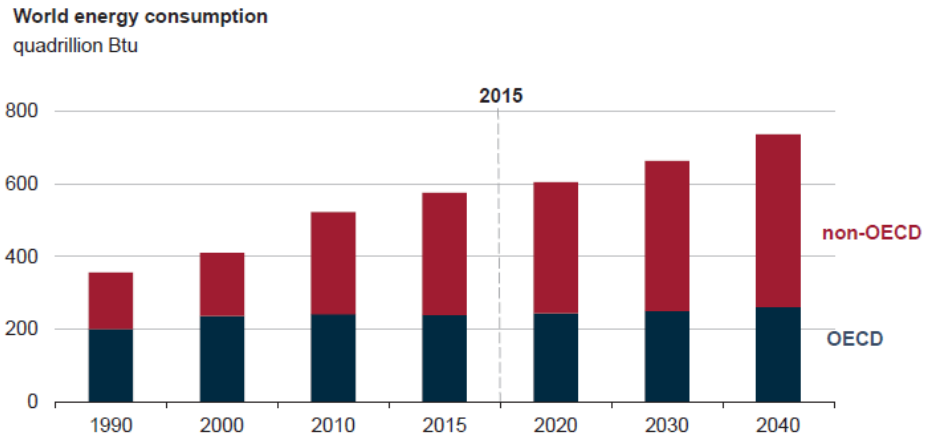

Figure 3 World Energy Consumption.

Figure 4 shows the non-OECD projected energy consumption by region. Fast-paced population growth and access to ample domestic resources are both important determinants of energy demand in Africa and the Middle East, where energy use is expected to increase 51% and 45%, respectively, between 2015 and 2040. (EIA 2017)

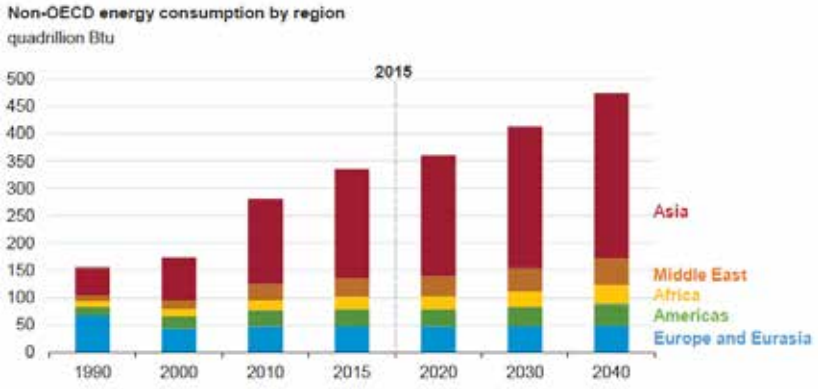

Figure 4 Non-OECD Energy Consumption by region. Source: EIA 2017.

Energy security fluctuates extraordinarily from one nation to the next in the Arab district. The nexus approach would take into consideration fuse of territorial endeavors to help the Sustainable Vitality for All (SEA4ALL) activity as a way towards enhanced vitality security and the accomplishment of SDG-7, gone for guaranteeing access to moderate, dependable, feasible what's more, present day vitality for all.

2.3 Food security

At the 1996 World Food Summit, food security was defined as (FAO, 2009, p. 8): "…a situation that exists when all people at all times have physical, social and economic access to sufficient, safe and nutritious food to meet dietary needs and food preferences for an active and healthy life." This definition implicitly singled out undernourishment as one of the indicators of food insecurity. Among the targets agreed upon at the Summit included the call for at least halving the number of undernourished people in the world by the year 2015 (UNESCAP 2013)

The Sustenance and Horticulture Association of the United Nations characterizes nourishment security as existing "when all individuals, consistently, have physical, social and monetary access to adequate, sheltered and nutritious sustenance that meets their dietary needs and nourishment inclinations for a dynamic and solid life" (FAO, 2002). Figure 5 shows undernourished population by region.

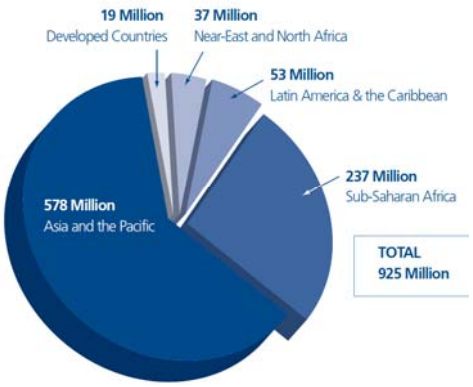

Figure 5 Undernourished population by region, 2010 (UNESCAP 2013).

Another aspect of food security involves the food surpluses/deficits. Figure 6 shows food surpluses and deficits by region.

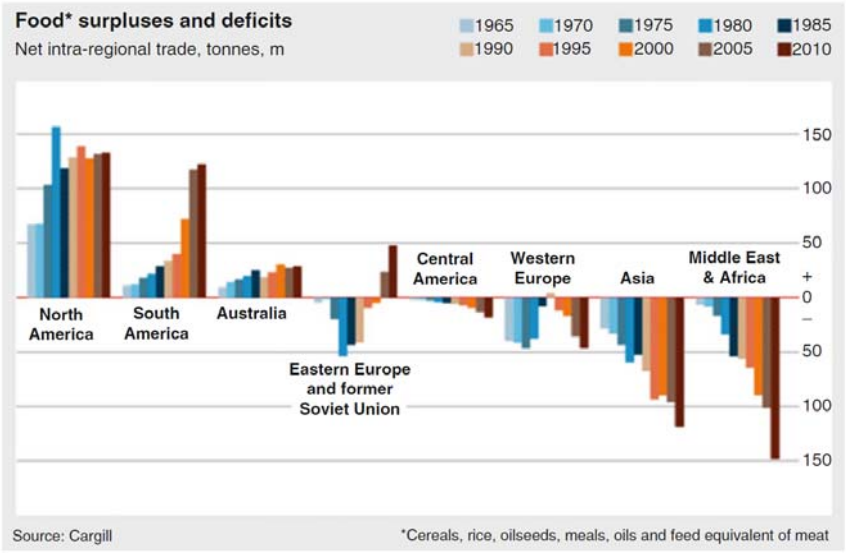

Figure 6 Food surpluses and deficits (Waterbury 2017).

The Arab region produces about 75% in value of what it consumes of agricultural products but in terms of cereals that ratio drops to about 25%. Its cereal import dependency is by far the highest of any region in the world. Arab countries are net exporters only of fruit and vegetables, although Syria briefly became a cereal exporter before 2011. Egypt is the world's largest importer of wheat (Waterbury 2017).

Another meter of food security is the hunger index. Table 3 shows the global hunger index for some Arab countries.

Table 3 State of hunger in Arab countries in 2014 (Alzadjali 2017)

Country	GHI	Classification
Algeria	Less than 5	Low
Bahrain[a]	Less than 5	Low
Comoros	29.5	Alarming
Djibouti	19.5	Serious
Egypt	Less than 5	Low
Iraq	12.7	Serious
Jordan	Less than 5	Low
Kuwait	Less than 5	Low
Lebanon	Less than 5	Low
Libya	Less than 5	Low
Mauritania	11.9	Serious
Morocco	Less than 5	Low
Oman[a]	less than 5	Low
Qatar[a]	Less than 5	Low
Saudi Arabia	Less than 5	Low
Sudan	26	Alarming
Syria	5.9	Moderate
Tunisia	Less than 5	Low
United Arab Emirates[a]	Less than 5	Low
Yemen	23.4	Alarming

[a]These countries state of hunger was estimated by AOAD

Food security in the area is firmly connected to the accessibility what is more, consistent supply of water and vitality. Feasible farming and dependable exchange are key instruments for accomplishing sustenance security and SDG-2 on completion hunger, accomplishing sustenance security and enhanced nourishment and advancing practical farming.

3. Nexus Approach

The Nexus approach was first launched at the Bonn 2011 Nexus conference in response to climate change and social changes including population growth, globalization, economic growth and urbanization (Endo *et al* 2017) The Nexus perspective focuses on the interdependence of water, energy, food (W-E-F) by understanding the challenges and finding opportunities. The Nexus approach recognizes the interconnectedness of W-F-E across space and time. Its objectives are:

- improve energy, water, and food security;
- address externality across sectors, and decision-making at the nexus; and
- support transition to sustainability.

Nexus consideration is often pursued with 'two at one time' analysis. For instance, energy-water nexus is analyzed through a two-way interaction in the use of water for energy production and the use of energy for water production. The same principles apply when studying the interactions of water-food nexus and food-energy nexus (Bazilian et al 2011). Another layer of complexity is introduced with the further link of energy-water to food security (UNESCAP 2013).

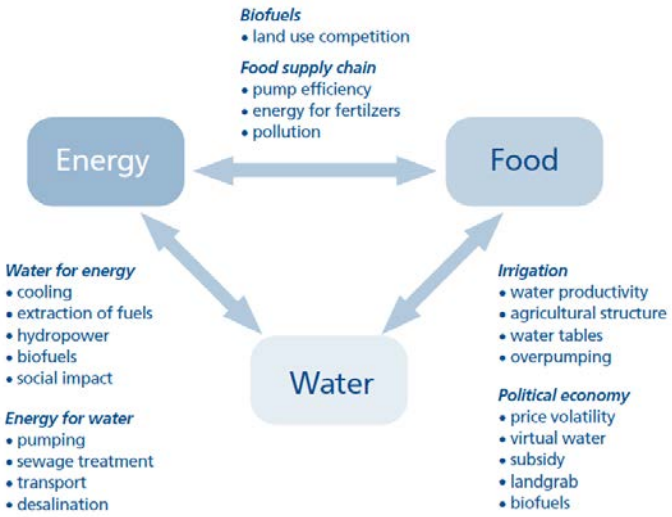

Figure 7 Interconnections of WFE (UNESCAP 2013).

The academic and policy literature on current and future challenges in water, food and energy security explores three main themes. The first theme is the nature of the relationships among the three elements (through input-output analysis). The second is the consequences of their changes and changes in other sectors, including geopolitical implications. Lastly, the third includes implications for policy development and actions for addressing the three securities (Bizikova et al., 2013).

4. Interactions

The approach to the energy, water, and food nexus normally depends on the perspective of the policy-maker. If a water perspective is adopted, then food and energy systems are users of the resource; from a food perspective energy and water are inputs; from an energy perspective, water as well as bio-resources (e.g., biomass in form of energy crops) are generally an input or resource requirement and food is generally the output. Food and water supply as well as wastewater treatment require significant amounts of energy. Of course, areas such as food-as-fuels (i.e., biofuels) tend to blur these descriptions due to additional impacts associated with land use, land use change and use of the available biomass resource. In any case, the perspective taken will affect the policy design. This is due to the specific priorities of the institution or ministry, as well as the data, knowledge and analytic breadth of the tools of the associated experts and support staff. There are very few people expert in all three areas (Bazilian 2011).

4.1 Water–food nexus

Before dealing with the water-food nexus certain terms must be known regarding water use and agriculture. The term “virtual water” deals with water used in food production, while “water footprint” deals with consumption. The term “IWRM” (integrated water resource management) deals with the entire life-cycle of water, and “nexus” deals with the life-cycle of water and other related processes including energy, land and food (Endo et al 2017).
Regarding the water–food nexus, activities on reducing water consumption for producing food and increasing efficiency of water resources for producing food were identified. Examples are shown in the sections below.

4.1.1 Food Trade

Although food trade may seem to be merely a food security issue, yet a new political economy of water management lead to focus on the acquisition of water “virtually” through imports of crops “from water-rich countries, while allocating scarce water resources to low-water consuming, high value crops that can generate foreign exchange”: a concept known as “virtual

water" trade (Badran 2017). Table 4 shows virtual water trade in certain countries. It is obvious that virtual water trade affects the net water savings.

Table 4 Virtual water trade in certain countries (FAO 2011).

	Total use of domestic water resources in the agricultural sector (km^3/yr)	Water saving due to import of agricultural products (km^3/yr)	Water loss due to export of agricultural products (km^3/yr)	Net water saving due to trade in agricultural products (km^3/yr)	Ratio of net water saving to use of domestic water
China	n.a.	79	23	56	0.08
Mexico	94	83	18	65	0.69
Morocco	37	29	1.6	27	0.73
Italy	60	87	28	59	0.98
Algeria	23	46	0.5	45	1.96
Japan	21	96	1.9	94	4.48

A similar concept involves direct investment in agricultural lands (land acquisition/land grabbing) in other countries, mostly developing countries. In such a way, the investing country will rely on the other country's water resources. A study by Dell'Angelo *et al.* extensively discussed this topic, naming the trend as global "water grabbing" syndrome (Dell'Angelo et al. 2018). Saudi Arabia, for example, benefits from the virtual water trade and direct investment in agricultural land acquisition (Grindle et al. 2015).

A third term "Virtual Land" is like virtual water this concept relies on putting water-scarce lands to their best use; to produce cash, or industrial, crops for export, and import grain crops. For example, Egypt produces high quality cotton and imports wheat, thereby trading their cotton land for many more hectares of grain area. This allows the yield-gap potentials to be improved on the best quality and well-watered lands (Rogers 2017)

However, such practices should be carefully analyzed to avoid risks associated with political disputes and minimize potentially negative social**,** economic, and resource impacts and allow for long-term sustainability.

4.1.2 Green Water

This involves improving the efficiency of utilization of green water (the rainwater held in the soil profile), preventing depletion of residual soil moisture in the field after crop harvest by reducing the fallow period, and reducing the use of water through a shift to low water consuming crops (Endo et al., 2017).

4.1.3 Irrigation and Food Security

Food production accounts for 80-9% of consumptive water use from surface- and ground-water (UNESCAP 2013). Agriculture accounts for 85% of water use in the Arab region as compared with a world average of 70%. On-farm irrigation efficiency remains at 35% (Badran 2017). The following practices are considered best practices:

- development of new crop strains that tolerate better both aridity and salinity; the bio saline center for agriculture in Abu Dhabi is developing sustainable crop production by using saline water (Badran 2017)
- development of rain-harvesting systems (Badran 2017)
- application of precision irrigation: drip and center-pivot. Center pivots are popular in North Africa in Morocco, Tunisia, and Libya. They are also widely dispersed in Saudi Arabia (Rogers 2017).

4.2 Water–energy nexus

Projects on water–energy nexus ranged from energy for water to water for energy. Examples of consuming water for producing energy include hydropower generation and biofuel using water. Energy consumption examples included pumping water for food and treating wastewater using electricity (Endo et al 2017)

4.2.1 Water for energy production

Water use for energy production represents a vital role in water-energy relation. Water is needed in fuel extraction, processing, transportation and end-use. In contrast, renewable energy sources (except for biofuels) do not depend on water for production. Many studies taking estimated that oil extraction process requires 3-8.3 liters per million Btu; this depends on the geology, extraction and well-depletion regions.

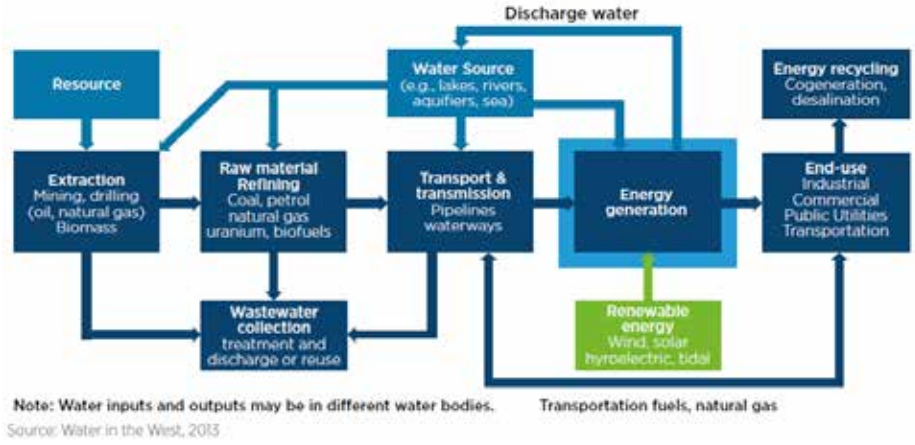

Figure 8 Flow chart of embedded water in energy.

The following figure shows the potential for reduction in water withdrawals for power generation in GCC region by 2030 if renewable energy is used.

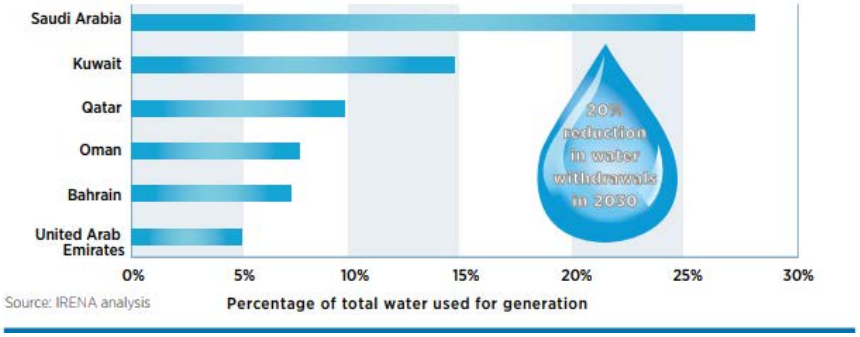

Figure 9 Total Water Usage in the GCC

Hydropower

Hydropower (from dams) provide a dual solution of generating power (electricity) and preserving water, hence affects the two issues of water and energy security. However, there are other factors to be taken into consideration when using hydropower such as environmental effects and geopolitical concerns. The cases of High Aswan Dam in Egypt (HAD) and Grand Ethiopian Renaissance Dam (GERD) are good examples.

- High Aswan Dam: the HAD provides about 15% of Egypt's national electricity demand and enhanced water security, allowed a doubling of the irrigated agricultural surface – projected to reach 45,360 km2 by 2017 – and promoted a significant intensification of irrigated agricultural productivity by extending the harvest season to allow up to 3 harvests per year. Its large storage volume also protects Egypt's water supplies from changes that will be caused by dam development in Ethiopia and in The Sudan. On the other hand, there are some negative impacts including: shrinking of the natural floodplain, salinization and subsidence of the Nile delta, decrease of soil fertility, loss of riverine connectivity, decrease in water quality, loss of biodiversity (Pacini and Harper 2016).
- Grand Ethiopian Renaissance Dam (GERD): In 2011 Ethiopia announced, without any prior agreement, that it would construct the Grand Ethiopian Renaissance Dam (GERD) near its border with Sudan to generate hydro-electricity. In 2015 with the dam half completed, Egypt largely acquiesced in its construction and entered negotiations on the dam's filling and operating rules. Egypt is now at a point where it may have to re-allocate water between agricultural and non-agricultural uses such that farm income is significantly lowered. In the longer term, the more worrisome stakeholder is the Sudan. It has already embraced the GERD from which it may buy power for Khartoum-Omdurman, and it will benefit from the GERD's ability to trap silt which would otherwise eat into the storage capacity of Sudanese reservoirs. More importantly, the Sudan has vast potential for horizontal agricultural expansion in the land lying between the White and Blue Niles. Now that the Southern Sudan has become independent, taking with it much of the Sudan's oil deposits, the new Sudanese state may have little choice but to pursue horizontal agricultural expansion aggressively (Waterbury 2017). A perfect example of geopolitical interaction with water and energy security.

4.2.2 Energy for Water

Energy is needed to either extract, transport or treat water. The figure below provides a comparison between seawater, waste water reuse, waste water treatment, ground water and lake or river and their use of energy and it was found that the sea water use a huge amount of energy. It was found that using Concentrating Solar Thermal Power (CSP) is common in places like Arab region. Amount of energy required to provide 1 m3 of water safe for human consumption from various water sources.

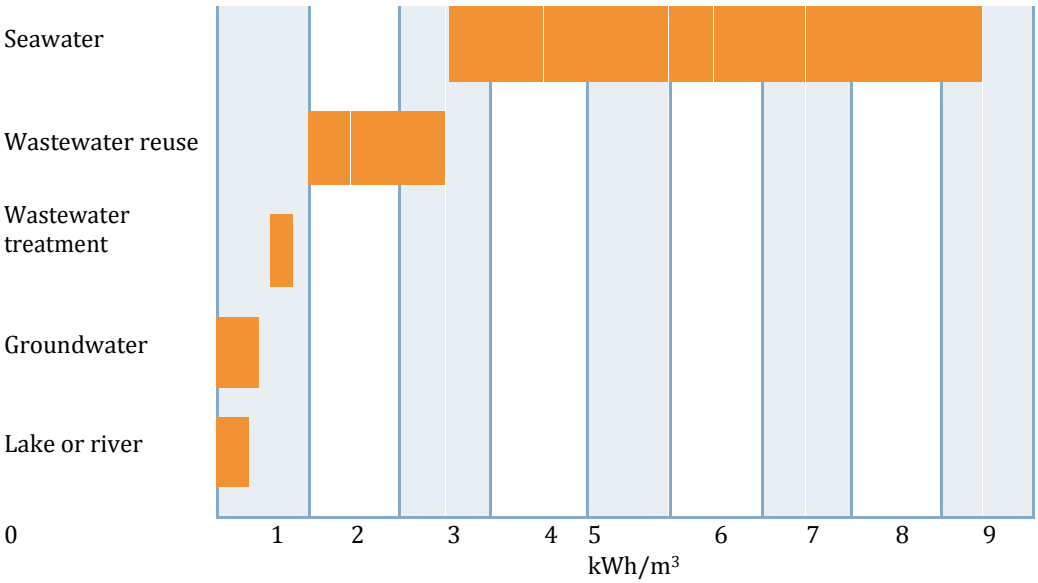

Figure 10 Safe water for human consumption. Source: UN Water, 2014b.
Note: This does not consider the distance the water is transported.

Currently, the Arab region, with 5% of world population, produces 50% of desalinated water of the world (AFED 2010). Technology can help to extend the application of desalination and other water cleansing techniques to other areas throughout the world over 24 million cubic m per day is now in operation in the Arab Middle East (Water World 2013). This is over 50% of the total global capacity for desalination, and is rapidly growing. Figure 11 shows Total contracted capacity of desalination plants in some Arab countries.

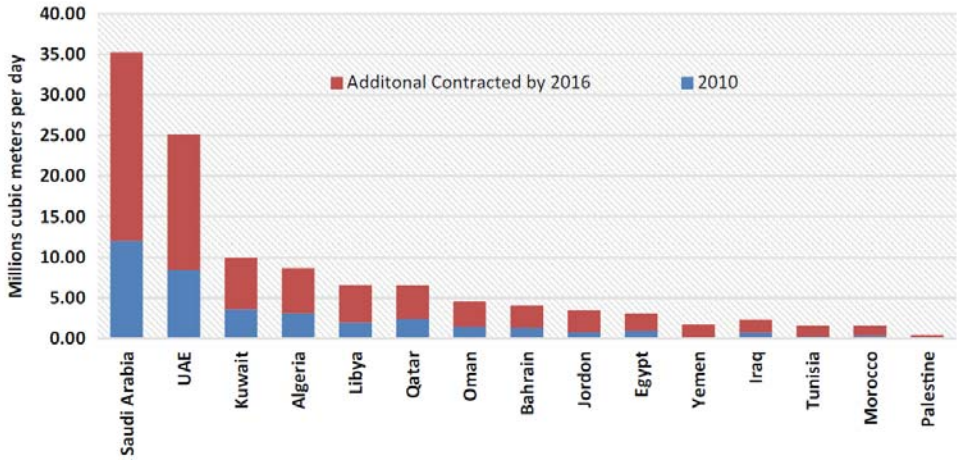

Figure 11 Total contracted capacity of desalination plants in some Arab country (UNDP 2013)

The water produced in these plants is still too expensive for most crops, but may in the future be economical for fruit and vegetable crops, particularly when they can be marketed on international markets at the season when other regions cannot grow them. New reverse osmosis, RO, plants have the advantage that they can use brackish water, recycled urban waste water, and ocean waters as their source. The advantage of relying on desalination is that, provided energy for electricity is available, then the source is 100% reliable, or essentially risk free.

4.2.3 Renewable Energy Integration with water.

Renewable energy has been highly deployed over the Past decade. In 2013, around 120 gigawatts (GW) of renewable energy capacity was deployed in the power sector, which accounts for more than half of all the deployed capacity globally.

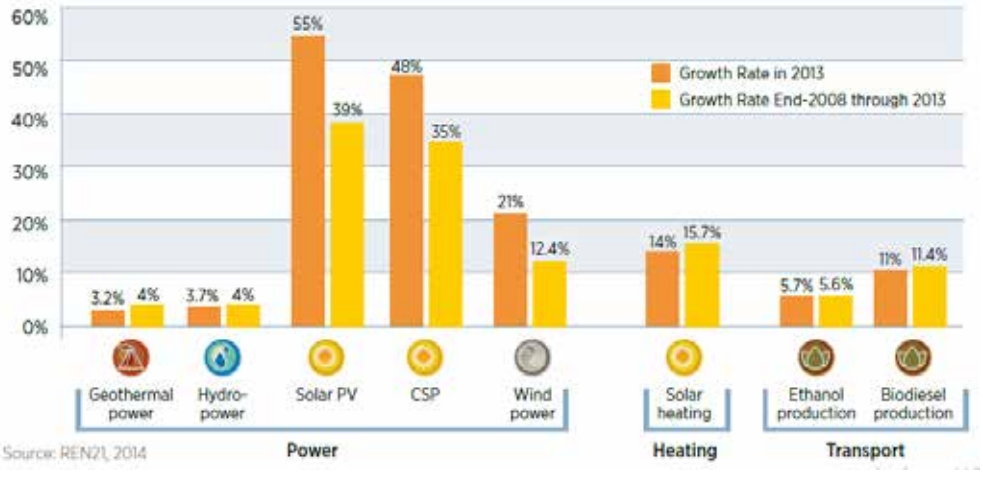

Figure 12 Average annual growth of biofuels production and renewable energy capacity.

The most challenging problems of water-energy interaction can be addressed using renewable energy technologies. These challenges are water supply and water heating.

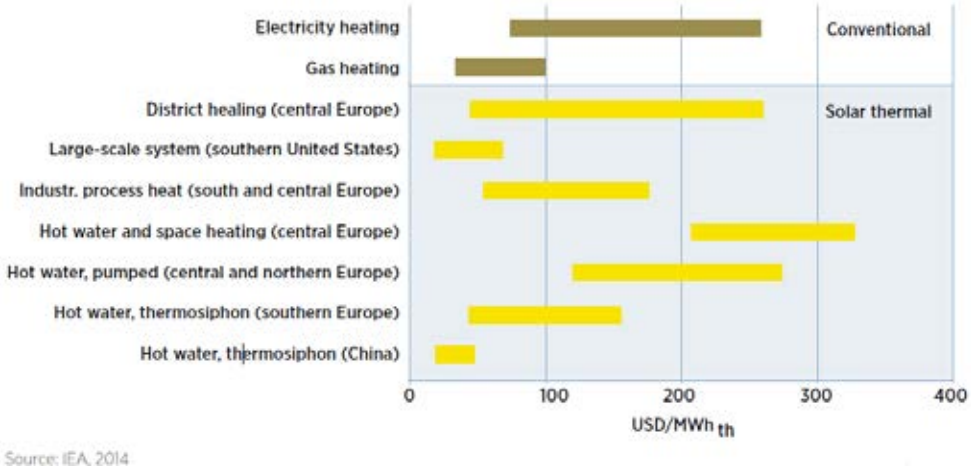

Figure 13 Solar heat production costs compared with electricity and natural gas-based heating in different regions.

The water's supply chain starts with a source, then water extraction (*e.g.*, ground water pumping) and moving directly to an end-use (*e.g.*, irrigation, commercial) or to a treatment or desalination plant, from where it is distributed to customers.

Water pumping and conveyance

Water pumping is considered a major energy consumer within the traditional water supply chain. Delivering water from its sources to treatment plants requires significant energy inputs.

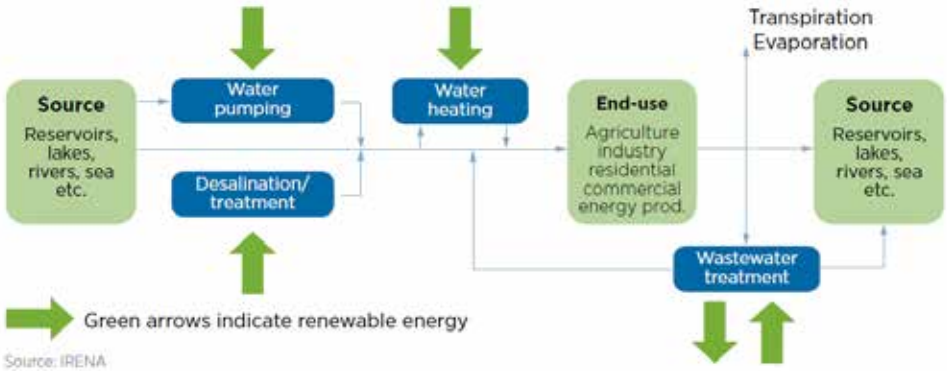

Figure 14 Renewable energy across the water supply chain.

A cost-effective alternative for water pumping is based on solar energy. The deployment of solar pumps can bring many benefits including delivering water services to undeserved communities and unirrigated lands, while reducing dependence on grid electricity.

Solar-based pumping arrangements offer a practical understanding other option to framework or diesel-based water system pump sets. Extensive scale arrangement of sun-oriented pumps can bolster the development of water system, lessen reliance on lattice power or petroleum product supply, relieve nearby natural effects and decrease government appropriation troubles. Perceiving these advantages, a few nations have propelled projects to advance sunlight based pumping. India, for instance, has reported plans to swap 26 million groundwater pumps for water system with solar-based pumps. Should 5 million diesel pump

sets be supplanted with universes in India, this could prompt reserve funds of almost 18.7 gigawatts (GW) worth of introduced limit, 23.3 terawatt-hours power, 10 billion liters of diesel and 26 million tons of carbon dioxide (CO_2) discharges. Despite the convincing case, vast scale selection of sun based water pumps is still ruined by an assortment of components, including generally high capital costs, inactivity in the appropriation of new innovations, building up business sectors for the innovation, and guaranteeing sufficient preparing for installers and administrators. Dangers are additionally connected with unreasonable water withdrawal, since operational expenses of PV pumps are insignificant.

Powering desalination

Desalination is the most energy-intensive water production technique available nowadays. It consumes at least 75.2 TWH per year, which accounts for 0.4% of global electricity production. Desalination plants based on renewable energy will play a great role in water gap. There are around 16000 desalination plants operating worldwide today with total capacity of 70 million m^3 per day. The shortage of water in the MENA region is approximately of 9.3 billion m^3, which can be met through desalination by 2050 according to the World Bank. Renewable energy base Desalination plants have proven to be cost-effective in remote regions were the cost of delivering fuel is high.

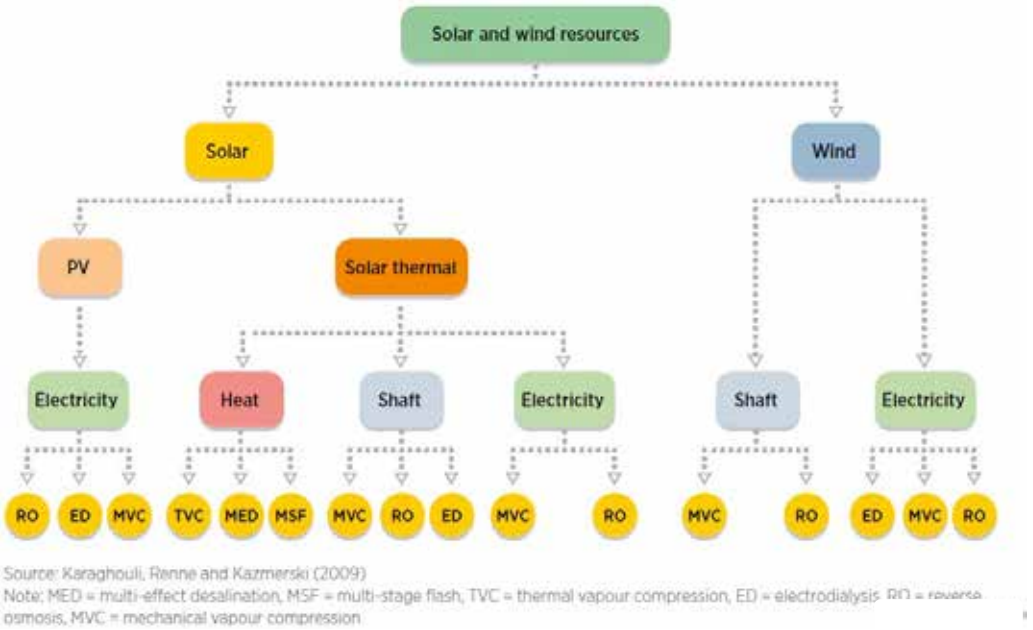

Figure 15 Chart for integration of solar and wind resources with different desalination technologies.

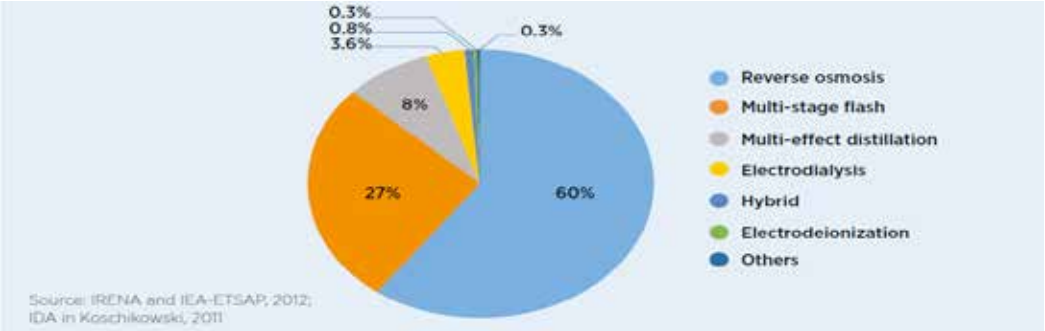

Figure 16 Desalination capacity by technology

Figure 17 Technology cost comparison of renewable energy-based desalination versus fossil fuel-based plants.

Sustainable power source based desalination advancements could assume an expanding part in connecting the water hole. In the Center East and North Africa (MENA) locale, a standout amongst the most water-rare areas on the planet, water deficiencies by 2050 will be met for the most part through desalination. All the more particularly, the Inlet district as of now depends on petroleum derivative based, vitality concentrated desalination to meet its water needs. Notwithstanding, proceeded with reliance on petroleum products for water generation is not maintainable from a monetary and ecological point of view. Sustainable power source advances offer the chance to decouple water creation from petroleum derivative supply, and to oblige the warmth or power needs of desalination plants. Perceiving this open door, Saudi Arabia declared Ruler Abdullah's Drive for Sun powered Water Desalination in 2010, which expects to improve the nation's water security and add to the national economy by growing ease sun oriented based desalination innovation. Even though desalination in light of sustainable power source still might be generally costly, diminishing sustainable power source costs, innovation propels and expanding size of arrangement, make it a financially perceptive and economical arrangement in the long haul.

Water heating

Water heating contributes around 15% of household energy use in Europe, 18% in the USA and 30% in Japan. Most solar thermal systems are deployed for domestic water heating, which typically meets 40-80% of the demand.

Figure 18 Solar water heating collectors global capacity, 2000-2013

Progressively, sustainable power source innovations are supplanting power or petroleum product use for water and space warming. In spite of the fact that the cost of warmth creation relies upon the innovation sent, and also on the size and area of the establishment, sun based water radiators for the most part is aggressive with power and

Gas-based warming. In Europe, the perceptive solar powered heat application is sun oriented locale warming in Denmark, where warm costs are as low as USD 43 for each warm megawatt-hour (MWhth). In China, sun powered water warmers cost an expected 3.5 times not as much as electric water radiators and 2.6 times not as much as gas radiators over the framework lifetime. All around, sun oriented water warming innovations as of now have acknowledged generous vitality and emanations investment funds. In 2012, net sun based warm vitality funds added up to 284.7 terawatt-hours (TWh) or 24.5 million tons of oil identical (Mtoe), which is equivalent to Bangladesh's essential vitality utilization in 2013.

4.3 Water-energy-food nexus

The challenge of understanding energy, water, and food policy interactions, and addressing them in an integrated manner, appears daunting. A vital step towards approaching the WFE nexus is to develop robust analytical tools, conceptual models, appropriate and validated algorithms, and robust data sets that can supply information on the future use of energy, water and food (Bazilian et al 2011).

4.3.1 Biofuels production

Bioenergy can give a limited answer for change country economies while upgrading vitality and nourishment security. At the point when overseen economically and effectively, bioenergy advancement could make new markets and produce work openings that could emphatically influence salaries and destitution decrease, while additionally adding to ecological destinations. This transformative capability of bioenergy can be tapped just when a comprehensive perspective of social, financial and ecological reasonability is embraced. The effects of bioenergy, and particularly biofuels, on nourishment costs, financial development, vitality security, deforestation, arrive utilize and environmental change are unpredictable and multi-faceted. As a rule, the encounter has demonstrated that vitality created from biomass can add to sustenance security as long as it is reasonably delivered and overseen. The generation of bioenergy in incorporated food– vitality frameworks is one such approach. Intercropping Gliricidia (a quickly developing, nitrogen-settling leguminous tree) with maize in Malawi or with coconut in Sri Lanka is considerably enhancing yields of farming items while additionally giving reasonable bioenergy feedstock. Such an incorporated sustenance vitality industry can upgrade nourishment creation and nourishment security, enhance vocations, ration nature and progress financial development.

4.3.2 Wastewater treatment and the WFE nexus

Wastewater generated by domestic and industrial sectors in the Arab region totals 10 km^3/year, of which 5.7 km^3 undergoes treatment. Of this volume of treated wastewater, only one third is reused. However, wastewater treatment plants currently handle waste loads that exceed their capacity limits. The untapped potential of wastewater should be the focus of appropriate policy interventions including national water management strategies for water reuse (Badran 2017). Figure 19 shows wastewater produced and treated in some Arab countries, 2009–2010 (UNDP 2013)

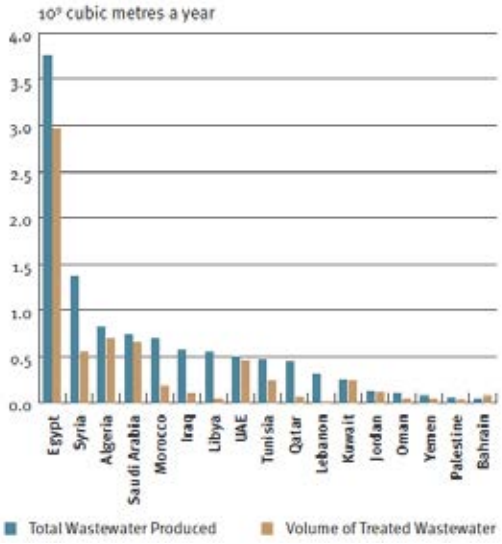

Figure 19 Wastewater produced and treated in some Arab countries.

Recent studies investigated integrated resource recovery in municipal wastewater treatment plants: onsite energy generation, nutrient recycling and water reuse (Mo and Zhang 2013; Vairavamoorthy et al 2015; Garcia and You 2017.

4.3.3 Modeling and Simulation

It became clear that nexus projects can utilize tools such as the Multi-scale Integrated Analysis of Social and Ecosystem Metabolism (MuSIASEM), SWAP models (Karimi et al., 2012), the Soil Conservation Service Curve Number method (CWC, 2015g) and other economic calculations (Mustaq et al., 2009) including land and water footprints of biofuel (Yang et al., 2009), a crop model called CropSyst (Marta et al., 2011) and the Integrated Analytical Model (Bazilian et al., 2011; Hoff 2011; WEF (World Economic Forum), 2011)

5. Conclusion

The nexus approach is currently the best practice to achieve sustainability goals. The nexus approach is successful as it does not only account for input-output interactions, but also other inter-related issues such as geopolitical issues. Arab countries can benefit from the nexus approach in order to: deal with the Water-Food-Energy (WFE) security issues, have an over-arching idea about resource allocation and resource efficiency and deal properly with geopolitical conflicts. It is recommended that researchers and policy makers from the Arab countries exploit the benefits of the nexus approach in dealing with WFE issues.

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Low Carb Diet

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Abstract

We are all familiar with diet plans and online offers: Low Carb Diet – 30 day program – lose 5,000 lb. Is this for you? It always catches my attention. But 5,000lb? Is it practical, accessible and effective? Global warming is definitely changing my world and your world. But the big question is: can I as an individual take action to change this thing called "climate change". Some say that if we contribute to the problem, then we can also contribute to the solution. So what are these solutions? This is where sustainable education is imperative. People need to understand that every action we take has a consequence and there are actions that will have a positive impact. When we hear the words global warming, we associate them with resources depletion, economic disruption, people dislocation and relocation, future chaos even anarchy. Or as 'armchair viewers of nature', we might associate climate change with big, bad events such as tsunamis, hurricanes, mud slides or heat waves. Yet the primary cause of global warming is CO2. A gas which we cannot see, feel or touch is changing our world. We simply emit this gas into our atmosphere through the burning of fossil fuels which power our cars, heat or cool our homes, light up everything and produce the goods we need. No other generation has been held responsible for such devastation before. That's where the "Low Carb Diet" comes into effect. If we want to achieve a sustainable future we all need to reduce our carbs.

Keywords: carbon emissions, low-carb diet, carbon footprint, per capita, sustainable, carb-rich lifestyle.

1. Introduction

Carbon emissions and global warming are two phrases that the every person hears regularly. Even if not fully understanding the complexity of the sciences associated with the terms, people are aware that these environmental terms have implications for our daily lives. In the context of sustainable education, one needs to understand what these terms are and the impact of our actions, behavior and lifestyle, in relation to creating a sustainable future for all to enjoy.

The use of the fossil fuels in anthropogenic activities such as transportation, generation of electricity, industrial application, and the production of an extensive range of products and services, are all essential components of society yet all contribute to global warming. We power our cars, homes, urban developments, industries and manufacture goods and services through the burning of fossil fuels which release carbon dioxide into the atmosphere. Carbon dioxide is one of the most significant greenhouse gases resulting in global warming

The climatic impact has been identified and monitored for decades although there were no studies on global warning before the 1950's (Weart 2008). The issues and concerns associated with global warming and climate change have escalated to a critical level. This is in part due to the ever increasing global population resulting in greater energy demands. There is also demands for a more balanced access to resources so that the growing population is able to achieve comparable standards of living all around the globe. But the excess of carbon emissions is driven by the individual craving for a carbon-rich lifestyle.

Therefore, this paper attempts to look more closely at individual energy consumption rates and the corresponding carbon emissions rates. To ensure a sustainable future, we need to realize that our rate of energy consumption is unsustainable across the globe. The implication of which is that there is a real need to decarbonizes our lifestyle. This raises the concern of individual and community awareness of our energy consumption, and the need to appreciate ways in which we can lower our carbon consumption and subsequently reduce our carbon emissions to ensure a sustainable future.

1.1 Statement of the Problem

This carbon dioxide emissions at the individual level are due to our activities such as driving to work, the food we eat, the energy we use to cool (or heat) our homes, the clothes and accessories that are purchased, our addiction to electronic devices, and our fetish over the light bulb and an almost insatiable appetite for luminescence. We know the words such as global warming but we lack appreciation of the hungry demand for energy and the consequences of our personal carbon emissions. We are obsessed in our energy consumption and need to consider a low-carb diet for the health of our environment if we have any genuine desire for a sustainable future.

2. Literature Review

The literature on energy consumption in the developed nations of the world's extends from professional research journals to everyday media sources. It all highlights the carbon-rich lifestyle of the developed world. It has been spear-headed by Al Gore's movie, "The Inconvenient Truth" (Guggenheim 2006) and an endless source of environmental movies and documentaries on conservation and sustainability this millennium.

The quantities of CO2 emitted from individual households in developed nations are revealing. Collectively, households in the US contribute 55,000lb (25 metric tonnes of CO2) annually (Gershon 2007). This is approximately 8% of global CO2 emissions while European household emissions are significantly lower. German households contribute half of the US amount and collectively emit 27,000lb (12.25 metric tonnes) (Gershon 2007). This is approximately 4% of the global emissions while Swedish households contribute half of the German amount at 2% of the global emissions. This equates to 15,000lb (6.8 metric tonnes) (Gershon 2007).

According to data for 2014, about 86% of global energy is consumed in the form of fossil fuels (Figure 1.)

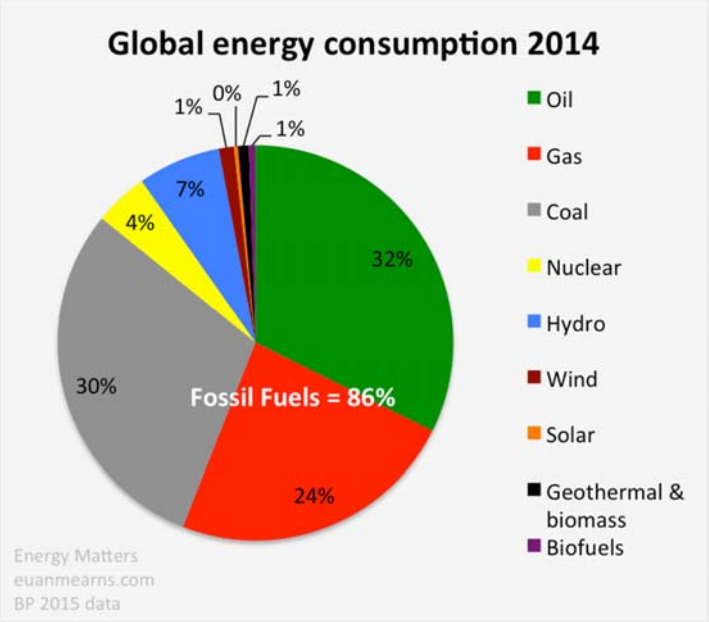

Figure 1 Fossil fuels represent 86% of all energy consumed in 2014, down 1% from the previous year. Source: Global Energy Trends – BP Statistical Review 2015.

The annual records reveal that there has been little change in consumption rate over the past three decades (Figure 2). The new renewable (alternative energy) is not impacting the fossil fuel consumption but rather is replacing the decline in nuclear power (Figure 2).

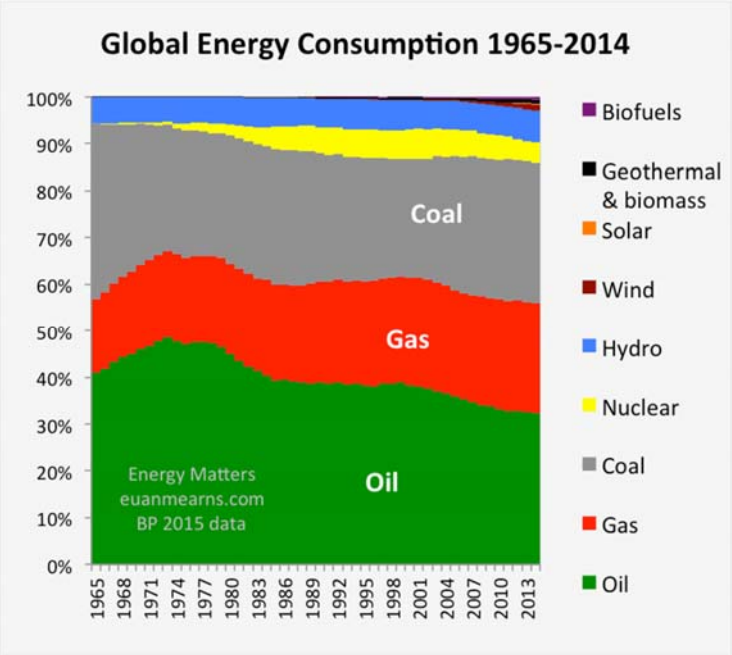

Figure 2 Global Energy Consumption from 1965 to 2014. Source: Global Energy Trends – BP Statistical Review 2015.

Fossil fuels consumption has been steady over the past 10 years. Nuclear power consumption is being replaced by the new alternative energy sources and not by a drop in fossil fuel consumption.

Other sources of data are available for CO2 emissions per capita per annum. The Carbon Dioxide Information Analysis Center (CDIAC) located in the Climate Change Science Institute at Oak Ridge, Tennessee, USA is a depository for World Bank meta-datasets. The World Data Center for Atmospheric Trace Gases is one of the most relevant datasets pertaining to this study. The fossil fuel CO2 emissions data dates from 1960-2014 (Figure 3) (Retrieved May, 2017). The global average CO2 emission per person per annum ranges from 2.91 to 5.25 metric tons. The record began in 1960 with 3.093 metric tons.

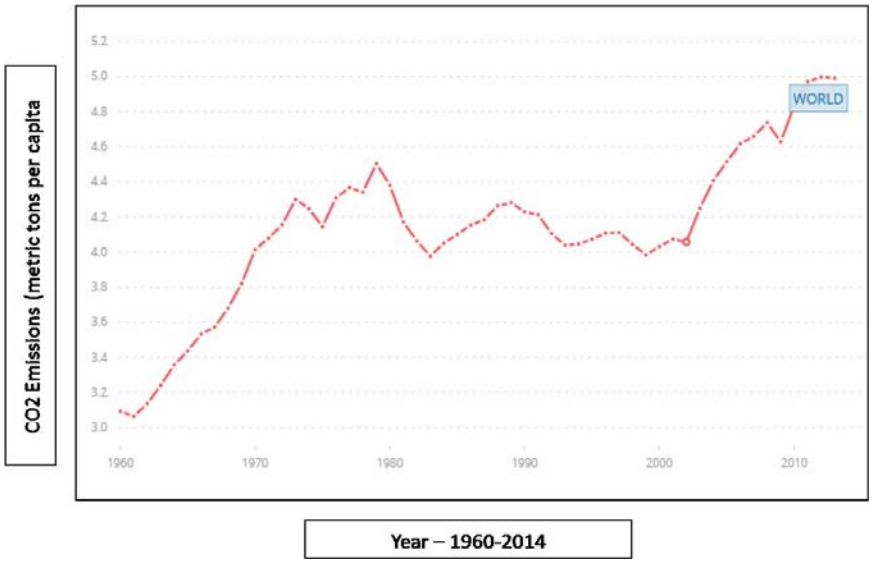

Figure 3 Word Bank Data – CO2 Emissions (metric tons per capita).
Source: http://data.worldbank.org/indicator/EN.ATM.CO2E.PC

The CO2 emissions rose steadily during the 1960's and 1970's, peaking in the late 1970's with 4.3 metric tons in 1973 and 4.5 metric tons in 1979. Emissions dropped away over the next two decades then began to rise again from 2002. The next peak was in 2012 with the individual global average CO2 emission of 4.997 metric tons.

The Middle East nations have major reserves of oil and natural gas. This has meant that the GCC nations have experienced extensive economic growth, rapid urbanization and development of infrastructure. Consequently, the GCC countries are significant contributors of CO2 emissions per capita. In terms of total global emissions per country, the CO2 emissions are not top rankers but they are highly significant at the per capita level.

According to Hussain (2014), residents in the GCC region emit two to ten times the CO2 emissions of the average global citizen. In Figure 4, Qatar emissions are 8.7 times that of the average global citizen, while Kuwait are 6.7, Oman are 4.4 and the UAE are 1.7 times the global average. These numbers are based on 2010 data.

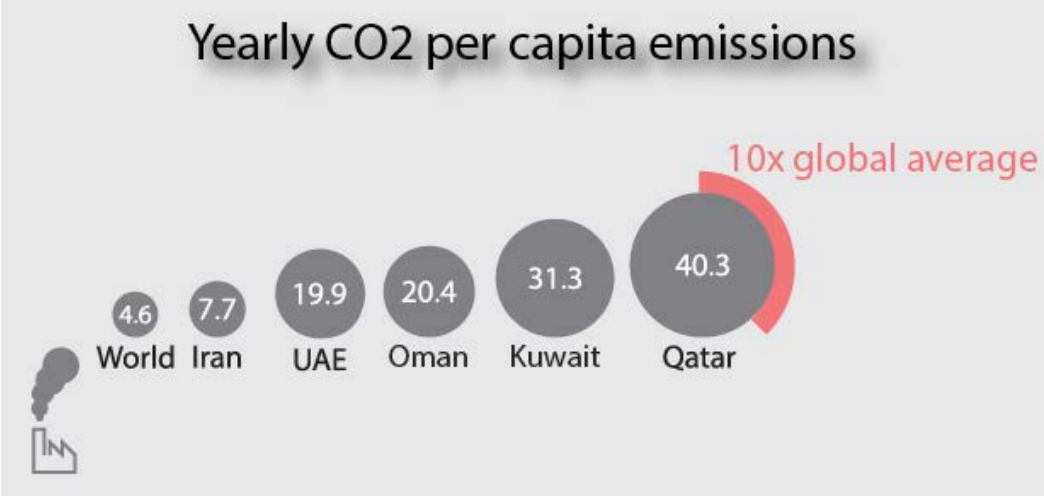

Figure 4 Yearly CO2 per capita emissions in the GCC compared with the average global citizen in 2010. Source: http://www.bq-magazine.com/gcc-illustrated/2014/08/co2-emissions-gcc-countries#.

The 2013 data was retrieved from the World Bank CO2 emission per capita dataset (World Bank 2017). Data for selected countries are tabulated in Table 1 shown below. The GCC countries: Qatar, Kuwait, Bahrain, UAE, KSA and Oman are all in excess of figures for the USA, Germany, U.K. and Sweden.

Table 1 CO2 Emissions per capita per annum for 1960 and 2013. Source: World Bank Data (2017)(n/a – not available).

CO2 Emissions per capita per annum for 1960 and 2013 Source: World Bank Data (2017)		
Country	**1960 (metric tons per person)**	**2013 (metric tons per person)**
Qatar	3.7	37.8
Kuwait	28.9	27.2
Bahrain	3.5	24.3
UAE	0.1	18.8
KSA	0.7	18.1
Oman	n/a	16.5
USA	16	16.4
Germany	n/a	9.4
U.K.	11.2	7.1
Sweden	6.6	4.6

Based on the available World Bank data (World Bank 2013), Qatar has the highest per capita emission with 37.8 metric tons, followed by Kuwait, Bahrain, United Arab Emirates, Saudi Arabia and Oman with 27.2, 24.3, 18.8, 18.1 and 16.5 metric tons respectively. The data for all the Arab nations brings the per capita figures down closer to the average global persons with 5.9 metric tons for the Middle East North Africa (MENA) countries and to 4.6 metric tons when nations from the Levant are included in the Arab world.

The per capita values have risen dramatically in the past decades as the nation's strive to achieve livable environs within the desert ecosystems of the region. This is primarily due to the high dependence on air cooling systems and where the dominant water source is from desalination. Over 70% of global desalination plants are in Middle East region (Parise 2011).

The annual global carbon budget does indicate a steadying or a slowing down of global CO2 emissions from the use of fossil fuels. In the Global Carbon Budget 2016 report (Le Quéré 2016), an annual document prepared and released from the Global Carbon Project (GCP) does reflect a leveling off in the carbon emissions since 2014. The global CO2 emissions are holding around 36 gigatonnes (GT) per year. This indicates that it is possible to stop the continuous increase of CO2 emissions, but according to Le Quéré, the Director of the Tyndall Centre: "This is a great help for tackling climate change but it is not enough. Global emissions now need to decrease rapidly, not just stop growing." (Le Quéré 2016). This brings us to the purpose of this paper. Individuals are contributing to the CO2 emissions therefore it is reasonable to state that individuals can also be part of the solution in reducing CO2 emissions. This can be achieved by making a conscious decision to adjust and modify one's lifestyle based on informed decision making processes.

The aim as set out by Gershon (2007) is for the individual to reduce his/her annual CO2 emissions by 5,000lb (2.3 metric tonnes). This means to reduce his/her individual carbon footprint. To achieve this, the individual needs to appreciate that personal choice and subsequent action can have an impact. The power of this approach is that the individual action can extend and include the whole family, then reach out into the neighborhood, then the lager community, and finally all the people of a nation. A chain reaction and a collective decision means that individual action leads to group action, and group action can lead to national action. By starting with individual steps, a nation can succeed in securing a sustainable future for its people.

3. Methodology

The concept of global warming and resultant climate change is generally understood. Because of our carb-rich diet, our electronic addiction and our high energy consumption, the people are responsible both individually and collectively. The large-scale action of the government and industrial sectors can be set aside so we can focus on the individual and their need for a low-carb diet. Lower energy consumption means less CO2 emissions and that leads to less heat-trapping gases in the atmosphere that causes the enhanced warming and an imbalance in our climate system.

A low-carb diet is all about lifestyle choices. As with any diet, a low-carb diet requires a decision and a commitment at the personal level. All diets deal with consumption and this diet is no different. Food diets are basically the consumption of energy while a carb-diet is the direct consumption of energy.

By understanding what amounts of CO2 emissions are generated when supplying the needs of the individual will provide the basis for choosing a low-carb diet. Over 85% of the energy consumed in developed nations is derived from fossil fuels. This fact highlights the petroleum industry and the downstream industries. It also includes natural gas reserves, coal mines and power plants, and their subsidiaries. This highlights the need to rethink and redevelop energy producing infrastructures. This is easier to contemplate than act upon.

Next is the transportation sector going from individual private transportation to service vehicles to mass transit people movers on land, in the air and at sea. In addition to people movers, there are goods and services transported across the globe. With the continued growth of global population, there will be parallel growth in energy demands and transportation needs.

In conjunction with population growth and expansion, there is a corresponding growth and expansion in residential and commercial building demands to service all the occupants. This means further increases in the demand for energy in the form of electricity, thermal energy

such as air cooling and heating, as well as luminescent energy. This does not even consider chain suppliers, life style assessments, or cradle to grave monitoring. But it does highlight the main areas of a low carb diet.

The first step is to calculate your CO2 emission. You first need to collect your last household electricity, natural gas or thermal oil power bill. Next you need to calculate the average weekly, monthly or annual mileage that you travel. Then calculate the fuel efficiency of each of your cars. This is determined by a simple calculation: distance/fuel consumption. And finally, information pertaining to the air travel that you typically take every year. You need the distance between Bahrain and your final destination. Remember to include the return trip so multiply by 2. Then visit the website below to calculate your own personal emission rate (or for your household).
http://www.empowermentinstitute.net/index.php/community/low-carbon-diet/household-co2-calculator

There are 10 levels with Level 10 being the best with carbon neutral status, and Level 1 is the least desirable. (Table 2) (Gershon 2007).

Table 2 Annual Household CO2 Emission Levels (lb).

	Annual Household CO2 Emissions (lbs)
Level 1	>80,000
Level 2	70,000 – 79,999
Level 3	60,000 – 69,999
Level 4	50,000 – 59,999
Level 5	40,000 – 49,999
Level 6	30,000 – 39,999
Level 7	20,000 – 29,999
Level 8	10,000 -19,999
Level 9	1,000 – 9,999
Level 10	Carbon neutral (<1000)

The next stage is introducing actions that one can take at a personal level and then at the household level. Once you have the information to make choices, one then needs to develop an action plan for oneself (or for the whole household). After one progresses through the basic concept of being "eco-friendly" and "pro-active" in reducing one's own CO2 emissions, the next stage is to adopt an action plan for managing the whole household. The final step is to share the low-carb diet and your success with others. This is creating "eco-teams" or eco-neighborhood groups.

The climate challenge is for everyone even though national and multinational companies produce and consume the greater portion of the energy. The services are all intended for the individual consumer. In the U.S. individual consumptions are almost double those of the European consumer but the consumers in the Middle East are almost in a league on their own. The GCC nations are very small nations living on limited land resources under very harsh climate conditions and plagued with extreme water scarcity issues. Individual energy consumption in the Middle East is way up in the top ranking countries. Per capita figures are extremely high even though figures at the national level are not extreme.

The low-carb diet is targeting the individual energy consumer. The low-carb diet details actions that should be taken by the individual.

4. Results that can be achieved on a low-carb diet

To be successful on a low carb diet, one needs to save kilowatt-hours of electricity, drive fewer miles (or kilometers), fly fewer miles (or kilometers) and burn fewer gallons (or litres) of car fuel. Other ways to reduce CO2 emissions is to use "green" or renewable sourced energy, insulate the home, eat local foods and reduce food waste, consume less meat, be more vegetarian, and embrace a more healthy consumption rate in general.

Individual action plans can become household action plans and these can be come community action plans. Eventually, these will create city action plans which in turn will influence government decisions and actions.

Individual action can be decisive and immediate, such as selecting energy efficient light bulbs while national action can ensure a wider acceptance and adoption of pro-active behavior. Government policy and action need to be in alignment e.g. in energy-efficient office lighting, street lighting, institute lighting, stadium lighting, and safety lighting. More rigid building codes that ensure energy efficiency and appliance efficiency requirements, mass transit systems that ensure transportation energy usage is both efficient and convenient. Waste reduction is both a personal responsibility and a community responsibility.

As energy consumption is the driving thrust of climate change, then energy efficiency at all levels is an obvious target for all sectors of the community. Efficiency needs to be the driving force of decision making and action taken in homes, offices, factories and industries. Energy losses have been the wasteful 'norm' which needs to be replaced by energy capture and energy conversion into further 'useful' energy sources. Clean energy technology needs to be not just a vision but a reality.

These individual measures are effective. But alongside of these actions, there needs to be strong national action under good leadership and government policy that ensures the national body is also moving towards a low-carb diet.

4.1 Low Carb Diet Plan

Three diet meals: breakfast, lunch and dinner are set out below. Over the next month, select as many options as possible from each of the following three diet meals. 'Breakfast' options will save you between 1 and 100 carbs by the end of the month. 'Lunch' options, which are more challenging and longer-term, will knock between 100 and 1,000 carbs from your starting weight, and 'Supper' options, which will require the most effort and the biggest changes, will lose you more than 1,000 carbs.

Table 3 Low-Carb Diet Plan (Target Carb loss per month).

Low-Carb Diet Plan (Target Carb loss per month)	
"Meal Time"	Carb Units
Breakfast	1-100
Lunch	100-1,000
Dinner	>1,000

Based on measurements and calculations from the Tyndall Centre for Climate Change Research, Defra, and the Rocky Mountain Institute (Siegle 2007).

To carry out the low-carb diet, refer to the Table of Carb Diet Equivalents (Tables 5,6 & 7). Each activity has a carb figure associated with it. Read the table to identify actions that you already take. Convert your current actions into carb equivalent amounts (I carb = 100g of CO2). Add up your present carb-actions and subtract it from you pre-determined CO2 footprint value.

Next step is to take further action and reduce you carb-usage. Select the tasks that will bring immediate results such as unplugging electronic devices that are not being used. Ready-mode means the device is draining 'phantom' energy for powering the "on" light. But the device is not actually operating in full capacity.

The diet requires an on-going note taking of your actions. This creates a self-monitoring system and helps keep the dieter on target towards the designated goal of reducing CO2 emissions.

Remember, the aim is to reach the designated target weight in one month. Target weight can be determined at two levels: active (50% reduction) or aggressive (90% reduction). According to the literature, these could be named: 'light green' and 'dark green'. (Table 4).

Table 4 Low-Carb Diet approach and corresponding target weight loses.

Low-Carb Diet Approach and Corresponding Target Weight Loses		
Diet Approach	**Carb Reduction Rate as a percentage**	**Name of Approach**
Active approach	50%	Light green
Aggressive	90%	Dark green

Depending upon you present carbon footprint, decide on your preferred approach and target weight. There are two levels promoted: an action based 'light green' diet and an aggressively active 'dark green' diet.

According to the World Wildlife Fund (WWF 2017), an individual carbon diet of 1.5 tonnes is sustainable to achieve the 'one planet living target. This level is considered as a sustainable individual emission rate for life on earth (as we know it) to be viable and sustainable.

Table 5 Breakfast Menu and corresponding target weight loses.

Breakfast Menu – small bite-sized energy savers

Breakfast Menu Lose 1-100 cards per action	
Action	**Carb Savings**
Only boil as much water as needed for coffee, tea, etc	8 carb (for 5 cups a day)
Recycle one piece of paper or one plastic bottle	1 carb
Recycle one aluminum can	2 carb
Turn off electronic devices 0 no standby mode	
Phone chargers	6 carb
Stereo	5 carb
DVD	3.4 carb
TV	15 carb
Amplifier	3 carb
Shower – short shower (3mins) *instead of bath using 77 carb*	77 carb
Laptop – *instead of desk top*	29 carb
Ride share – *one short journey, one person*	10 carb
Vacuum clean home every other week	16 carb
Buy unpackaged fruit and vegetables – *14kg wrappings*	26 carb
Warm up meals in microwave (*4min) – instead of oven*	15 carb
Cooking on stove top – match pan to ring	14 carb

Table 6 Lunch Menu and corresponding target weight loses.

Lunch menu – more challenging options with greater reduction in CO2 emissions

Lunch Menu Lose 100 – 1,000 carbs per action	
Action	**Carb Savings**
No more umbrella heat lamps on patio	491 carb
Turn lights off – on leaving the room	132 carb
Wash towels less frequently – *use 2-3 times*	204 carb
No drive to cold store or local market	200 carb
Divert food waste from garbage – *instead compost it*	443 carb
Remove extra fridge - *only used to cool beverages*	132 carb
Insulation in home – *highly variable numbers*	800 carb
Water heater – *sensor that adapts to different weather conditions*	1,000 carb
Water heater unit WITH insulation jacket	920 carb
Water heater temperature setting – no hotter than 60 degrees	600 carb
Car transport – use only 6 days per week	583 carb
Install solar thermal heating system	333 carb

Table 7 Dinner Menu and corresponding target weight loses.

Dinner menu – hardest choices with greatest carb savings

Dinner Menu **Lose more than 1,000 carb per action**	
Action	**Carb Savings**
Reduce weekly driving by 40 miles per car – (65km)	1,756 carb
Turn up the thermostat by 1° - to 24° C for cooling – down for heating	1,600 carb (over a year)
Change showerhead to low-flow unit	1,292 carb
Clothes washing – *twice a week – at 30°C (not higher option)*	1,756 carb
Select green energy supplier	xxx
Install photovoltaic system - *to provide electricity for the home*	2,400 carb
Use insulated cladding	2,000 carb
Single home occupancy – disproportionate use of energy - share	2,000 carb
Change light bulbs for eco bulbs – for every 6 bulbs	3,120 carb
Buy local produce - >90% foodstuffs flown in from overseas	4,800 carb

Over time, one will develop a taste for a low-carb diet and enjoy the benefits of this in terms of health and financial savings. Once one is convinced, then one can share with the family.

If one is too busy for an itemized approach where you keep an on-going running record of one's achievements, alternative sites such as http://calculator.bioregional.com/step01.php can provide general action plans. This website at Bioregional will provide you with an individual action plan with recommended actions for you to take without the need to monitor your actions.

5. Conclusions and Recommendations

5.1 Conclusions

The intent of the article is to reveal how feasible it is for the individual to take responsible action to counteract the CO2 emissions that each individual is responsible for. There will be areas where one cannot minimize the input of CO2 any further, but there will always be alternative actions to balance out. Once one has a taste for a low-carb diet, the process will simply become part of one's lifestyle. Once it becomes a habit of the individual, personal actions will be observed by others who will also want to partake in a low-carb diet for the healthy fitness and sustainability of the environment.

It is all about lifestyle choices but first one needs knowledge to understand the severity of the situation and the consequences of no action. The developed sector of the globe cannot continue to live as it has been for the past five decades. The present population needs to make the youth generation aware of all our responsibilities to achieve a sustainable future.

5.2 Recommendations

The recommendation is for individuals to read through the entire low-carb diet and focus on the action items. Conducting a personal carbon footprint assessment is not essential but it does provide a reference point against which one can assess their personal low-card reduction journey. The key is taking action to reduce personal carbon emissions and then to encourage other individuals and families to take similar action. This will then spread through the community achieving results that will all help to protect the environment and sustain the lifestyle of the earth's inhabitants.

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A Review of Energy Efficiency in Urban Development based on both Traditional Design and Contemporary Technology

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Abstract

Making our homes, schools, offices and workplace energy efficient is a big step towards lower energy demands and a more sustainable future. This is very critical in the GCC as the per capita consumption of electricity is extremely high and the greater portion of this is used in the mechanical cooling of the buildings. The hot, arid climate of the region is challenging but it is essential that the GCC nations are proactive in achieving building energy efficiency. Over 90% of the time is spent indoors carrying out the daily routines whether domestic or in the workplace. Given this, it is reasonable to state that the cooling of the buildings is, directly or indirectly, responsible for a significant portion of the greenhouse emissions from cooling the buildings. In fact, over 40% of emissions are attributable to homes and office buildings (Elgendy, 2010) with up to 70% of the electricity consumption in the GCC being used for mechanical air conditioning. With this high temporal occupancy of buildings, there is an equally high dependence on fossil-fuels used in power plants to provide the energy to heat, cool and light the buildings. Given this high dependency on electricity to create a habitable environment, the key for a sustainable future is energy conservation. This paper explores and reviews realistic and feasible passive design as part of traditional building design and contemporary technology to secure energy efficient buildings as a crucial part of urban building design. It appears that a mix of traditional measures suited to the climate of the region coupled with more contemporary options will make life in the Gulf more sustainable and environment-friendly. This is crucial in order to achieve a sustainable future in urban development in the region.

Keywords: urban building design, passive cooling, high performance envelope, traditional design, climate responsive approach.

1. Introduction

The nations of the GCC have all gone through extremely rapid urban growth and development. This development has been driven by both real demand by local residents and speculation by developers. In parallel with this growth, many of the architectural designs and urban development originated from the western world by western architects. The imported designs often were aimed at meeting the aspirations of the developers. There appears to be less consideration of the desires of the potential occupants and even less appreciation of the hot, arid climate in which these buildings were built (Elgendy, 2011).

The question of long-term sustainable design with regards to energy consumption, does not appear to have been a part of the development equation. The region has two factors that may be considered advantageous but may in fact have been weaknesses. Namely, the heavily subsidized electricity meant that less consideration was given to energy consumption and efficiency and second, the lack of building codes, standards and regulations. Without being bound by these two factors, building design has been unconstrained. Consequently, the building designs may be visually pleasing with their extensive facades of glass window panes. However, the buildings are exposed to very high and constant levels of solar irradiation throughout the year and have a very high energy consumption rate for cooling the interiors.

Sustainable development needs to strive to maintain certain aspects such as a balance between economic growth, and the social needs of the people while protecting the local ecosystems and reducing the negative impact of growth and development on the environment. In actuality, the focus has been more on addressing the basic development of economic expansion while placing less emphasis on such factors as water scarcity, food security and health-related concerns arising from the natural environs. The environmental aspect tends to be of less importance in development and design.

In the present growing and expanding urban development, there is great urgency to adopt sustainable strategies that will establish and maintain an eco-balance in an advanced society. The pressures exists that future growth and development needs to be achieved through urban design strategies that integrates environment issues into the economic growth and development models. Some of these urban and building design models can incorporate tradition passive features and utilize present day technology for enhancing and evaluation these design models.

2. Literature Review

The design of cities influences how society functions. The reality is that urban development is a series of long term ventures, that will last over decades, and that have a long lasting impact on the society. The building design determines the use of energy to maintain a thermal balance of comfort from season to season. It is estimated that heating and cooling of the buildings, both homes and workplaces, contribute 40% of global carbon emissions. (Elgendy, 2011). The urban design also determines the energy consumed in transportation. So another significant portion of the carbon emissions are contributed from transportation requirements between individual residences and the workplace. The building design also determines the amount of artificial lighting versus natural lighting that is available within the building structure.

The GCC nations experienced very rapid growth and expansion by being thrust into the developed world by the richness of the oil reserves. This urban growth took place even though the region is subjected to extreme scarcity of water. (FAO, 2007). The revenue from the oil reserves secured the future of the region by introducing desalination water plants. With rapid development came all the malaise associated with rapid expansion. The regional increase in the population is not a result of rapidly increasing population growth rate (PGR) but from the imported labor force, professionals and laborers. Now, the global population is poised and waiting for the arrival of the next 2 billion inhabitants on the planet. Again, this is not due to an increasing PGR but because the greater portion (40%) of the present global population is under the age of 25 years. (World Demographics Profile, 2017).

2.1 Development in the GCC region.

With the jettison into the developed zone, the countries in the GCC region have not had the opportunity to focus squarely on either a sustainable framework or urban development strategies that embraces the local environs in a sustainable manner. The process is now being reversed after significant development has already taken place. Now sustainable strategies and frameworks need to be drafted and implemented. The region now needs to address energy efficiency and alternative energy options as part of sustainable building design.

At the individual building scale, the biggest challenge is the hot, dry climate of the region. The inhabitants have grown accustomed to and demand a stabilized and 'cool' level of living comfort. To ensure the acceptable living conditions, air conditioning coupled with very high level of energy to power the equipment is the prerequisite. In addition to the cooling factor, there is an equally high energy demand to sustain the constant supply of potable water through the desalination process. Fortunately, the entire region has been able to supply these high energy demands through the sale of the oil and gas reserves. Because the oil and gas reserves were so extensive and the market has been very lucrative, funding has seemed unlimited. Consequently, there was less demand for stringent or conservative planning, economic growth and urban development grew without regulations and building codes, and without any concept of sustainable strategic planning.

The building forms and structures that dot the landscapes of the modern day cities in the GCC are mostly imported. That is, they have been designed by western architects and urban planners that appear to have failed to fully consider the climatic conditions of the region. This has resulted in even greater reliance on energy-intensive air conditioning. The author does not mean that one should deny the occupants acceptable levels of comfort and coolness but considering the extreme nature of the regional climate, it would be wise to consider the ways of the past in coping with the needs of the future, such as the cooling of the indoor space via more natural methods. This does not imply that extreme or elaborate design measures are called for but rather to study the past techniques that have been developed in the region and consider continuing to deploy them in the region. Then embrace the concepts and advanced

technology of contemporary development to ensure cool environs for human occupation without the excessive energy demands needed to power the cooling systems.

This points to fact that the building and construction industry requires regulated and monitored building codes that target sustainable development coupled with energy efficient design and structure. Urban development and architectural design have moved forward in line with sustainability and energy efficiency as prerequisites. With the green building certification standards such as LEED, BREEAM and Estidama (Sustainability), it is becoming a mandate to achieve sustainable growth and development.

The built environment in the GCC nations is a significant consumer of all the electricity generated in the region. About 70% of the electricity consumed is used for cooling buildings for approximately 8 months of the year. (Yassine and Elgendy, 2011). This figure also includes artificial lighting. (Kazim, 2007). These figures are not sustainable in terms of generating energy for the growing population with this rate of consumption.

2.2 Traditional Build Designs

There is an urgent need to review passive cooling techniques and to reassess traditional techniques developed over the centuries that may be adapted to contemporary construction and design. In addition to using traditional techniques, present advancements in technology needs to be incorporated into building solutions, especially cooling factors, for securing a sustainable future living in the hot, arid conditions of the region.

The regional traditional design consisted of building clusters with inner courtyards and inward-facing buildings. These houses were connected via narrow pathways, which typically ran north to south (or north-east to south-west) creating shaded areas that aimed at reducing heat gains, and took advantage of the prevailing winds. (Figure 1) (Nabavi et al, 2012) This urban pattern allowed residents to live in relative comfort even during the harsh summer months. Urban developments could embrace the orientation aspect.

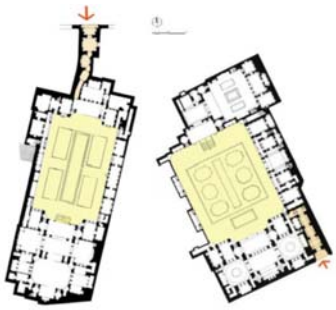

Figure 1 Two different house orientations. Source: Nabavi , et al, 2012.

Another prominent feature of traditional architecture is the use of wind towers. Rising above buildings' rooftops, the traditional wind tower is open in all four directions. (Figure 2).

Figure 2 Shaikh Isa House, Muharraq, Bahrain. Source: Ali, Alamoudi, Alajmi, Khayat and Aishraim, 2014.

These towers provide ventilation and passive cooling by capturing wind and directing it into the interior spaces of the building through narrow shafts. This has the potential of being a zero-energy cooling system adapted for contemporary housing (Shadbolt, 2014). As the wind hits the tower, the moving air is funneled down the inner tower to the lower levels. The buildup of air in the inside is positive with a negative pressure on the outside that draws the stale inside air up the tower and releases to the surroundings. Masdar City in the UAE has experimented with the wind tower concept with adjustable openings to avail the building of variable wind sources. (Figure 3).

Figure 3 Wind tower in Masdar City, UAE. Source: Shadbolt, 2014.

Traditional buildings also benefited from high thermal mass building material, which moderated the interior temperature from excessive solar heat gain. Traditional wall thicknesses ranged from 0.4-1.0m thick (Ali, Alamoudi, Alajmi, Khayat and Aishraim, 2014). New insulated building materials and external cladding that are available today are able to enhance the thermal mass factor without the excessive thickness of the wall structures.

2.3 Recommendation of Alternative Measures

In order to curb this is insatiable consumption of electrical energy, alternative cooling methods must be fully explored, adapted and implemented. There are now many more indigenous architects and energy efficiency professionals in the region, as well as a greater awareness of the need to build urban environments that compliment and work with the environment in a sustainable and viable manner. This needs to be partnered with building standards, codes and regulations that are geared towards energy efficiency in building design.

Traditional architecture all across the Gulf region offers passive techniques for cooling and heating both domestic and workplace buildings in a sustainable manner. A climate responsive approach offers ways in which to deal with searing heat and arid conditions while managing the ever-increasing demand for energy (St Clair, 2009). The basic building design should be based on innovative ways that ensure energy efficiency. This should include passive cooling, orientation, massing, shading, thermal insulation, high performance envelope, natural ventilation and improved building pressurization. Many aspects of traditional building concepts can contribute to these building measures.

In addition, new technologies need to be aggressively explored looking for viable and tractable solutions for sustainable urban design and development.

2.4 Passive Cooling

There needs to be a curtailing of the dependence on energy intensive mechanical cooling. In achieving this goal, it will also reduce on-going operational energy expenses, improve indoor air quality and possibly reduce investment capital in the construction stage. Yassine and Elgendy (2011) indicate that passive cooling systems could reduce the heat gain in urban developments by up to 25%. The two main approaches are to reduce the heat accumulation in the building design in the first instance, then to utilize wind and extraction of heat (sun chimneys) to cool and ventilate the internal living or working space.

2.5 Orientation

Orientation of urban building is a simple approach that incorporates no additional expense. It may reduce the number of buildings or size of buildings due to orientation. This approach aims to minimize solar penetration through the window areas, minimize solar absorption through the walls and roof top and maximize cross ventilation using the natural flow of air (St Clair, 2009).

This may result in unusable space in terms of building construction but could be readily turned into usable outdoor space such as children play area, communal area with outdoor tables and chairs and so forth. These spaces would also enhance the design environment.

Based on climate data such as solar radiation, wind patterns and ambient air temperatures, the greatest heat gains will presumable be on the south facing walls particularly in summer. Therefore, developments should ideally be orientated on the east-west axis as the sun's angle will be lower when it impacts these wall facings. The window glazing will also need to be assessed for glare control. However, specialty glazing will increase the construction costings. Specialty glazing will reduce maximum exposure under full sunlight in the peak of the day, especially on the south facing walls. Building design should consider physical shading as part of the built environment design. Natural shading from vegetation is ideal but tends to only be feasible at the lower levels and definitely at ground level. Therefore physical design features, such as overhangs or recessed areas, need to be incorporated at high elevations.

For precision and exactness, built designs need to be tested using simulation methods of microclimate features that may exist in different construction zones.

2.6 Traditional architecture

Orientation was a key consideration in traditional architectural design (Nabavi, Ahmad and Goh, 2012). The buildings examines are all introverted with rooms opening out on to a rectangular, open courtyard. This enclosed space provided space for trees and water features for evaporative cooling. The Iwan or semi-open areas typically orientated southward, created shade and cool living spaces during the day.

Figure 4 Iwan of a traditional building. Source: Ali, Alamoudi, Alajmi, Khayat and Aishraim, 2014.

Other research of traditional design achieving sustainability was reported as being very successful in dry, arid climates of the Middle East. (Ali, Alamoudi, Alajmi, Khayat and Aishraim, 2014). Semi shaded and arcade areas were favored in Bahrain traditional architectural design, as well as shaded interior courtyard. Monsoon windows or narrow, horizontal slit windows also permitted hot air to escape. The very thick walls and roof tops ensured thermal massing. (Ali,

Alamoudi, Alajmi, Khayat and Aishraim, 2014). Low-energy design guidelines were developed for buildings in the UAE (St Clair, 2009).

2.7 Massing of buildings

The aim should be to enhance and ensure air movement at all levels. Therefore, crowding urban areas with tall buildings of the same dimensions will impede and obstruct air flow. The alternative approach is to have buildings of various height and mass to enhance air movement. Needless, to say, avoiding extreme turbulence or gustiness is essential as this is equally unacceptable.

2.8 Shading

The idea of shade and shading is an essential element of building design. This can be achieved by a wide variety of methods. Natural shading is viable in terms of trees and has a strong aesthetic value and psychological benefits. Overhangs can be very creative and part of the design especially in walkway and public outdoor seating areas. (Ali, Alamoudi, Alajmi, Khayat and Aishraim, 2014). Building clusters to create inner courtyard areas is another possibility. Then there is the use of shading devices that are either fixed or operable depending on climatic conditions. Wise design should incorporate shading to allow natural light in without permitting excess thermal energy to enter the building so raising the indoor air temperatures.

2.9 High Performance Envelope

The use of thermal insulation building materials is essential both on the roof surface as well as the sides of the building. The goal is to reduce and even prevent heat entering the building while retaining any mechanical cooling effects built into the environment. The effectiveness of the insulating materials needs to be determined prior to construction. The effectiveness is termed the U-value, a measure of the effectiveness of the building material as an insulator. In other words, it's a measure of heat radiation that can enter a building based on one degree temperature differential over an area of one square meter.

2.10 Thermal Insulation

Insulation materials should ideally perform in the range of a U-value of <= 0.3 value, e.g. cavity wall blocks will have a lower U-value ($1.6W/m^2$) compared with solid brick ($2.0W/m^2$). Double glazed windows are around $2.8W/m^2$. Ideally, the aim is to reduce the heat capacity of the external structure of the building as well as reducing solar heat gain inside the building. A building can gain most of the interior heat via the window glazing. To ensure a low rate of heat transmission via glazing one can also select glazing with a low Solar Heat Gain Coefficient (SHGC) of 0.22 value. This value is the ratio of heat that hits the building to the amount of heat that can enter via the windows.

2.11 Natural Ventilation

Orientation is the ideal way to allow natural air flow and ventilation to occur. The air flow will naturally reduce the ambient temperature. If this is not feasible, one can revert to traditional designs such as the wind tower and solar chimney. A solar chimney however does require a low level cooling cavity to cool the low level air entering the building while ejecting warmer air up and out the solar chimney.

The traditional wind towers or *Badjir* is open on all four sides to accommodate all four wind directions. This has many disadvantages. The ideal would be to have operable vents on each side of the wind tower that can be opened and closed according to the wind direction. By opening the vents on the side of the prevailing winds would ensure better efficiency of the traditional wind tower.

2.12 Improved Building Pressurization

Improving the pressurization within buildings basically means eliminating air leaks from the building. This means double door entry ports and evenly sealed windows. This is because warm air leaks through poor seals which will have a big impact on the cooling of the internal space.

2.13 Façade Solutions and Levels of Opaqueness

Facades that are semi opaque or of variable transparency are another option for reducing solar penetration into the interior of the building. This in turn lowers the need for mechanical cooling of the interior (St Clair, 2009).

2.14 Contemporary Solutions

As technology advances and new concepts are developed and tested, contemporary solutions will also offer viable options for managing the urban development. Solar powered cooling systems as developed by the Swedes, is finding testing ground in the Gulf. The solar thermal collectors (panels) are non-porous glass which tends to collect less dust. This is an ideal match as solar energy is in abundance and cooling is a major requirement in the region. The dust factor is also a major concern in the region (Todorova. 2011). Other investigations into radiative cooling are presently being trialed. Operating on the principle that heat-carrying infrared radiation is re-radiated back out into space, then one should consider trapping unwanted thermal energy and converting it to IR wavelengths for reradiating off the planet (The Economist, 2017). This requires a special film that is able to emit thermal energy while only absorbing solar energy at a very low level. This is possible due to the imbalance between solar irradiance and the low infrared reradiation flux from near ambient air temperature surfaces (Zhai, *et al*, 2017).

There are many initiatives researching better construction materials with higher thermal ratings, alternative heat repulsion methodology and applications of alternative energy sources. But many of these applications are based on individual building application. With the ever growing demands for housing for a growing population, a more comprehensive approach to urban neighborhoods addressing the energy consumption and carbon emissions for neighborhoods has found its place in GIS simulation modeling. (Stauffer, 2013). Software such as “Mapwell” is able to determine solar energy capture efficiency with in USA neighborhoods. (Stauffer, 2013). It is able to determine optimum number of solar panels, potential energy production, costing, payback period. This approach is also able to address the influences of neighboring building on each other that in turn affect the resource efficiency and overall desirability of neighborhoods. The four metrics determined are the energy consumption, transportation, indoor daylighting and outdoor comfort. This incorporates satellite imagery and local climatic data for the region to determine neighborhood sustainability in terms of energy efficiency and carbon emissions. Some software packages are able to determine the amount of energy feasible from buildings based on PV cells on roof tops. (Stauffer, 2013). MIT faculty and students have devised urban modeling software (UMI) that is being applied globally. (urbanmodelling.net). This adds an essential dimension to urban development going beyond a single building and embracing whole neighborhoods.

3. Conclusion

3.1 Opportunities and Natural Potential

The GCC is challenged to achieve sustainable urban environments that do not continue to consume extreme amounts of precious energy. Some considerations are in the early stages of implementation. They include developing self-sufficient individual and community based alternative energy sources. There needs to be re-deployment of traditional building design models especially in terms of energy diversion. Interior air cooling needs to be restructured to reduce the dependence on high energy consumption and geared towards greater energy efficiency. The region is sun-saturated so needs to utilize the readily available solar energy. This needs to be integrated into the building design concept and other development strategies.

There also needs to be consideration of the inclusion of other alternative energy sources, such as wind power and biogases, into the energy matrix.

Advances in more energy efficient and sustainable measures have, in the past five years, raced ahead with government, non-government, institutions and energy efficiency agents realizing the potential of the natural solar energy resource immediately available in the region. Although, the standard fossil fuel sources will remain they are not in sustainable quantities nor are there manageable emission control methods to ensure a sustainable future.

The United Arab Emirates (UAE) government has introduced energy efficiency standards for buildings. Non-governmental organizations (NGOs) and professional organizations in Qatar, Bahrain and the UAE have established green building councils with the goal of promoting sustainable design in conjunction with the development and adoption of green building standards.

4. Recommendations

Imported building designs although aesthetically pleasing to the urbanized perspective are massive consumers of energy due to the need for mechanical air conditioning and cooling for a significant portion of the year. Ways and means of securing lower-energy demanding buildings is crucial in hot, arid climates. The use of low-energy design incorporating orientation, thermal massing, and insulation via construction materials, facade design and overhang shading are all viable options. Micro-climate assessment needs to be a critical component of building design to ensure the most appropriate features are incorporated into the buildings. Therefore, a mix of traditional concepts and contemporary materials seems the more feasible approach to building sustainable living and working environments in the Gulf region. New concepts and designs will always be presenting themselves. The nature of the challenges faced by the region requires a commitment to sustainable development and a willingness to embrace the concept of sustainability in all aspects of society. This will require collaboration between governments, non-government bodies, professional bodies, institutes and the general public community.

The bottom line of sustainable design for the Middle East region is to advance in the inclusion of alternative energy sources to the point of making buildings self-sufficient in energy supply. Solar energy is abundantly available in this region so avail upon it and embrace it to the fullest extent. And embrace traditional concepts of energy diversion and cooling effects to help reduce dependency on conventional energy sources and lower the high energy consumption in the region.

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Section 4

Engineering Futures and Futurology

Improving the Resilience of Infrastructure to Create Sustainable Futures

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Abstract

Climate change cause extreme weather patterns that have adverse effects on the infrastructure in UK, resulting in disruption to all stakeholders. These include extreme temperature highs; storms, windstorms, hurricanes; high levels of precipitation and associated flooding and lack of precipitation and associated drought. In recent years flooding has had severe impact on infrastructure and related physical assets in UK. The transport systems struggle to cope even though advancements are made in research and mitigation strategies. This paper examined areas of infrastructure related to land transport that fail or seem to fail and cause extreme disturbance to its users. It sought to identify the elements that are more vulnerable and need reinforcing in order to strengthen the resilience and the capability to cope in extreme weather. A broad-ranging literature review including government and stakeholder reports, case studies and action plans provided the foundation for the study. The paper attempted to capture the key lessons that can inform future adaptation and mitigating strategies and identifies areas that need further improvements in strengthening the resilience of the key infrastructure facilities. The information illustrated that it is not only the responsibility of one organisation but also a collective effort from government, local authorities, health, police and other infrastructure providers. Roads, railways, ports and other infrastructure assets must be constructed, refurbished or retrofitted to withstand extreme weather conditions. The design standards and thresholds must be re-visited and reviewed to encompass new weather scenarios and effects.

Keywords: Infrastructure, Resilience, Resilient Infrastructure, Transport, Flooding

1. Climate Change and the infrastructure

Climate change is one of the major global challenges faced in the 21st century and has a significant impact on the built environment. The 'extreme weather events' caused by climate change include: extreme temperature highs; storms, windstorms, hurricanes; high levels of precipitation and associated flooding; and lack of precipitation and associated drought (Anderson et al, 2006). New research suggests that many areas in England are projected to see an increase in severe weather over the next 30 years (Oven et al 2012, BIOPICCC, 2011). These extreme events are associated with major disruptions to essential services such as transportation and communication networks, energy and water supplies and can have severe repercussions to people's health, well-being, social and economic activity and employment. Safe guarding infrastructure to extreme weather works on three levels: maximising the physical resilience, ensuring processes and procedures are restored quickly and ensuring clear and effective communication to all stakeholders so that impact is minimised (CCC, 2017a). The transport functions that are most likely to be affected by climate change include, provision of public passenger transport including tube, rail, bus and river services and functions of Highway Authorities and Traffic Authorities for roads. In London, UK, Transport for London (2015) have forecasted the risks from climate change related extreme weather conditions for 2050 as -

- Higher summer temperatures- with the average summer days being 2.7°C warmer and very hot days 6.5°C warmer than the baseline average.
- Warmer Winters - with the average winter day being 2.2°C warmer and a very warm winter day 3.5°C above the baseline. Increase in seasonal rainfall – drier summers, with the average summer 19% drier and the driest summer 39% drier than the baseline average.
- Wetter Winters - with the average winter 15% wetter and the wettest winter 33% wetter than the baseline average.
- Sea level rise - projected to rise by up to 96cms by the end of the century.

Flooding is the most significant climate change risk to UK infrastructure and assets and according to UK Climate Change Risk Assessment (2017); the number of assets exposed could double under expected changes in climate by the 2080s. The most common sources of flooding include: river flooding, coastal flooding, surface water flooding (including sewer flooding caused by rainfall overwhelming sewer capacity), and groundwater flooding (CCC, 2017b). Storm surges and rising sea levels pose a major threat to coastal infrastructure as well as cause sea erosion. Rain runoffs quickly undermine structures such as dams, railroad beds, bridges, and buildings. In the future, tunnels may become more vulnerable, both because the risk of their entrances and vents flooding will be greater, and because the hydraulic pressure on the tunnel walls increases as water tables rise (Titus, 2002).

This paper examines various extreme weather phenomenon that have significant impact on infrastructure that result in major disruptions to its users. It focuses on land transport systems emphasizing the impact on road and rail networks and related assets. A broad-ranging literature review including government and other stakeholder reports, case studies and action plans provided the foundation and an understanding of the wider context and the debate. Methodology is based on both secondary and primary data sources captured from different case studies carried out in the region and synthesizing the information and findings to draw out lessons that can be learnt. The aim is to identify the key areas that need strengthening and have an insight to how the mitigation strategies adopted by individual stakeholders can contribute to the sector as a whole. An objective is to examine how the infrastructure providers can improve collaborative working to increase the future resilience and capability of land transport systems. This in turn can have a major influence on economic and community resilience that contribute to sustainable futures.

2. Extreme weather and transport systems

UK transport network is the most intensively used in Europe and this will increase steadily in the future as both passenger and freight demand grows (EWENT, 2014). Dependable transport systems are appreciated for safety, cost, travel time, and regularity of service (Koetse et al, 2009). Maintaining the volume of traffic flow on the network, whether public transport or private travel, is fundamental for production, logistics, and business (Jenelius et al., 2006). Heathrow is the most intensively used two-runway airport in the world in terms of takeoffs and landings per runway and Gatwick is the most intensively used single runway airport (Chapman, 2014). The Strategic Road Network managed by the Highways Agency is also intensively used, operating at capacity on a number of sections at busy times and with traffic volumes forecast to increase by more than 45% by 2040 (High Ways Agency, 2009). Many local roads are also similarly at or close to capacity at busy times. In recent years, the impact of extreme weather on transport systems has been significant and many road and rail users experienced major and prolonged disruptions. Flooding impacts this in a number of ways through both direct impacts (physical damage) and indirect impacts (disruption to traffic flow, business interruption, increased emissions) (Brown et al, 2016). Numerous local roads were closed due to flooding and falling trees brought down power lines, which resulted in road closures and blocked carriageways. The reduction in performance of transport systems due to flooding is the most detrimental factor for the society and economy and it has been estimated at around £100k per hour for each main road affected (Arkell et al, 2006). Meanwhile, studies have shown that roads are among the first cause of deaths in cities during flooding, due to vehicles being driven through flooded roadways (Jonkman et al, 2005). The airports were affected and Gatwick suffered severe disruption with partial closure of its terminals due to basement flooding disrupting power, communication and IT systems.

2.1 Extreme weather impacts on road infrastructure

The road transport network is known to be a key enabler of the UK economy (Eddington, 1996) and has been emphasized as the UK's most expensive asset (DfT, 2005). It is also understood to be running near capacity (CCC, 2017a) and weather is a key factor in causing frequent major disruptions and accidents. The most damaging weather conditions for roads are, flooding, heavy rain, low temperatures and heavy snowfalls and high gusts of wind (EWENT, 2014). A combination of these can cause major damages to the physical infrastructure and disruption to its users. Heavy rain may result in landslides, mudflows and floods that destroy and erode

roads, break and wash away bridges, pavements, drains and culverts resulting in major disruption, injury to users and sometimes fatalities. Floodwater can also enter underground transport systems. Melting snow, heavy wind in coastal areas can lift water and sea levels to abnormal high levels. Heavy snow and freezing rain result in poor visibility, slippery roads, slow traffic and accidents. Heavy snow and wind gusts result in fallen trees on roads, which again disrupt transport links.

According to the Department of Transport (2014), flash floods that start speedily due to heavy rain are the main cause of weather related disruption to the transport sector. This can be severe on the road network in urban areas owing to the high proportion of impermeable surfaces that prevent the infiltration of water into the soil (Chapman, 2014). Heavy rain causes over flows that can result in drains exceeding their capacity and increasing the likelihood they become blocked by debris, before flood warnings can be widely disseminated.

2.2 Extreme weather impacts on rail infrastructure

The most harmful weather conditions for rail are listed as snow, low temperatures, flooding, wind and a combination of these. Snow can block tracks, yards, and damage overhead cables. Low temperatures can freeze switches and locks and cause tensional failures (EWENT, 2014). Snow and freezing may cause loss of electricity and signaling failures. Freeze thaw processes are also known to put excess strain on material and equipment (Chapman, 2014).

In recent years flooding has had severe impact on rail transportation and the related physical assets in UK. Rails tracks are washed away; embankments, slopes, bridges and other supporting structures are damaged and flooded underground tunnels un-useable by passengers due to safety concerns. Strong winds, tornados and tidal waves in coastal areas have similar effects. Fallen trees and debris on tracks, dangers of lightning hitting traffic controlling apparatus are other disruptions that can be faced.

3. Improving Infrastructure resilience-

The literature highlighted substantial amounts of research into the impact of a wide range of natural hazards, including snow, ice, rain, fog, wind and heat, on transport disruption. These studies span events of different spatial scale and magnitude and include results from a number of different countries. The increased frequency of flooding is the most significant climate change risk to UK infrastructure including transport, energy, communications and services resulting in lengthy and expensive repairs averaging an estimated £1 billion per year in the UK (DEFRA, 2012). 'A large number of assets (17% of railway tracks and 16% of railway stations, 9% of A-roads and motorways are in locations which are prone to river or coastal, ground or surface flooding and it is projected that this risk will increase. Future Climate Change predications involving 4°C of global warming by the 2080s imply large increases in possible flood damage in UK. This scenario would lead the 2,400km of the UK rail network vulnerable to flooding rising by 120% by the 2080s' (CCC, 2017a).

Rainfall intensity has repeatedly been shown to be a factor in transport disruption, reducing driver visibility, and reduced speeds. More intense rainfall will also increase sewer-flooding events. Rising sea levels of 0.5–1m by the end of the century will increase the proportion of assets vulnerable to coastal flooding. The need to realign coastal defenses in some areas in response to rising sea levels will have implications for infrastructure assets in the coastal zone, increasing their annual cost of maintenance. In order to address these major issues the government has created a long-term statutory framework for assessing and managing the risks to the UK from the changing climate. The Act requires the Government to assess the risks and opportunities relevant to the UK every five years and present a report to Parliament. As a result of these assessments priorities for further action and research have been identified (CCC, 2017b):

- Residual risks: while investments have been increased in flood prone areas, the residual risk of flooding remain high across the UK. Improved flood defences will not be possible or affordable in every area, and with climate change a greater disparity in risk between protected and non-protected areas may emerge. Some individual coastal communities are vulnerable to coastal erosion and sea level rises.
- Urban water management: heavy rainfalls stretch the capacity of sewers in many urban areas already at or over capacity. Redesigning urban landscapes and sustainable drainage

systems are needed to protect individual properties to be able to cope with more intense patterns of rainfall.

- People and communities: as well as residential homes and other buildings, a significant number of hospitals and other care facilities are located in exposed areas. The evidence suggests that the long-term health and wellbeing impacts of flood events are considerable and more research is needed to assess and understand how best to manage these.
- Infrastructure: electricity sub-stations, road and rail networks, water treatments works, ports and airports, and fixed line and mobile communications assets, are all exposed to increasing flood risks. Further work is needed to assess and address vulnerabilities, including interdependencies between networks and includes the risk of sewer failure and consequential flooding.
- Agricultural production: strategic choices need to be made about the value of protecting agricultural production in flood risk areas when this could further increase run-off rates, silt deposition in rivers and downstream flood risk.

Building the capacity for resilience to flooding needs both formal and informal structures and processes and importantly requires clear linkages and accountability between those structures, so that resources can be freely transferred and exchanged. Community resilience cannot be built in a vacuum (Defra, 2014). There is a range of academic literature that specifically addresses the issue of measurement of community resilience and social vulnerability to natural hazards such as flooding. The information shows that the extreme weather effects have an influence over infrastructure users and related staff as well as service provider personnel, physical assets, economic and commercial activities and social wellbeing of communities. Case studies illustrate that it is not only the responsibility of one organization, but also a collective effort from government, local authorities, health, police and other infrastructure providers. Government support and funding are key factors in this process. Roads, railways, ports and other infrastructure assets must be constructed, refurbished or retrofitted to withstand extreme weather conditions. The design standards and thresholds must be re-visited and reviewed to encompass new weather scenarios and forces.

3.1 Rail networks

In relation to rail networks, the risks have not changed significantly since the risk assessments were carried out in 2011 (CCC, 2011) but the level of detailed internal analysis and the investments and implications on long-term resilience have changed. Table 1 illustrates weather related hazards, the risks that are associated with related assets and consequences.

Table 1 Key climate change risks to rail infrastructure (Network Rail, 2015).

Weather-related hazard	Asset associated with risk	Consequence
Temperature (high, low and rate of change)	Track	Buckles and breaks and derailment risk, Reduced opportunities for track maintenance
	Switches and crossings	Frozen or snow blocked points, Failure of point operating equipment
High temperatures	Overhead line equipment	Sag of overhead line and risk of de-wirement
	Line side equipment	Failure of temperature controls and overheating of electronic equipment
Low temperatures	Third rail and overhead line, equipment	Loss of power to rolling stock due to ice and snow build up and contact failure
	Overhead line equipment	Icicle build up causes damage to pantograph
	Buildings (depots, stations and offices)	Slips, trips and falls risk to staff and station users
	Level crossings	Ice on roads and vehicle incursion onto track system

Increase in flooding	All	Closure of line due to track flooding, Failure of line side equipment due to inundation of water, Access issues to depots, stations and offices, Scour of embankment material
Change in river flows	Bridges	Risk of asset failure from: Scour of river bed material at bridge, foundations due to hydraulic action, Accumulation of debris under structure
Increased rainfall	Earthworks	Landslip and earthwork failure and risk to rolling stock and staff
Decreased rainfall	Earthworks	Desiccation of embankments resulting in track geometry faults and failures in supported line side equipment
High winds	Overhead line equipment and track	Risk to rolling stock, staff and asset failure from falling trees and debris (plastic bags, sheds and trampolines)
Sea level rise and storm surge	Coastal assets	Closure of track due to flooding, Structure or earthwork failure and risk to rolling stock and staff, Increased overtopping and sea water ingress into rolling stock and line side equipment
Extreme weather	Staff	Poor working conditions for staff in extreme weather conditions
Seasonal changes	Vegetation	Changes in growth rates and impacts on maintenance budgets and leaf fall management, Changes in invasive species and impacts on maintenance budgets and risk based assessment
Lightning	Line side equipment	Asset failure as a result of lightning strikes and electrical surges

Consequences of extreme weather events on rail infrastructure illustrate that frequent testing, monitoring, review and updating is essential to keep the infrastructure and assets from failing. While the main responsibility lies with the rail authorities, it also demonstrates that collaborative thinking and working is essential from several stakeholders as disruptions to one service can have a ripple effect and put pressure on to other services. Frequent and routine maintenance, new and innovative asset management techniques that identify potential failures well in advance are needed to identify risk and carry out mitigation and adaptation. Improved asset data shared by different infrastructure service providers in differing systems supported by a range of data maintenance and assurance procedures can be used to better understand the vulnerability of each asset type to climate impacts. Advanced methods and tools are also needed to capture, maintain and access high-quality asset data. The ability to join and view asset data in collaborative environments and share decision support tools to better manage the assets will help in improving future resilience.

3.2 Road networks

Flooding, snow and ice represent the biggest risks of disruption to the road networks. The majority of flooding events are localised and of short duration, typically resulting only in lane closures rather than complete closures of roads. However they can, cause more significant disruption. High winds are also a significant source of disruption because of the risk of high-sided vehicles being blown over, and the increased risk for other vulnerable vehicles such as motorbikes, caravans and other towed trailers. Extended hot periods can increase the risk of damage to certain types of road construction, due to thermal expansion, resulting in an uneven road surface that needs repair. Extreme heat can also accelerate the rate of deterioration of older types of road surfaces, such as those formed of hot rolled asphalt, through softening and rutting of the surface (Chapman, 2014). Hot conditions also pose a heightened welfare risk to road workers, road users and livestock in transit, particularly when vehicles are delayed. The impacts of high wind speeds on the strategic road networks are largely operational, because of

the vulnerability of certain types of vehicle and the risk of accidents or vehicle blow-overs. The infrastructure itself, particularly its structures, is resilient to very high winds (CCC, 2017a). The main responsibility in these scenarios is therefore to manage user behaviour and access to minimise the risk of accidents and avoid the resulting disruption to traffic (CCC, 2017b).

4. Embedding infrastructure resilience in sustainable development

As a result of The UK Climate Change Risk Assessment 2017, 'Flooding and coastal change risks to communities, businesses and infrastructure' has been identifies as an urgent, high risk, priority area where immediate action is needed. It is also identified as a priority research area. Climate change risk assessment identifies and sets out the main threats and opportunities arising from climate change over a defined period and evaluate the risks for adaptation priorities. Adaptation is the adjustment or preparation of natural or human systems to a new or changing environment that moderates harm or exploits beneficial opportunities. Climate resilience is the capacity to anticipate, prepare for, respond to, and recover from significant climate threats (GLA, 2011). Physical and economic resilience can be improved through adaptation measures, which minimise the impacts from climate threats on businesses, workers, supply chain and the environment.

Table 2 Selected case study review- London, UK extreme Weather Incidents since 2011-2014 (TFL, 2015).

Year	Event	Actions/ Lessons Learnt
2012	Lightning Strike at DLR Cross harbour equipment room	Changed design standards to ensure that earthing and bonding is more rigorous and introduced measures to break the charge.
2013	Fore Street tunnel drain gullies temporarily blocked with ice by a hail storm	Needed help from the police to unblock the gullies, as contractors couldn't access the site through the traffic jam.
February 2014	Storms and subsequent groundwater flooding	Pumping processes in place. Local authority and emergency services assisted communities in Croydon to be evacuated due to groundwater flooding.
July 2014	Excessive Heat	Control with passive and mechanical air conditioning
August 2014	Localised rainfall in major roads	Major review of locations where topology and drainage could make them susceptible to a similar impact
2014	Cloudburst flooding affecting Island Gardens DLR station	Addressed through improved preventative maintenance (improved proactive gully sucking)

The information from case studies (Table 2) illustrate that out dated design codes and standards need to be reviewed and changed to withstand extreme climate forces. If viable resilience targets are to be achieved, financial resources need to be allocated year on year and continuously developed. Infrastructure systems are inter-linked and a failure of one system can put pressure on the others. For example if rail networks are not performing to their capabilities the road networks will be stretched to their capacities with the extra passengers who will chose alternative transport methods. Rail and road networks have identified the main barriers for climate change adaptation of infrastructure as (Network Rail, 2015)-

- Funding, balancing short-term delivery of benefits with investment in long-term resilience.
- Uncertainties of long-term climate change impacts.
- Limited redundancy in the system.
- Competing priorities, e.g. biodiversity and environmental targets versus vegetation removal and safety impacts.
- Short-term reactive nature of media to individual extreme events.
- Regulations and legislation.

- Lack of information on some impacts such as rates of change and extreme events.

In addressing these barriers some roads and rail routes have applied for and received additional funding for specific resilience measures.

There is a need for green Infrastructure and sustainable drainage systems to be implemented at individual level as well as local, regional and national level. Transport for London has initiated installing, operating and maintaining vegetated tracksides and road verges as well as green infrastructure such as green walls and roofs and sustainable drainage systems (TfL, 2015). The need for more research in these subjects has been identified to reduce uncertainties. The need to embed resilience measures in organisational policy and regular reviews have been acknowledged and actioned with a legislative frame work so that new information can be absorbed in to new developments, not just ad hoc one-off actions. Improved relationships, sharing of activities and research with other infrastructure owners, providers and key stakeholders such as Environment Agency, Natural Resources Agency, Environment Protection Agency, National Grid, Highways England, water companies, HS2 and Transport for London is crucial in achieving robust, resilient infrastructure and asset base.

According to the Greater London Authority (2011) current and future flood risk in London can be reduced and managed by;

- improving the understanding of flood risk to identify areas at greatest current and future risk
- supporting collaborative working to enable a coherent cost-effective approach
- reducing flood risk to the most critical assets and vulnerable communities
- raising public awareness of flooding and individual and community capacity to cope and recover from a flood, to improve resilience to flood events.

5. Conclusions

The impacts of flooding and coastal change in the UK are already significant and expected to increase as a result of climate change. Improving protection for some communities will be possible whilst others will face the prospect of significantly increased risks. This will affect property values, risk and insurances, business revenues and in extreme cases the viability of communities. Risks to communities and local economies are closely linked to the resilience of local infrastructure, in particular transportation, energy and communications systems.

Although investments are made towards improving climate change resilience to extreme weather, there is still a long way to go. Joint up thinking, polies and strategies, pooling of resources, investing in stable and robust infrastructure via new design standards and codes, collaborative working seem to be the way forward. More actions are also needed to support communities facing increasing risks, especially in areas where formal flood defenses are unlikely and long-term viability is at risk. There are also gaps in research in areas such as the economics of climate change adaptation, metrics, system modeling and simulations, spatial decision tools and funding sources to drive this agenda forward.

The major challenge is maintaining a whole system approach, which balances the needs of the transport industry and integrate the different requirements of the systems so that joined up actions can be implemented. A coordinated approach and identification of independencies will support the industry to adapt to climate change more efficiently and to prioritise resources. A widely used resilience rating system applicable to both individual, public and business assets could support more informed decision-making around resilience setting requirements for new building developments and in designing new facilities. Individual and collective urban drainage and green infra structure systems must be incorporated to development standards and regulations in order to achieve resilient urban futures.

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The Fictional Story of Renewables: A Proposition for a Sustainable Future

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Abstract

Well-written science fiction may reach a larger cross section of the public, while emphasizing that climate projections are principally intended as warnings, not prophecies. Science fiction (film) makes global change information more widely available to the public. This paper looks at the problems associated with the persistence of presenting a dystopian view over a sustainable utopian perspective of the future. This paper aims to identify how informed the images of future cities in science fiction films are by the current developments in renewable sources of energy and their integration within the city. It can be argued that science fiction films generally lack references to renewable sources of energy as a proposition for a sustainable future. The scarcity of these references to renewable sources of energy in science fiction films can be attributed to the perception of these images as a representation of a prosperous future society while, in many occasions, science fiction films depict future cities as an unsustainable dystopia. This paper examines this assumption by comparing the dystopic visions of future cities to the utopic vision in science fiction films through the implementation of renewable sources of energy within the depicted future city and its buildings.

Keywords: Science Fiction, Film, Renewable, Utopia, Dystopia, Sustainable, Future.

1. Introduction

In the information society the dominant language is the image, and the most influential images are in the medium of film. Film is a cybernetic structure. The celluloid strip may be considered a sort of developmental code that is read by the projector to bring to life the specific form of a moving image within a certain context (Armstrong, 2000). Film has helped in paving the way for new ideas and generated popular acceptance of these ideas which might not be realized nowadays but might do so after many years (Hanson, 2000). This paper looks at the problems associated with the persistence of presenting a dystopian view over a sustainable utopian perspective of the future. This includes an investigation of how renewable sources of energy are portrayed in films in general and science fiction films in particular focusing on the significance of including these technologies in films through reviewing existing literature and recording observations from analysed films.

2. Background

Film has the ability to condition people to believe and accept. It holds the power of suggestion through visualization. People do not react (positively or negatively) to many current issues and events, due in part to the desensitization that has resulted from exposure to mass media. Film in particular, and the effectiveness of CGI (Computer –Generated Imagery) and f/x (Special Effects) in the fictional depiction of horrific events makes real events less impactful or disturbing. Even the initial reaction to occurrences such as 9/11 and the destruction from major weather events, had already been seen in films such as “Armageddon” (1998) and “The Day After Tomorrow” (2004) (Figure 1). Reality loses its shock value as the public sees an increasing blur between f/x and life events.

Figure 1 left: Armageddon (1998), fictional depiction of WTC destruction, right: WTC reality destruction in 2001.

Science fiction films have future speculation as their primary purpose. This genre is the perfect case for building upon existing scientific knowledge in renewable energy technologies, and to speculate on its widespread incorporation into architectural and urban environments. In this way, there is a huge positive potential in the film industry to assist in preparing society for the reality of our energy future through including inventive applications of renewable energy. Repeated exposure to the incorporation of different renewable energy systems in future environments has the potential to assist the energy sector in the implementation of these systems.

3. The Problem of Climate change in science fiction films

Although Broman and Kandpal (2011) argued that science fiction has miscommunicated the problem of climate change to the public due to dramatic requirements, Hughes et al (2000) asserted that novels play a powerful role in communicating climate change and educating the public of the consequences of global warming. The same applies to science fiction films especially in a digital world where the message is sent through film to a wider audience in less time. Gregory Benford, a professor of plasma physics and astrophysics at the University of California besides having been an advisor for NASA, the Department of Energy, and the White House Council on Space Policy, has been a science-fiction writer, and he distinguishes carefully between currently feasible technological solutions and the kinds of advanced possibilities that he writes about in his fiction (Williams, 2007).

Estok (2010) emphasizes the importance of narrativizations of science through books and films. Estok (2010) agreed that film lacks the depth of complexity of the lab; nevertheless, it has a profound value since narrativized science produces fact emotionally, and tangibly which simplifies the scientific facts to be easily understood by the public. This highlights the importance of documentary films that present scientific facts in a more interesting way while putting the scientific fact in a more serious and credible context than science fiction films.

Part of the problem with the majority of recent commercial science fiction films lies in the way they have chosen to portray energy related issues of buildings and environments in the future. Building related energy issues have been completely sidestepped. Most films present a future where the world is largely powered by “nothing”. Here lies the divide between “science fiction” and “science fantasy” in the creation of a blended genre film. Where many of the gadget or transportation-based suggestions might include credible research, the depiction of buildings, insofar as they are powered, is not addressed.

This would infer that power to buildings is likely supplied using similar methods to today. The use of fission, fusion, hydrogen or nuclear power would not translate into a visible difference in the image of the city. Alternately buildings are powered by some invention that is potentially too uninteresting or complicated to work into the story line. Or the filmmaker is simply not interested in visualizing this part of the future. Accordingly, it is very important

.0to investigate the image of future cities in science fiction films and examine the way in which these cities are portrayed.

4. The Built Environment in Science Fiction Films

Cinema acted from its beginning as a laboratory for the exploration of the built world (Vilder, 1999). Film was the medium that represented the city most persuasively to the general public. It can be argued that film itself evolved as 'urban art', frequently articulating the narratives of city and investigating its strengths and weaknesses. In this context, films became a useful instrument for understanding and critiquing the backdrops of the metropolitan city and its future (Albrecht, 1992). The powerful symbolism that is associated with city architecture has turned films that depict future cities into sophisticated agents for political statements, entertaining messages from the state of the environment to the adversaries of technology with social unrest in between. Film plays a significant role in introducing new ideas and debates to the public; they help clarify these ideas in a simple and interesting way. It is believed that film introduced modern ideology to the public through movies like The Fountainhead (1949). However, when it comes to science fiction films there are two main strands used by filmmakers to draw the image of the city; utopia and dystopia.

4.1 Utopia in Film

Much of science-fiction and fantasy literature of the pre-cinematic age was concerned with the creation of utopias (Staiger, 1999). Hence, utopian literature was and is still a key source for science fiction films. Utopian literature is broadly defined as writings about non-existent places whose politics, laws and living conditions are ideally perfect. Science fiction's attitudes towards such places fluctuate between idealism and cynicism, but a common plot element in utopian science fiction involves an intrusion from outside into: the narrative then explores the consequences of the changes brought about by the intrusion. The utopian tradition also embraces its antithesis; dystopias, places which are the very opposite of perfect. In constructing and exploring these extreme forms of social organization, utopian narratives are doubly fictional: they set up a utopian or dystopian place as a setting for a story, while at the same time the place itself becomes the story (Kuhn, 1999).

As early as the silent film era, utopian/dystopic fiction was deeply seated in set designs and storylines as a positive or negative response to the concurrent version of modernism and its utopian themes (Grigor, 1994). The films *Just Imagine (1930)* and, *Things to Come (1936)* provided seemingly a positive view of the future city. *Just Imagine* (1930) was one of the few overtly optimistic science fiction films of Hollywood's classical era.

In addition, Things to Come (1936), based on H. G. Wells's 1934 novel; *The Shape of Things to Come* attempted another utopian vision of future. Unlike so many Sci-Fi films which decried failure of science and technology to solve human problems, *Things to Come (1936)* looked forward optimistically to future scientific triumphs (Desser, 1999). The modern city of 2036, Everytown, was represented by multi-storey buildings, moving sidewalks, and a domed glass shell protecting the climate, marking off city from exterior countryside and diffusing light to an even glow (Staiger, 1999) (Figure 2).

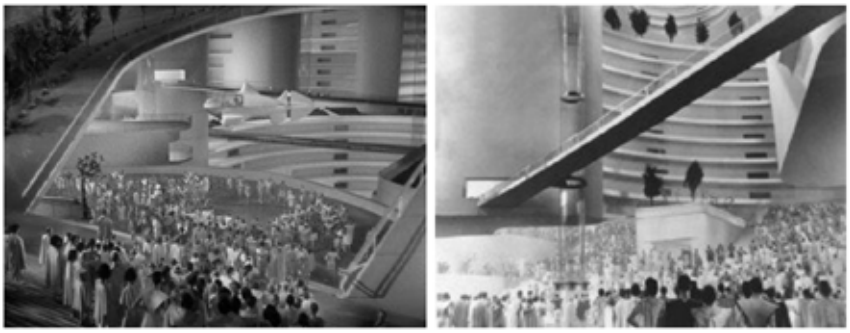

Figure 2 Shots from the modern city of 2036, Everytown in Things to Come (1936).

This utopia, however, had much in common with the conclusion of the dystopia of *Metropolis* (1927). In Wells's future, the human race would be saved by technocrats who had rationally determined humankind's appropriate course of action. The underlying worldview of *Things to Come (1936)* is in favour of the idea that the capitalist system is the true, natural order. The technocrats are the natural leaders because of their superior technology, and in the society they create, non-productive (i.e. technologically inferior) citizens were devalued (Desser, 1999).

4.2 Dystopia in Film

On the other hand, the dystopic image of the city of the future can be traced back earlier in *Metropolis (1927)*. In *Metropolis*, the city orderliness and symmetry above ground were perhaps more visible in Erich Kettelhut's set design, but balance and uniformity between parts were emphasized for the factory scenes through camera framing and for the workers via blocking of actors' movements. Additionally, *Metropolis's* poster provided a strong concentration of pertinent motifs - sleek skyscrapers, critical arteries, and pyramid peaks (Figure 3). The modern functional utopia of Le Corbusier's contemporary city and *Metropolis (1927)* on the one hand versus the radical visions of Well's and *Things to Come* (1936) on the other illustrated different modes of political analysis of a proper utopia. Yet in such diverse anticipations of the future, similarities occurred in the features of architecture (slab-block high-rises and peaked skyscrapers, breath-taking vistas from the more significant buildings, diffused lighting); symmetry and balance in the cityscapes; orderly and rational, mass transportation systems; and efficient, immediate, and extensive methods of communication (both films visualize television and computer screens as signal media for mass information) (Staiger, 1999).

Figure 3 Poster of the movie Metropolis (1927).

Subsequently, this wave of utopian/dystopic model of fiction had an influential shift with the advent of WWII where the genre of utopian science fiction was almost banished in favour of more pessimistic modes of literature and the gloomy model of film noir (Desser, 1999). The embodiment of the city in this period was neither extrapolative nor speculative but more of an urban introspection. Future noir films drew upon and quoted from a reserve of shared cultural images of progress in the built environment. There was a series of iconographic motifs which were associated with well-known utopian visions that were often quoted in the future noir genre with irony. In doing so, these films expressed a significant loss of faith in the idealism from which these images originated (Staiger, 1999). It used some certain features of utopian designs like symmetry, order, and clarity of which future noir dystopias played for signification, as a sort of oppositional strategy for constructing a dialogical criticism of the social or political order the ideal community represented. The next wave of city depiction in science fiction films was a reaction to the influence of post-

modernism on the city. It brought fears of urban decay, growing threat of pollution and potentially destructive class differences, all of which were mirrored in Ridley Scott's *Blade Runner (1982)*. In this film, the visual of 2019 Los Angeles City had specific architectural reference back to Lang's *Metropolis (1927)* and later influenced *Batman (1989)* and *Dick Tracy (1990)* (Neumann, 1999). The plot did not cohere around a central plan for reform, rather, the film seemed as random shots at deficiencies and grievances of present-day life. Integral to all these dystopias is a bleak criticism of utopian versions of high modernist architecture and modern cityscapes, structures which harboured corrupt economic and social institutions. It can be argued that the post-modern model of future city in Sci-Fi films featured a denunciation of the utopian vision through both narrative propositions about the society and also via Mise-en-scène as impaired physical constructions, and visions of the makers' hopes.

The previous argument showed that dystopias have the upper hand over utopian fiction. It sets out that the fear that humanity can allow its own civilization to self-destruct, is far more significant than the hope of better sustainable future of the city.

4.3 The Potential of Advanced Buildings as Film Locations

The integration of existing urban or architectural settings into future scenarios is an effective means of creating persuasive films. Where research may lay beyond the scope or interest of current filmmakers, location shooting remains popular. Skyscrapers and exotic buildings such as the Burj Khalifa in Dubai are often used in films to create cutting edge environments.

Some architects have started designing buildings with novel ideas integrating renewables within buildings to have buildings that are near to being self-sufficient in terms of energy. Examples of this are the Bahrain World Trade Centre, Strata SE1 Building in London and the Pearl River Tower in China (Figure 4) (Abohela et. Al, 2010); all three building integrated wind turbines that make them potential locations for shooting scenes in science fiction films. Regardless of this being the case, ideas of buildings integrating renewable sources of energy or these already existing buildings have not yet been adopted in films as a potential proposition of a sustainable future (Abohela et. Al, 2013).

Figure 4 left to right: Bahrain World Trade Centre, Pearl River Tower in China, Strata SE1 project in London.

5. Integration of Renewables within the City of the Future

Science Fiction as a genre has been credited with the ability of raising public awareness about the degradation of the planet, with particular reference to visualizations of the impact of Global Warming (Perkowitz, 2007).Well-written science fiction may reach a larger cross section of the public, while emphasizing that climate projections are principally intended as warnings, not prophecies. Science fiction film makes global change information more widely available to the public. In addition, fictional scenarios may suggest new directions of research, and offer unexpected insights into potential impacts, which may have been overlooked or underestimated (Kadonga, 2009). Although the depletion of earth's resources is evident and it has been demonstrated in many films the dark future earth might face, one can notice the

scarcity of the scientific based and practical solutions offered for this problem. Where a significant number of recent science fiction films have chosen to develop plots based upon the effects of Global Warming, resulting in a highly dystopic view of the future, research shows that almost none have taken a more hopeful or utopian view.

5.1 Renewable Energy in Science Fiction Films

A thorough examination of future based films produces a very short list of those that have chosen to feature renewable energy or critical energy problems in their settings or plot. As was the case for "Things to Come", war based scenarios have often acted as the inspiration for these energy focused science fiction films. The destruction of war accelerates the plot development and creates a narrative that supports the existence of a world that has not simply devolved (due to Global Warming) but is spectacularly different. A number of films cite nuclear power as the destructive force, giving way for renewable, clean energy, to be included as a means of going forward.

James Cameron has assumed an environmentally engaged directorial role in his films (Rosenfeld, 2010). Greatly influenced by the cold war, the threat of nuclear annihilation has been a constant theme in his films. His film, "Avatar" (2009) brings to life an untouched, utopian landscape. This presents the audience with simultaneous references to what might have existed (before humanity ruined the world with technology) as well as what could exist in the future. Current methods of renewable energy such as PV and wind turbines are not used in the film. The extraterrestrial landscape assumes a science fantasy position on the generation of energy in parallel to a science fiction position in the creation of the machinery and technology that forms the basis of the human settlements that are depicted.

Much of the Japanese manga/anime genre derives its plot and environments in reference to the destruction experienced at Hiroshima during WWII. Many of the future environments are depicted to either include parts of the city or world that continue to exist in a degraded state or that provide a more fantastical environment. Hayao Miyazaki, one of the chief creators at Studio Ghibli includes environmental themes in many of his animated films. One of the most environmentally focused was "Nausicaä of the Valley of the Wind" (1984). The story revolves around a future world that has been devastated by a nuclear holocaust. While nuclear devastation is not a new theme, the film stands out in its clear adoption of wind energy powering the small pockets of humanity that have survived. It is notable that the style of wind machine closely replicates traditional Dutch windmills. The landscape and pastoral setting invoke a nostalgic feeling for the 19th century past in spite of being set at least 1,000 years in the future. This generates a positive feeling towards wind as an energy solution but fails to create an innovative application of new technologies (Figure 5).

Figure 5 "Nausicaä of the Valley of the Wind" (1984): This animated film from Studio Ghibli uses traditional wind turbines to power the valley.

"Oblivion" (2013) is another science fiction film that portrays the future of earth as a dystopia. The plot suggests that after the moon was destroyed by extraterrestrial invaders, tsunamis and earthquakes hit the earth hard. However, for humans to survive they used nuclear power to win the war but contaminated the planet to the point of inhabitability. The references to energy in this film are quite pointed given that water (lakes, oceans) is being entirely removed from the earth in order to power the energy needs of a new, off-planet society. This is one of the few future based films where the creation of energy is the cause of major action in the plot as opposed to an incidental detail.

In Oblivion, one can notice three distinctive areas on earth; the vast contaminated area; the futuristic clean, smooth and elegant blue monochrome newly built space settlement and the remote and seemingly limited green, fresh areas that remain. This lush area is used as a secret retreat and shows the protagonist's house powered by a vertical axis wind turbine, a photovoltaic array and a solar panel (Figure 6). Although the wind turbine looks rusty and the solar panels look very old (pre-war), the context they are put in implies that people who lived here were keen on harnessing wind and sun power and generating their own electricity. Using these elements within this context promotes the idea of depending on renewables and integrating them within buildings for having buildings that are self-sufficient in terms of energy. However, this raises questions about the dependence of that society on renewables although they are very advanced in using nuclear power, which eventually led to the contamination of earth.

Figure 6 "Oblivion" (2013): The vertical axis wind turbine, photovoltaic cells and solar panels on top of the protagonist's house.

None of the films produced to date undertake an innovative or aggressive speculation on the positive impact of renewable energy. There is nothing compelling that is presented to promote renewable energy, certainly nothing significant enough to have the potential to condition the general public into acceptance of photovoltaic cells and wind turbines. However, this seems to be the intent of the film "The Hybrid Project – Air" (The Hyprid Project, 2013) which has been completed within the Victoria and Albert Museum in London. The plot centres on a future society that has been driven to living underground.

The potential for digital and film based media is being used very proactively to promote the design of future green cities in the exhibitions of the environmental education centre called "The Crystal" in London, England (The Crystal, 2013). The building, funded by Siemens, hosts the largest exhibition in the world on future cities. The state of the art exhibits assist the visiting public in envisioning how current and future technologies will be used to actively transform cities into viable, healthy centres for urban living.

In addition to interactive, physical exhibits, a number of films have been produced that look at the transformation of recognizable, existing major cities such as New York, London and Copenhagen, by overlaying new systems and buildings over the existing urban fabric. This is a similar technique as was used to lend future credibility to the Chicago based setting in "I Robot". Here though, for the first time in film we are given a comprehensive overlay of wind and photovoltaic systems, implemented on a broad urban scale using a smart energy grid

(Figure 7). The film also incorporates advanced urban farming as well as addressing a general cleaning of water and land based environments (The Crystal, 2013). The future cities presented by this short film present a thoroughly utopian view of future life that could easily be seen as persuasive science fiction that has been based upon current and future technologies.

Figure 7 "The Crystal Future Life Video": A screen capture from the film showing the incorporation of green energy systems in the city of Copenhagen.

5.2 Renewable Energy: Utopian or Dystopic?

Early science fiction films, although negative and dystopic in their portrayal of future culture and politics, tended to be fairly optimistic about inventions. Most films referenced videophones, large projection systems as well as advanced and sometimes flying automobiles. Where such technology would have seemed visionary to theatre-goers of the time, the current generation cannot imagine life without such communication technology. The impact of this film device becomes somewhat lost, validating the assumption that film does a very good job at conditioning the acceptance of future technologies.

Future-based films normally also include "futuristic" designs for buildings and urban environments. In the early days of film (1920s and 30s) futuristic building design was derived from the lines of early modern International Style architecture which was not very common at the time. The materiality was often concrete and glass, with a certain amount of steel. Concrete was able to be used to portray highly curvilinear forms that were very much in contrast to the more traditional Victorian, Gothic or Neoclassical revival styles of the period.

Utopian films present the future in scientifically optimistic terms. The environment is extremely bright (sunny), with clean air and modern buildings. These films will often include advanced technologies such as streamlined cars that tend not to use fossil based fuels, holographic displays and robots. Scientific advances are often included in the plot and theme. Although there may be social problems depicted in this utopian view, these are presented as quite separate from the perfect environmental condition of the planet. Typical of this type would be "Minority Report" (2002) and "I Robot" (2004). Through this we see that renewable energy likely requires a utopian, optimistic vision of the future.

The evolution of CGI technologies permitted the creation of increasingly realistic and detailed environments. Early films such as "Blade Runner" and "The Fifth Element" tended to present fairly dark, dystopic environments. In part, many of the early dystopic films used darkness as a means to mask the technical limitations of settings created with green screens and combinations of models and real urban buildings and sets. Dark, dystopic settings in reality would have precluded the incorporation of photovoltaic cells as it would not have been able to function due to the highly degraded environmental quality.

Films that were created in the early 2000s were able to create very credible environments as a direct result of developments in CGI technologies. "I Robot" (2004) in particular was able to blend very recognizable existing Chicago buildings and streets with a sleek set of future buildings and interiors. The realistic inclusion of "shiny" and reflective materials such as photovoltaic cells in film environments requires better CGI technologies. As these have evolved CGI based film environments can be seen to have become brighter and better lit and so could easily incorporate the materiality of photovoltaic cells into the palette. Thematically, such films would most likely be utopian or at least neutral in terms of the condition of the environment.

The few films that were seen to be depicting the use of wind turbines, for instance, were set in the present time. “Slow Burn” (1986) was a noir murder mystery that used the large fields of wind turbines outside of Palm Springs, California as an unnerving setting for the plot of the film, thereby assigning the wind turbines with a negative feeling. As film genres tend to reuse popular scenarios and themes in the creation of new films, it is not surprising that the fields of turbines that are used in “The Perfect Sleep” (2009) are again assigned a setting role that raises angst (Figure 8). The setting for the film is described as “a nourish dreamscape”, assigning the fields of turbines to a dystopic vision. The motion and sound of the turbines is depicted as relentless and threatening. This type of presentation of wind energy type does little to encourage public acceptance.

Figure 8 “The Perfect Sleep” (2009) Closing scene of the film showing the protagonist alone in a field of turbines.

6. Conclusion

The majority of studies related to the role of film in conditioning people’s perception of renewables tend to focus on what could be called more “academic” exploratory pieces rather than commercial films whose motivation lies in the generation of box office revenues. This seems to have made such films deemed unworthy of academic study. However, the impact of the latter type on society as a whole is far more significant as the viewing is more extensive and thereby has more possibility in future conditioning the general public.

“Oblivion” (2013) is one of the few films, if not the only one, which directly shows images of renewable sources of energy integrated within buildings. It can be argued that adopting such approach is novel, which might be attributed to the knowledge of the filmmakers and the background of Joseph Kosinski, the director, who is an alumnus of Columbia Graduate School of Architecture, Planning and Preservation (GSAPP). This draws the attention to the architectural education Fritz Lang received and how it affected the set design of “Metropolis” (1927) which is considered as one of the most striking images of future cities in science fiction films and affected the whole genre of science fiction film set designs. It can be argued that the background of these filmmakers provided them with the relevant tools and imagination to produce credible images of future cities.

When it comes to encouraging public acceptance of the integration of forms of renewable energy into the mainstream environmental condition, this is critically important. The challenge herein lies in finding the means to encourage directors and producers to incorporate positive future visions into their films as they can play a pivotal role in moving society forward in the direction of accepting the integration of renewables within the built environment as a mean for a sustainable future.

Where many science fiction films have explored space or extra-terrestrial settings, most fail to engage renewable energy altogether. Why might this be? Likely building systems are well beyond the focus or skill level of most set designers. Most were not educated in the field and if so, they were most probably not taking environmentally focused courses. You need experts on board. You also need the Director to find engaging potential in using renewable energy in either the set or the plot. Nonetheless, informed science fiction films play an

important role in examining certain predictions and offering scientific based solutions to the problem.

In conclusion it would seem that the real significance of the image of renewable sources of energy in science fiction films lies in the failure of contemporary films to embrace the visual potential of renewable forms of energy such as photovoltaic cells and wind in the creation of sustainable architectural and urban environments of the future. Given the current state of 3-D modelling software, sustainable energy solutions and the power of digital and film media, we are presented with an important opportunity. Commercially produced science fiction films can still be used as the means to create vital future environments that demonstrate the engagement of renewable energy systems proposing a more sustainable future.

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Computational Fluid Dynamic Analysis for Pipe Flows

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Abstract

CFD methodologies are widely used for the prediction of various flow phenomena in industrial applications. One of the most important scopes is the simplicity as well as the accuracy of each proposed methodology. In the present paper we develop a simple numerical procedure which can be applied in every pipeline flow with no restriction for pressure and temperature control, optimization of flows, specification of pipeline diameter, limitation in pipelines lengths and other industrial applications. The Cartesian grid generation is based on grid nodes and grid lines while in order to avoid the huge number of cells in some extended pipeline flows. We also develop a refinement technique based on nested grids with very satisfied results. Flows inside various pipes are numerical estimated for incompressible, laminar, viscous, one phase and steady fluids. It seems that our methodology is simple and accurate for pipeline simulation and it can be applied for various industrial flow phenomena as in Kingdom of Bahrain's industries, where extended pipeline networks are developed.

Keywords - incompressible flow, flows inside pipes, recirculating flows, block nested grids

1. Introduction

The CFD analysis of pipeline industrial flows provide useful results in separation and recirculation zones, or pressure and velocity limitations according to the safety conditions which are absolutely necessary for all the engineers in flow control or in the development of thermal industrial applications, where the working fluid pressure and temperature values have certain ranges. Kingdom of Bahrain is fortunate with a high oil and gas production where extended pipeline networks have been developed for the transportation and distribution. Water distribution network also is extremely extended in the Country due to the hot climate as well as the geomorphological configuration. All the above factors make the pipeline flows to be high applicable in Bahrain: flows of oil, of gas, air or water. Many computational techniques have been developed and applied in some of the industries for the prediction of flows. We believe that a simple and accurate methodology can provide valuable support in flow engineering and help all the Bahrain engineers and technicians to improve their work and ensure the safety in pipelines.

Many accurate approaches can be met (Louda P. et al, 2013) (Louda P., Kozel K. et al, 2013) where a numerical approach for backward facing steps is presented giving detailed results, or Wallin's methodology (Wallin S. and Johansson A.V., 2000) and Torres's (Torres Maj. And Garcia J., 2014) for turbulent flows with interesting recirculating zones in short pipes. Very interesting experimental approaches have been developed for various flows in pipes by Lee (Lee T. and Mateescu D., 1998) and Manzan's (Manzan W. et al, 2013), as well as various numerical approaches for other types of pipes (Santos R., 2010) (Kaiktsis L., 1991) (Razavi S. et al, 2009). Cartesian grids seem to be the most appropriate for the case of flows in pipes, but also this type of grids, can be applied for complex geometry bounds, where the specification of the geometry description is simple, using most of the times only grid lines. (Coirier W.J. and Powell K.G., 1995) (Georgantopoulou Chr. et al, 2002) Refinement mesh techniques have been developed in order to face the huge number of cells, which some physical (pipe) domains demand for the numerical simulation, as Wang's (Wang, Z.J., 1998), or the flow solver based on cell cutting - (Karai E. at al, 1988), (Agresar G. et al, 1998) and Pan's work (Pan D. and Sehn T., 2008), where a ghost cell method for incompressible flows is presented..

In the present paper a Cartesian grid generation algorithm is developed in order to obtain the flow variables, recirculation zones and important characteristics of incompressible viscous laminar flows in pipes. Particular interest will be given in the simplicity of the methodology

without losing in accuracy, in order to simulate the internal flows in industrial pipes. The main objective of our work is to create a simple and flexible algorithm which will be used by any engineer or technician for the simulation and optimization in industrial flows. In order to create the approximated Cartesian bounds of the physical domains we develop a method using only grid lines (Georgantopoulou Chr. et al, 2006) (Georgantopoulou Chr. et al, 2010) while for the refinement methodology we use block nested sub-grids (Coirier W.J. and Powell K.G., 1995) (Georgantopoulou Chr. et al, 2010) (Berger M.J. and Collela P., 1989). The numerical solution of Navier –Stokes equations is based on an artificial compressibility technique (Pappou Th. And Tsangaris S., 1997).

2. CFD Analysis

There is no doubt that various commercial software have been developed for the accurate simulation and estimation of various flow fields. The numerical approach of flow fields consists of several steps, where plenty of methods can be applied. The main objective to our methodology is to provide a simple as well as accurate enough computational method which will be easy applied by an engineer or a mechanical technician in the industry, in order to simulate and estimate short or extended pipeline flow applications. The main steps of our methodology are:

- Creation of approximate geometry bound and grid generation
- Refinement grid technique development (optional)
- Boundary conditions application (according to the grid)
- Differential equation modelling.
- Numerical iterative solution of pipeline flow fields.

To the following paragraphs we present the basic steps of our approach giving details mainly for the geometry discretization of each domain.

2.1 Cartesian Grid Generation for Pipes

In our numerical approach, if the physical domain bounds are aligned with Cartesian grid lines, we have no need to produce any approximated bound. This is the most common case in pipe flows and that is why we believe that the Cartesian grid generation is the most appropriate one. However, if the domain consists of complex or curvilinear bounds, we have to create a new approximated one in order to proceed to the grid generation. (Georgantopoulou Chr. et al, 2002)

The new approximate bound is parted only by the use of grid lines, on x or z-axis either and this is our benefit. The method is used, called saw-tooth and is has been chosen as the most appropriate for the finite volume cell centered numerical simulation of flow fields. This method provides independence and automation of grid generation for problems with complex boundaries, with or without existence of an analytical function.

We project the original contour of the curvilinear geometry onto a Cartesian grid and in order to define the new points we apply the rule of minimum distance. We finally connect the new points using only grid lines (saw-tooth method), (Figure 1)

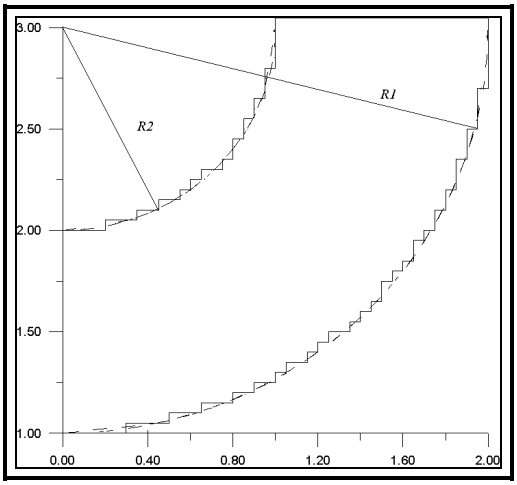

Figure 1 Method for the connection of the Cartesian approximated points (saw-tooth)

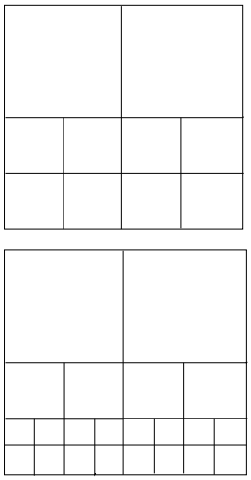

Figure 2 Block nested refinement, grid levels=2 and refinement factor = 2

2.2 Block nested refinement

As we have fulfilled the above procedure, we can create a Cartesian grid, excluding the cells that there are no more included to the flow field due to the above approximation. Therefore a new Cartesian grid is generated where all the "new physical" bounds lie on grid lines.

Although most of the times the above grid generation technique is appropriate for the solution, sometimes a huge number of cells is needed in order to simulation the whole physical domain. That is why we develop a block refinement technique by the use of a hierarchical structured grid approach. The method is based on using a sequence of nested rectangular meshes in which numerical simulation is taking place (figure 2). The whole domain is a rectangle whose sides lie in the coordinate directions. We simulate the domain based in as many refine grids as we need. (Georgantopoulou Chr. et al, 2007)

The proposed nested algorithm contains several levels of grids. We create a coarse level at the beginning and we solve the domain. We name this coarse level m=0 and each next refine sub – grid is named m+1. The coarsest grid is uniform on x and z direction respectively. We define an integer refinement factor, like. For convenience the above factor should be a second power.

As we have created the coarse grid we simulate the flow field and calculate the variables. At this time the coarse-fine interfaces are neglected since no information from the finer level is available yet. Of course the geometry approximation error is quite big but this is not a problem, as we have just a prediction for the fluxes near the geometry bound. We have already defined the limits of the refinement levels and we proceed the calculation to the next refinement level. The sub-grids bounds must lie on a grid line of the previous level grid. As we use staggered grids and the variable values are expressed on the cell's center, we consider pseudo – cells all around the physical domain and the sub – grids too. By this way we estimate the variables using interpolation between pseudo – cells and their neighbor cells. The pseudo-cells of each sub-grid m are lying on the level m-1. We continue this process for all the sub- grids. As we have fulfilled the simulation in all sub-grids and we have the flow field results at level, we resolve the problem in the coarser levels again to ensure conservation. In this step of the procedure we have to be careful because we can apply the numerical simulation only in rectangular sub-grids. As we resolve in m-1 levels, all of them have to be rectangular. We find a new solution, this time by the influence of the fine levels. In addition we must satisfy both Dirichlet and Neumann matching conditions along coarse-fine and fine- coarse interfaces. That's why we give the velocity values, but we solve for pressure. With nested grids, each grid is separately defined and has its own solution vector, so that a grid can be advanced independently of other grids, except for the determination of its boundary values. The information exchange between two successive levels is described in the next section (Georgantopoulou Chr. et al, 2006).

The grid algorithm is comprised of multiple levels. As we have already created the cartesian approximate geometry bound, the grid generation and the numerical simulation procedure is as follows:

- Create a coarse Cartesian grid (level m=0), simulate, (imposition of proper boundary conditions) and solve the flow field.
- Transfer the solution to the next grid level (m+1) by using the appropriate boundary conditions.
- Solve the flow field on the new sub-domain.
- Transfer the solution to the next level (m+2) with new boundary conditions.
- (Repeat the procedure for all the levels)
- Simulate and solve the flow on the last sub-domain (level mmax).
- Transfer the solution to the coarser grid level (mmax-1) as its boundary conditions.
- Solve the sub domain with the influence of the refined grid results.
- (Repeat the procedure for all the levels)
- Solve the coarsest-initial sub domain (level m=0).
- Take the solution of the variables by the finest grid.

2.3 Boundary conditions

In the case of uniform grids, we apply wall conditions along the pipes and we give the velocity profile at the inlet of the pipe and the pressure value at the outlet (Georgantopoulou Chr. et al, 2007). It seems by this way that the numerical results are accurate enough. If we use the aforementioned refinement technique, related boundary conditions must be applied along the neibouring bounds of each sub-grid. This is achieved using artificial cells, linear interpolation for the velocity values and solution for the pressure (vertical vector $\frac{\partial p}{\partial n}$)

$$u^{m+1}(i,k) = \frac{u^m(l,n) + u^m(l+1,n)}{2} \qquad w^{m+1}(i,k) = \frac{w^m(l,n) + w^m(l+1,n)}{2} \tag{1}$$

where $u^{m+1}(i,k)$ and $w^{m+1}(i,k)$ are the values of the velocity components on the sub-grid pseudo-cells and the $u^m(l,n)$ and $w^m(l,n)$ are the corresponding coarse grid values into the physical domain. The above technique is not the only one, but it seems that provides accurate numerical results in various fluid or thermal applications (Ospir D. et al, 2010) (Mavromatidis L. et al, 2010) (Mavromatidis L. et al, 2010)

2.4 Governing Equations and Numerical Scheme

The governing equations are the Navier – Stokes, as you can see below, which in combination with the mass conservation equation (continuity) provide the desired flow domain solution:

Mass conservation:

$$\frac{\partial \rho}{\partial t} + \frac{\partial(\rho u)}{\partial x} + \frac{\partial(rw)}{\partial y} + \frac{\partial(rv)}{\partial z} = 0$$

Momentum equations:

$$\frac{\partial(\rho u)}{\partial t} + \frac{\partial(\rho u^2)}{\partial x} + \frac{\partial(\rho uv)}{\partial y} + \frac{\partial(\rho uw)}{\partial z} = -\frac{\partial p}{\partial x} + \frac{1}{Re}\left(\frac{\partial \tau_{\chi\chi}}{\partial \chi} + \frac{\partial \tau_{\chi y}}{\partial y} + \frac{\partial \tau_{\chi z}}{\partial z}\right)$$

$$\frac{\partial(\rho v)}{\partial t} + \frac{\partial(\rho uv)}{\partial x} + \frac{\partial(\rho v^2)}{\partial y} + \frac{\partial(\rho vw)}{\partial z} = -\frac{\partial p}{\partial y} + \frac{1}{Re}\left(\frac{\partial \tau_{\chi y}}{\partial \chi} + \frac{\partial \tau_{yy}}{\partial y} + \frac{\partial \tau_{yz}}{\partial z}\right)$$

$$\frac{\partial(\rho w)}{\partial t} + \frac{\partial(\rho uw)}{\partial x} + \frac{\partial(\rho vw)}{\partial y} + \frac{\partial(\rho w^2)}{\partial z} = -\frac{\partial p}{\partial z} + \frac{1}{Re}\left(\frac{\partial \tau_{\chi z}}{\partial \chi} + \frac{\partial \tau_{yz}}{\partial y} + \frac{\partial \tau_{zz}}{\partial z}\right)$$

where ρ is the density, t the time, u, w and v the velocity components, x,y,z the Cartesian coordinates, Re the Reynolds number, p the pressure and τ the shear stresses. Our modeling is 2D, for laminar, incompressible, viscous and steady flows. Consequently the above equations are transformed accordingly to the flow conditions as well as the initial conditions provide the desired flow characteristics. The incompressible governing flow equations are the above Navier-Stokes equations and in order to solve and define the variables we use the pseudo-compressibility technique. (Gartling D.K., 1990).

The systems of equations for the flow problems consist of the two-dimensional incompressible Navier – Stokes equations after the addition of the pseudo-compressibility term (or artificial compressibility term), which take on a hyperbolic character with pseudo-pressure waves propagating with finite speed. In such types of problems "the information" inside the flow field is transmitted along its characteristic curves. Here, we extend the FVS method for solving incompressible flow fields implicitly. In such flow fields the splitting of the convective flux vectors has to change sense because of their non-homogeneous property.

3. Results

Two common short pipe incompressible steady, laminar flows will be presented in order to prove that our methodology provide accurate results in such flow cases. Although all these domains have bounds on Cartesian grid lines, these are appropriate enough in order to prove the stability and chase out the accuracy of the refinement technique and our numerical scheme.

3.1 Flow inside a channel with step

At the first test case, we will study and estimate the incompressible flow inside a channel with a step. Great importance in this test case is the estimation of the length of recirculation inside the cylindrical tube and the accuracy that is provided by the proposed nested algorithm. This test case is an approach in order to prove that our methodology can be applied for the numerical solution of flows inside pipes even with high aspect ratios as sometimes we meet at industrial applications. The physical domain is presented in figure 3. As we can see the flow problem is axisymmetric.

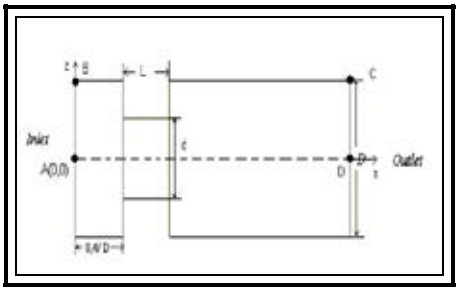

Figure 3 Geometry description of the channel with step

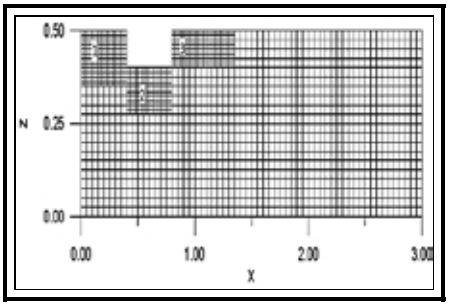

Figure 4 Parts of the numerical grids for the channel with step numerical solution.

Although there are no curvilinear or complex bounds to the above geometry, we have to exclude some grid cells, if we want to estimate the flow with the appropriate accuracy. It seems that if we don't exclude these cells the provided solution is not the appropriate one. The industrial application of the aforementioned channel are various, not only industrial engineering ones (power plants, water distribution channels etc) but also to the biomedicine (arterial stenosis etc.).

In order to define the geometrical characteristics of the physical domain we have to obtain the diameters' ratio (internal d/external D). For the grid refinement we have used one (1) level of sub grids with integer factor equal to 2. Regarding the numerical scheme for the N-S

equations, the value of the artificial compressibility set equal to 1, as optimum choice for the reduction of the computational time. (Pappou Th. And Tsangaris S., 1997). Two velocity profiles are presented in figure 4 along the channel, which present very satisfied convergence. The comparison has taken place among uniform a block nested grid results, where the accuracy is satisfied enough.

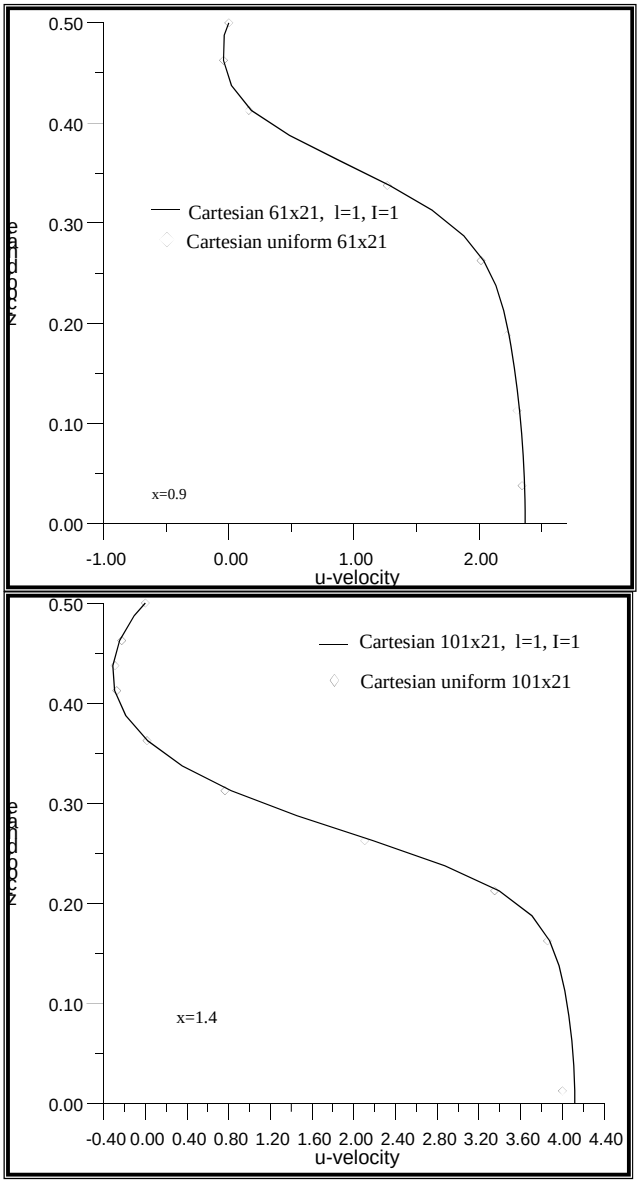

Figure 5 Velocity profile along channel with step. a) Based grid size 61x21, d/D=0.8 b) Based grid size 101x21, d/D=0.6

3.2 Flow Over a Backward-facing Step

The simulation and estimation of the flow over a backward-facing step is a classical problem in CFD. The main reason that this test case has been chosen is not only the appearance of a complex flow but also the close relationship of the specific case with the numerical modelling of air in an urban environment which we intent to develop in our future research. However this flow appears detachments and reattachment points (Georgantopoulou Chr. Et al, 2014) as well as recirculation zones and boundary layers.

The expansion ratio is equal to 0.5 while all the variables are estimated with the reference length to be equal to the diameter of the cylinder. (L_{ref} =H). The grid generation and the numerical method that was described above were used for the calculation of steady flow inside this channel. The used numerical refinement grid is level=1 and I=2. The Re number, that was based on the maximum inlet velocity and the diameter of the inlet, was set equal to 400 as well as to 800. The recirculation lengths at upper and lower bound are presented at table V. Two velocity profiles along the flow field, upper and lower wall pressure distribution, as well as the pressure distribution are presented in figures 6 and 7. It seems that the convergence between block nested algorithm results and uniform grid's is very satisfied.

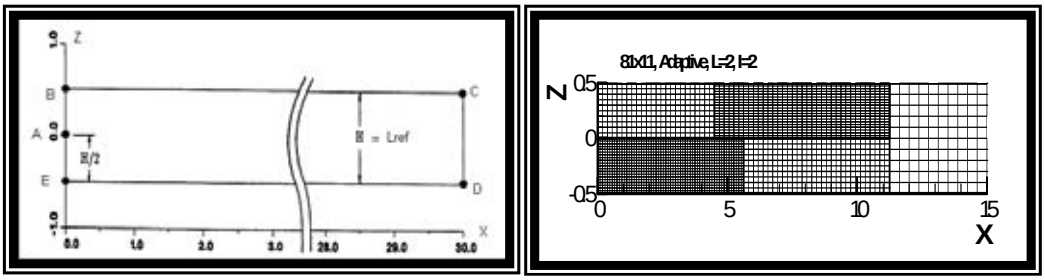

Figure 6 Physical domain of the backward – facing step channel. And part of the used numerical grid, m=2,I=2.

Table 1 Recirculation Data.

$L_{ref} = H$ (*fig* .5)	**Lower Wall Recirculation**	**Upper Wall Recirculation**		
Grid Type	**Recirculation length**	**Detachment point**	**Reattach-ment point**	**Recirculation length**
Re=400				
161x21, Uniform cartesian	5.25	No detection	No detection	No detection
81x11, Uniform cartesian	5.33	No detection	No detection	No detection
81x11, Nested cartesian, l=1, I=2.	5.27	No detection	No detection	No detection
Re=800				
161x21, Uniform cartesian	6.10	4.87	10.37	5.50
81x11, Uniform cartesian	6.20	4.80	10.50	5.70
81x11, Nested cartesian, L=1, I=2.	6.10	4.85	10.40	5.55
Gartling, BFC, 400x20, [32]	**6.10**	**4.85**	**10.48**	**5.63**

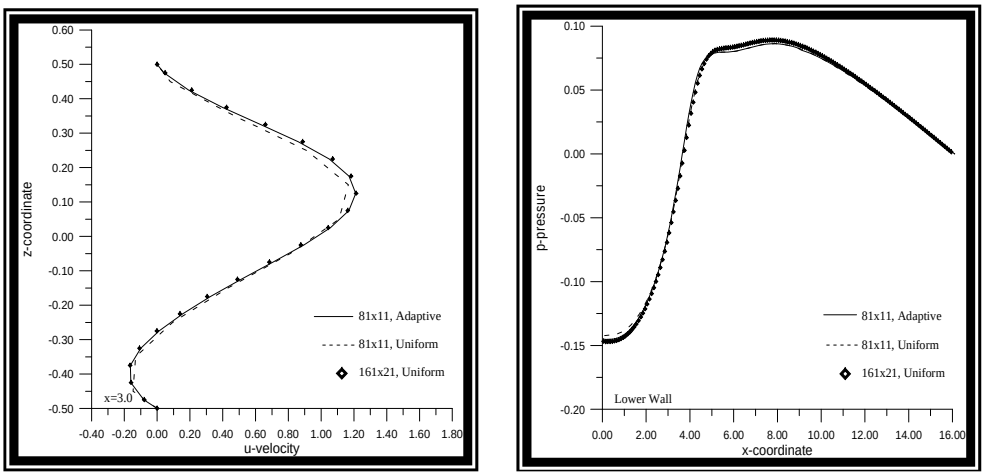

Figure 7 Velocity profiles along the channel flow field an pressure distribution. Re=400

4. Conclusions

At the present paper we present a numerical approach for the prediction of flows inside pipes. The approximation of the physical domain is taking place by the use of only Cartesian grid lines using block nested structured sub-grids, where the numerical approach demands. We use a cell center discretization and the boundary transfer is demonstrated in the interfaces by the use of interpolation, while the method is applied for steady, laminar, viscous and incompressible flows. The main purpose of this paper is to test and evaluate the above algorithm in order to be used for the numerical simulation of pipeline's flows and create a flexible numerical scheme which be able to be used by any engineer and technical for pipe flows simulation and estimation. We present various numerical solutions using a variety of sub-grids, and we prove that with the appropriate choice of the local sub-grids, we succeed high accuracy with an important reduction of the computational time simultaneously. All the above numerical results, regarding the flow variables' values, computational time, and recirculation data prove that the Cartesian block refinement method is stable and accurate enough, and it can provide accurate modelling, simulation and results to recirculation zones of a pipeline flow domain for any industrial usage.

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Structural Settlement Monitoring Using Single-Epoch Relative GPS Positioning

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Abstract

GPS provides positions for the monitored object together with corresponding time. The continuous comparison of these positions can be used to create a model of the object's movements. This object could be an engineering structure, a landslide, an Earth tectonic plate or a vehicle. The availability of GPS data allows the monitoring of the movements to be undertaken in real-time or near real-time, which could be a crucial factor in some monitoring tasks (e.g. structural deformation monitoring).

This research uses a single-epoch software to process the data. In this technique, each data epoch is processed independently and so measurement errors and outages occurring in previous epochs cannot affect the current epoch's accuracy. However, careful processing is required. Employing an epoch by epoch technique provides fast data processing which allows structural monitoring to be undertaken quickly (Ince and Sahin, 2000). Using a long baseline allows one GPS reference station to cover a large area of which the monitored objects might span over. This in turn reduces the cost of the monitoring operation. Single epoch GPS processing has been used to track moving vehicle velocity and positions and to monitor structural deformation (de Jonge *et al.*, 2000). It has also been used to monitor landslide deformation in Jiangxi Province, China (Liu *et al.*, 2005).

Synthetic RINEX files have been created to simulate real settlement motion. The modified RINEX files have been used as a moving station to create various baselines. The baseline data have been processed using a single-epoch software. Data for various baseline lengths, with synthetic displacements added, indicate that the single-epoch GPS results are reliable for monitoring movements exceeding 20 cm for baselines up to 54 km.

Keywords: GPS, Single-epoch positioning, Structural deformation monitoring, RINEX, GASP.

1. Introduction

Monitoring structural stability provides information that can assist in the prediction of hazards which may occur due to movements or structural failure. The advancement of technology over the last few decades has improved the precision of the measurement systems, allowing reliable results for monitoring structural movements to be obtained (Hsieh et al., 2006; Nickitopoulou et al., 2006; Abdel-salam, 2005; Knecht and Manetti, 2001). Satellite-based positioning techniques (Global Navigation Satellite Systems (GNSS)) including; the US Global Positioning System (GPS), the Russian GLObal NAvigation Satellite System (GLONASS); the European Galileo system, and the Chinese Compass system, have many advantages over conventional positioning methods (Erol, 2010). Such space based technologies offer greater flexibility in the selection of the station location, as visibility between stations is not required. Space based approaches also reduce manpower requirements for conducting deformation surveys, and their measurements can be taken throughout the day and night, and under all weather conditions. They have therefore been considered as an impressive, economic, and efficient technique for any application that requires the determination of positions (Nickitopoulou *et al.*, 2006).

2. Positioning Algorithm

This research uses the GPS Ambiguity Search Program (GASP) single-epoch software developed at Newcastle University (Corbett 1994; Corbett and Cross 1995). GASP uses the Ambiguity Function Method (AFM), (Counselman and Gourevitch 1981; Mader 1992) for resolving the double differenced phase integer ambiguities. The AFM relies on the assumption that all the errors that affect the GPS carrier phase are mitigated, so the double-differenced phase observation equation is of the form

$$\Phi_{AB}^{ij}(t) = \frac{f}{c}\rho_{AB}^{ij}(t) + N_{AB}^{ij} \quad (1)$$

$\Phi_{AB}^{ij}(t)$ is the raw carrier phase double-difference observation (from receivers A, B and satellites i, j), ρ_{AB}^{ij} is the computed or estimated double-difference geometric distance, N_{AB}^{ij} is the double-difference initial integer ambiguity, c is the speed of light and f is the signal frequency.

The AFM search volume is formed around the roving antenna's initial position, which may be specified *a priori* for a "static" antenna (or one experiencing only mm-scale movements), or computed using the GPS pseudorange observations in the case of a highly dynamic antenna. Within the search volume, candidate positions are tested using the Ambiguity Function Value (AFV) statistic. For a single epoch of data spanning a baseline, the AFV at a test rover position (x_i, y_i, z_i) can be represented as follows (Counselman and Gourevitch 1981):

$$AFV(x_i, y_i, z_i) = \frac{1}{n_f*(n_s-1)} \sum_{l=1}^{n_s-1} \sum_{m=1}^{n_f} \cos 2\pi(\nabla\Delta\Phi^{l,m} - \frac{f}{c}\nabla\Delta\rho^{l,m}) \quad (2)$$

where n_f is the number of observation frequencies (at this time, $n_f = 2$), and n_s is the number of observed satellites. $\nabla\Delta\Phi^{l,m}$ represents a double-difference carrier phase observation for satellite l (relative to a common reference satellite) at frequency m, and $\nabla\Delta\rho^{l,m}$ represents the corresponding double-difference geometric distance for the assumed trial position. Because the AFV depends on both GPS frequencies individually, the ionospheric effect should be eliminated before evaluating this function , or the baseline should be limited to a length less than 10 km for which the ionospheric errors are effectively removed when differencing is applied (Counselman and Gourevitch 1981).

The trial coordinates are found by adding increments to the antenna initial position. The creation of the search volume in GASP uses four chosen satellites, the highest elevation satellite as a reference and the other three satellites which with the reference satellite give the best Positional Dilution of Precision (PDOP) geometry. The volume includes all the possible positions as the double-difference carrier phases are perturbed by integer numbers of cycles within a specified search range surrounding the rounded values at the initial position. For the method to work, it is heuristically found that the initial coordinates should be within ±1.2 m of the correct final position (Corbett 1994).

The search for the best rover location involves L1 and L2 observations of all of the possible double differenced observations for the satellites above the minimum allowed elevation angle. A statistical F-test is performed on all of the successful candidate positions (which have an AFV greater than the specified threshold) to identify the final correct position for each epoch.

Equation (1) assumes that all observational biases have been removed, which we attempt using final GPS data and correction models (Assiadi et al., 2014) as described here. The International GNSS Service (IGS) Final satellite orbital positions and clock data have been used (Kouba 2009). Satellite and ground antenna phase centre offsets are removed from the undifferenced measurements using IGS values (Schmid, Rothacher et al. 2005), as are elevation- and azimuth-dependent ground antenna phase centre variation corrections. The undifferenced measurements are also corrected for the relativistic Sagnac effect (Leick 2004), for the ionospheric propagation error using the IGS single-layer global model and mapping function (Schaer, Gurtner et al. 1998), and for the hydrostatic neutral atmosphere delay using the Saastamoinen model and Niell mapping function (Saastamoinen 1972; Niell 1996). Inter-frequency code pseudorange biases are corrected using the calibration values

associated with the IGS ionospheric model. Remaining atmospheric, receiver and satellite hardware and clock biases are negligible in the code pseudorange solution, and are largely cancelled in the carrier phase solution by applying the double differencing technique, as are solid Earth tidal deformation effects.

3. Structural deformation settlement synthetic test

To study the capabilities of the GASP software for structural movement detection, a synthetic moving receiver RINEX data set has been created. The RINEX files of the LEEP, TORP and HOLP IGS stations have been used to generate the synthetic data. These stations have been chosen as they are typically representative of the stations used in this research and a network of baselines has been created by adopting these stations as 'moving' stations (Table 1).

Figure 1 shows the IGS station network in the Californian region, and the red lines represent the baselines which have had their data processed.

Table 1 Stations and baselines used in the structural synthetic motion trials.

Base station	Moving station	Baseline length (km)
BRAN	LEEP	7
UCLP	LEEP	13
TROP	HOLP	20
CSN1	LEEP	23
HOLP	LEEP	27
UCLP	TORP	32
AZU1	LEEP	39
BRAN	TORP	43
CSN1	HOLP	50
CSN1	TORP	54

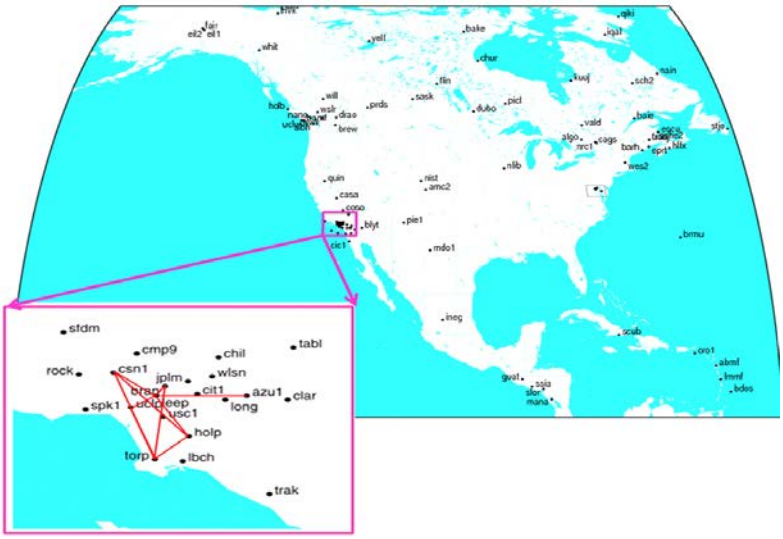


Figure 1 The IGS stations which have been used in this chapter. The red lines show the baselines which have had their data processed see.
Source: http://igscb.jpl.nasa.gov/network/maps/all_socal.html

A synthetic motion has been applied to the height of the 'moving' station of each baseline in Table 1. This has been done by employing a MATLAB based software called Tidefree (King *et*

al., 2000). The software uses the station RINEX observation file, the RINEX navigation file and a tide model (or more generally a movement model) to create a modified RINEX file. The Tidefree software modifies the RINEX file by adding or subtracting a correction to the carrier phase and the pseudorange of each observed satellite at each epoch depending on the receiver satellite geometry and the applied motion. For the settlement simulation, the moving station height has been decreased by 20 cm every 2 hours starting from 2 am as shown in Figure2.

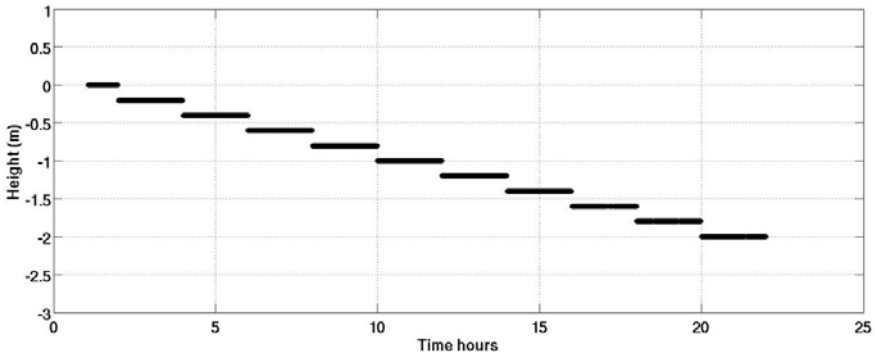
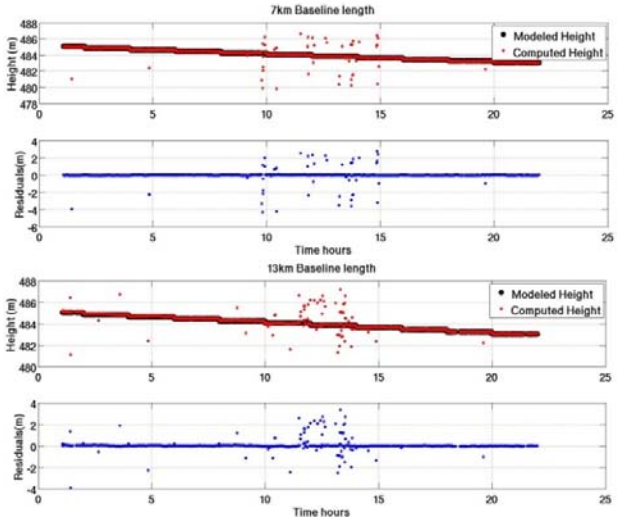
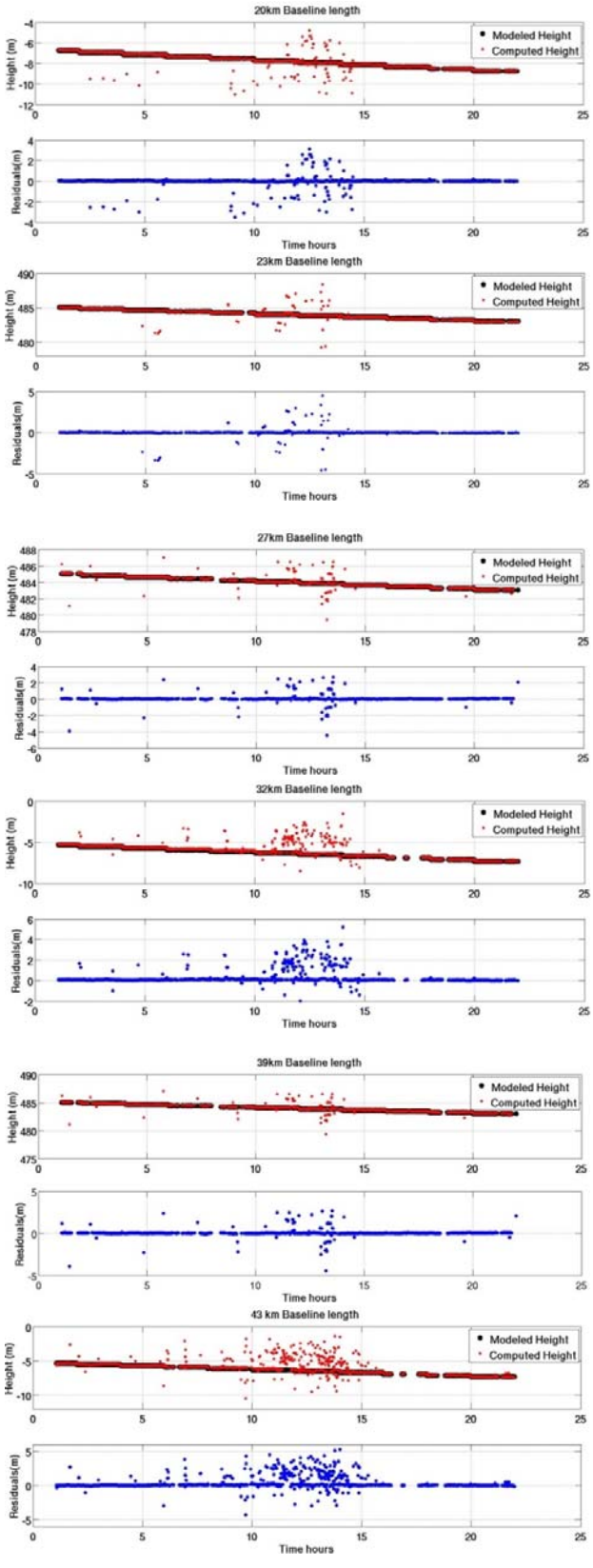


Figure 2 Synthetic time series displacement of station height.

The GASP software has been used to process the height modified RINEX files. Figure 3 shows the results comparison between the GASP results and the modelled height time series.




20km Baseline length
Modeled Height
Computed Height
Height (m)
Residuals(m)
Time hours
23km Baseline length
Modeled Height
Computed Height
Height (m)
Residuals(m)
Time hours
27km Baseline length
Modeled Height
Computed Height
Height (m)
Residuals(m)
Time hours
32km Baseline length
Modeled Height
Computed Height
Height (m)
Residuals(m)
Time hours
39km Baseline length
Modeled Height
Computed Height
Height (m)
Residuals(m)
Time hours
43 km Baseline length
Modeled Height
Computed Height
Height (m)
Residuals(m)
Time hours

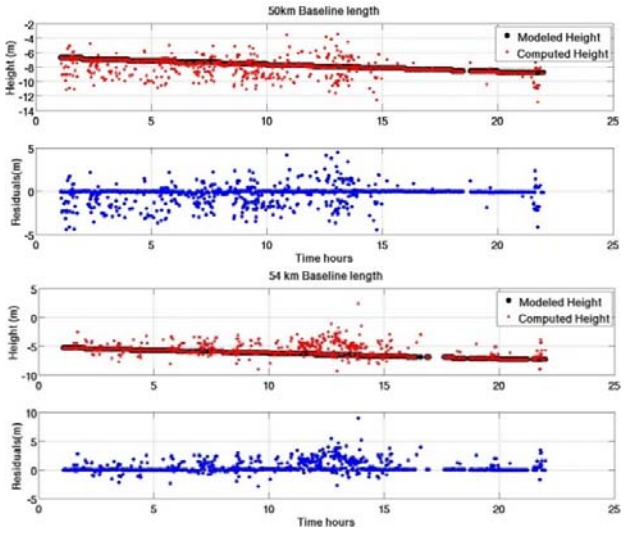


Figure 3 The moving stations' modelled and computed heights and the differences between them for the baselines which have been used in the settlement test.

A visual inspection of Figure 3 shows that the GASP software has, in most cases successfully processed the modified RINEX files and determined the correct height values. However, it is clear that the results become noisier as the baseline length increases

To check whether the epoch movement is a step change, a shaking wave or an outlier the following progressive movement criteria have been used:

$$((h\_2-h\_1)>3\sigma) \text{ and } ((h\_3-h\_2)>3\sigma) \text{ and } ((h\_3-h\_1)>3\sigma) \quad (3)$$

Where h_3 is the computed height of the tested epoch, h_2 is the computed height of the previous epoch to the tested epoch, h_1 is the computed height of the epoch before the h_2 epoch, and σ is formal error of the height difference obtained at the previous to the tested epoch. Figure 4 shows that:

if ((h_2-h_1)>3σ) and ((h_3-h_2)>3σ) are true only, then the movement is an outlier.
if ((h_2-h_1)>3σ) and ((h_3-h_1)>3σ) are true only, the movement is settlement.

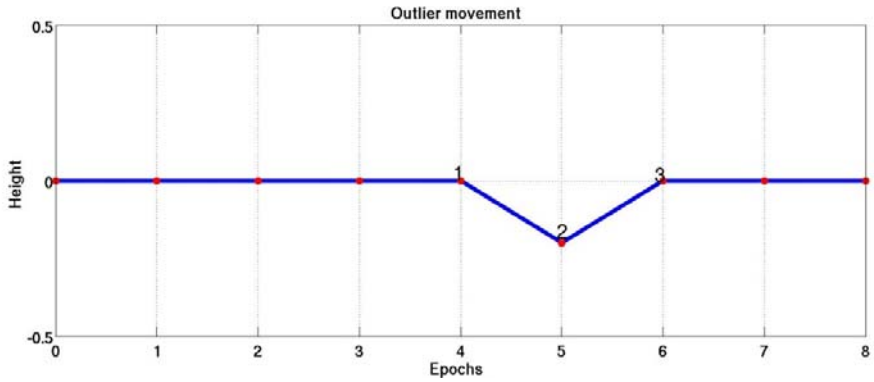


Figure 4 Progressive movement criteria.

To verify the ability of GASP in detecting step changes, the percentages of Type I and Type II errors of the results have been computed for each baseline in Table 3. Type I and Type II errors in the context of deformation studies are defined as follows (Ott and Longnecker, 2008).

- A Type I error is when movement is present but not detected by GASP. The results in Table 3 are out of the 10 step changes which have been applied to the stations.
- A Type II error is when there is no actual (synthetic) movement in the station, but the GASP results indicate that there is a movement.

To check whether the epoch movement is a step change or an outlier the progressive movement criteria have been applied to all of the non-moving epochs.

Table 2 Type I and Type II errors for the step change detecting test. Type I results are based on10 events, and Type II and the outlier results are out of the remaining epochs given in the right-hand column.

Baseline Length (km)	Type I	Type II	Outlier	Number of non-moving epochs
7	0%	1.3%	3.3%	2309
13	0%	2.1%	5.1%	2266
20	0%	3.5%	7.5%	2114
23	0%	2.1%	5.1%	2231
27	0%	2.3%	5.3%	2160
32	0%	2.4%	5.4%	2002
39	0%	5.3%	11.3%	2084
43	0%	4.6%	10.6%	1984
50	0%	6.5%	12.5%	2102
54	0%	6.8%	13.8%	1988

From Table 2, it can be seen that GASP is able to detect all step changes. However, at some epochs it gives incorrect detection measurements. Table 4 shows the percentage of incorrect measurements at the epochs where step changes in the station height occur.

Table 3 The percentage of step changes that have been successfully detected but with incorrect magnitude (at the 3-sigma level)

Baseline length (km)	Percentage
7	0%
13	10%
20	0%
23	10%
27	10%
32	0%
39	20%
43	20%
50	10%
54	20%

The settlement test results indicate that the modified GASP software is able to detect the applied synthetic movement. Figure 3 indicates that the positioning accuracy decreases around midday in the stations' local time. This may be explained by the fact that the ionosphere reaches its maximum value shortly after midday (Ho *et al.*, 1996), and could also be due to the satellite geometry.

The settlement test results show that the GASP software is reliable for use in detecting structural step changes. However, under certain circumstances it may give incorrect results although the probability of these false positives is small as shown in Table 4. For a baseline length that is less than or equal to 32 km, around 5% of results give a false indicator of a structural movement (Table 3). This percentage increases to 13.8% when the baseline length is 54 km.

4. Conclusions

In this chapter the GASP software has been shown to give reliable monitoring results. However, the degree of this reliability is baseline length dependent. As a general observation using more satellites in GASP tends to improve the accuracy. In the urban canyon this may be achieved by involving satellites from other satellite- based systems (e.g. GLONASS). However, GASP is currently coded to employ GPS satellites only. The GASP software is an epoch by epoch processing software; therefore the errors which may affect the results of the current epoch are not the same for other epochs. Taking advantage of this, it is recommended to check the current epoch result against the surrounding epochs' results to distinguish between the true and false computed movement. Moreover, this check can be used to improve the accuracy of detected structural movement when a step change occurs at an epoch. Applying this test makes the structural motion monitoring with the GASP software more robust.

The results show that the software gives reliable monitoring results. However this reliability is satellite geometry (PDOP) dependent. GASP is able to detect the beginning of a 20 cm structure movement over baseline lengths up to 54 km in at least 80% of the cases, which makes it reliable software for structural health monitoring. Also they indicate that the software can be used to detect a step change with a high reliability, which makes monitoring structural settlements (e.g. embankment, foundation of a dam or a building etc.) achievable.

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Effect of Repeated Loading on Mechanical Behaviour of Track Ballast

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Abstract

Al-Qa'im quarry located in Al-Qa'im which is an Iraqi town sited in about (400km) northwest Baghdad the Capital of Iraq, characterizes the main source that supplies track ballast for the maintenance of the existing railway network and construction of the new railway lines in the middle and northern parts of Iraq. Track ballast subjects a complex combination of stresses during its service life time, primarily from the repeated axial loads of the train in addition to stresses generated from the environmental conditions. The ideal evaluation of the behaviour of ballast must be tested under real field loading conditions, however such field tests are usually costly and time consuming. On the other hand, laboratory model tests simulating field loads under limited boundary conditions can provide satisfactory indication about the suitability of the material.

This paper investigates the deformation characteristics of Al-Qa'im track ballast, based on repeated load model tests, simulating ballast layer under a certain selected track section. A test setup was designed and manufactured capable to applying both monotonic as well as repeated loading under different cycles and simulated tamping processes. The repeated model tests which simulate as close as possible the field conditions shed the light on the generated settlement, modulus of deformation and degradation of the ballast particles under different repeated loading levels. Statistical analysis in terms of breakage index and repeated applied load revealed satisfactory correlations that assisted understanding the overall performance of the ballast material. The results also demonstrate that 4-5 tamping are capable of controlling both the settlement and modulus of deformation of the ballast material.

Keywords: repeated load, railway ballast, settlement, modulus of deformation, Al-Qa'im quarry.

1. Introduction

Ballast is basically granular crushed stone produced of crushed large rocks and can be found as granite, basalt, limestone, slag…etc.(Selig, & Waters,1994). It is the main fundamental of the railway substructure, due to its flexibility in construction, mechanical properties and low cost of maintenance. In railway construction, granular product placed as top layer of substructure bed. It should be capable of transmitting high imposed pressure on sleeper/ballast interface to subgrade layer and provide adequate stability to sleepers against different patterns of forces generated by train movements. So, this layer should providing a firm and stable support with high bearing capacity. In order to provide all that, "ballast layer must also maintain sufficient resistance against crushing, attrition, bio-chemical and mechanical degradation and weathering, in addition to adequate permeability for drainage purposes" (Jeffs, 1989). Economic considerations is main effectiveness in selection of ballast material for railroad construction. So, location of Al-Qa'im quarry is the best cost-effective choice for all rail networks located on the middle and North West parts of Iraq due to its low delivery cost.

Complex patterns of stresses, static and dynamic, experience on ballast. As well known, static stress is generated from static loads representing by whole railway structure and trains weights, while the dynamic stress depends on the train speed, load and track conditions, as well as to stresses from maintenance operations. The main concern of the available literatures focus on the ballast behaviour under different levels and frequencies of dynamic loading through theoretical and laboratory approaches. Another research line are often used

to simulate the overall behaviour of ballast material that is Prototype models of different section dimensions. Types of ballast, applied stress and repetition of stress, generated settlement and breakage behaviour are also covered in the literatures (Panucio et al, 1979, Morgan & Markland, 1981, Janardhanam& Desai, 1983, Harry et al, 1985, Dave, 1998, Indraratnaet al, 1998, William & Key, 2000, Salim, 2004, Wee, 2004).

Current research considers physical and mechanical properties of Al-Qa'im quarry ballast material, which is one of the main depending materials in railway construction and maintenance in Iraq. Overall performance, evaluation and determination degradation and breakage of the ballast particles, investigated through specially designed model tests.

2. Model Setup Selection and Testing Procedure

Figure 1 shows plan of rail and sleepers and simulate rail section part of a test model designed and manufactured (Al-saoudi and Shubber, 2013). As shown in the figure, the loading section represents a 600mm length by 300mm width and 450 mm depth. The tested model is a steel box contains a wood plate on the base of the box and covered by a 10 mm thick rubber sheet to replicate a typical stiffness of the subgrade layer (Wee, 2004). The prepared ballast was poured into the box to 300 mm height, then a simulating section of the sleeper was placed on the surface of the ballast and additional ballast was added on both sides of the sleeper up to the top level of the steel box. Plate 1 shows the loading frame (Al-saoudi and Shubber, 2013). Four dial gauges were measured deformation in plate load under different cycles of repeated loading. The ballast bed was subjected to repeated cycles of minimum load of approximately 3kN and maximum load of approximately (10, 20, 25, 30 and 40 kN) the maximum value roughly equivalent to an axle load of 20-25 tones, (Brown, 1996). The repeated loads were applied for 500,000 cycle at frequency of 3Hz per minute.

The ballast tamping process was simulated in accordance with (Wee, 2004, Al-saoudi & Shubber, 2013) after approximately 100; 500; 1000; 5000; 10000; 50000; and 100000 cycles. Additional ballast was added to top of the box after each tamping in order to keep stable bed underneath the sleeper and to maintain correct amount of crib ballast as soon as possible.

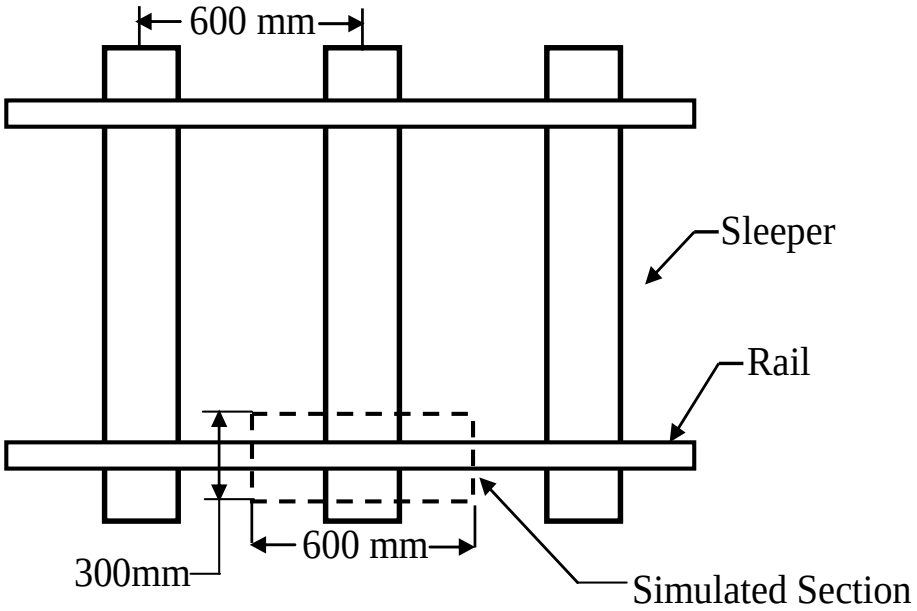

Figure 1 Rail and Sleepers Plan and Simulate Rail Section Part, (Wee, 2004).

Plate 1 The Loading Frame (Al-saoudi and Shubber, 2013).

3. Material Properties

As mentioned earlier, ballast used was crashed stone brought from Al-Qa'im quarry. Sieve analysis, compression test and abrasion test are required according to the Iraqi Railway ballast specifications (IRR, 2000), to assure the quality of the ballast to be used in the construction of the railway networks.

Sieve analysis test

Figure 2 shows the particle size distribution of Al-Qa'im ballast tested and comply with (IRR, 2000). According to (IRR, 2000) there are only upper and lower particle size limits, sieve 60 mm and 30mm respectively.

Compression test

According to (IRR, 2000), the average strength of the four cubic samples shall not be less than 60 MPa. The tested samples exposed an average compressive strength of 65 MPa which comply with specifications

Abrasion test

Los Angeles abrasion test, ASTM C131-55, is recommended by (IRR, 2000) to qualify the ballast used in railway construction. The results of three ballast samples established an average wear percentage of 6.5% which is much less than the maximum limits, 25% recommended by specification.

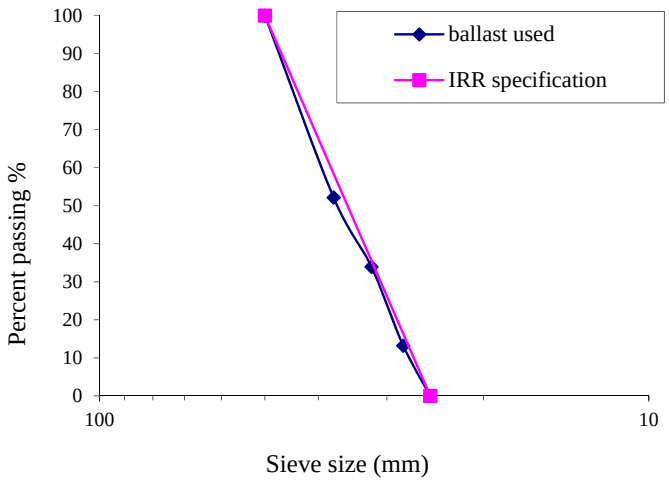

Figure 2 Grain Size Distribution of Ballast Used and (IRR 2000) Specification limits.

4. Model Test Results

Figure 3 contains five figures (A to E) illustrate relationship between the settlement in sleeper level and number of cycles under maximum repeated loads of 10, 20, 25, 30, and 40 kN respectively. Each spike in the figure represents a tamping process made after 100, 500, 1000, 5000, 10000, 50000 and 100000 cycle. The tamping process was successful in reducing rate of settlement generated after half a million cycle compare to earlier cycles bearing in mind the x-axis is a logarithmic scale.

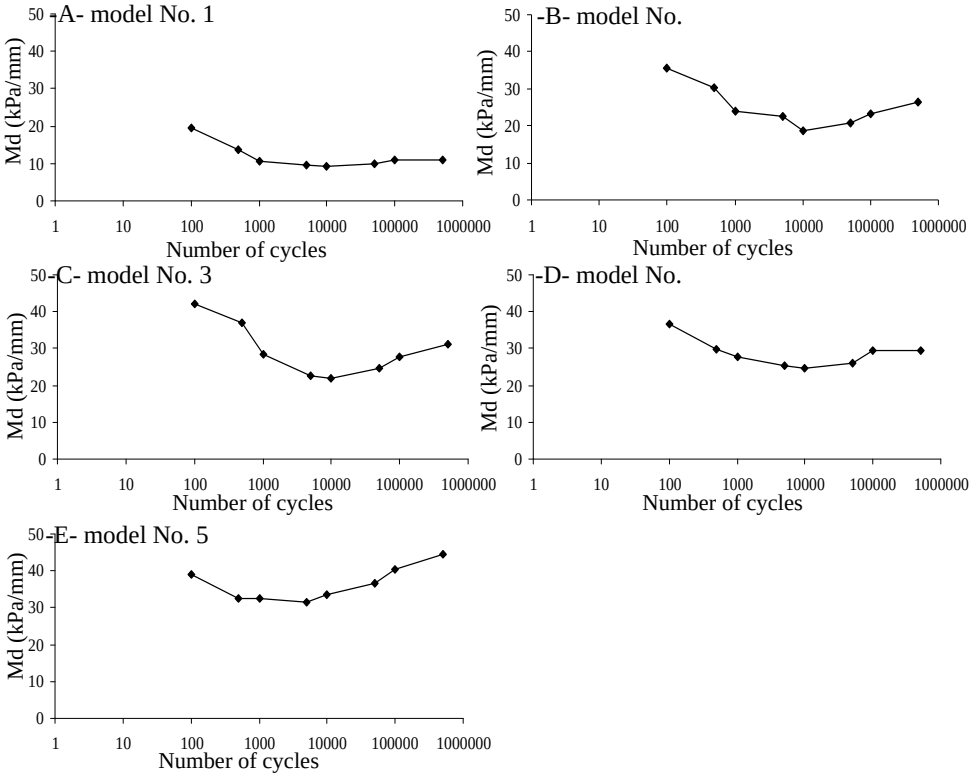

Figure 3 Settlements against number of Cycles for Tested Al-Qa'im Ballast.

Deformability is characterized by a modulus describing the relationship between the applied load and the resulting strain. The fact that jointed rock masses do not behave elastically has prompted the usage of the term modulus of deformation rather than modulus of elasticity or Young's modulus (ISRM, 1979). Modulus of deformation of a rock mass define as the ratio of stress to corresponding strain during loading of a rock mass, including elastic and inelastic behavior (Arild& Rajbal, 2001). So, modulus of deformation (M_d) at any tamping cycle is calculated as:

$$M_d = \frac{\Delta\sigma}{\Delta_c} \qquad \text{.....(1)}$$

Where $\Delta\sigma$ is difference between maximum and minimum applied stresses in (kPa) and Δc is total sleeper settlement per selected number cycles in (mm). Figure 4 shows the charts of modulus of deformation (M_d) against number of cycles for all five tests performed on Al-Qa'im ballast. The figure illustrate a reduction in modulus of deformation during first 10000 cycles followed by an increase with increasing number of tamping. In other words, the first four tamping processes showed a marginal decrease in modulus of deformation, then modulus of deformation reached a stable value followed by a gradual increase with continuous tamping. This is consistent with fact that tamping improves ballast performance after several trials. The increase in M_d with increasing number of tamping is more significant at higher applied loads.

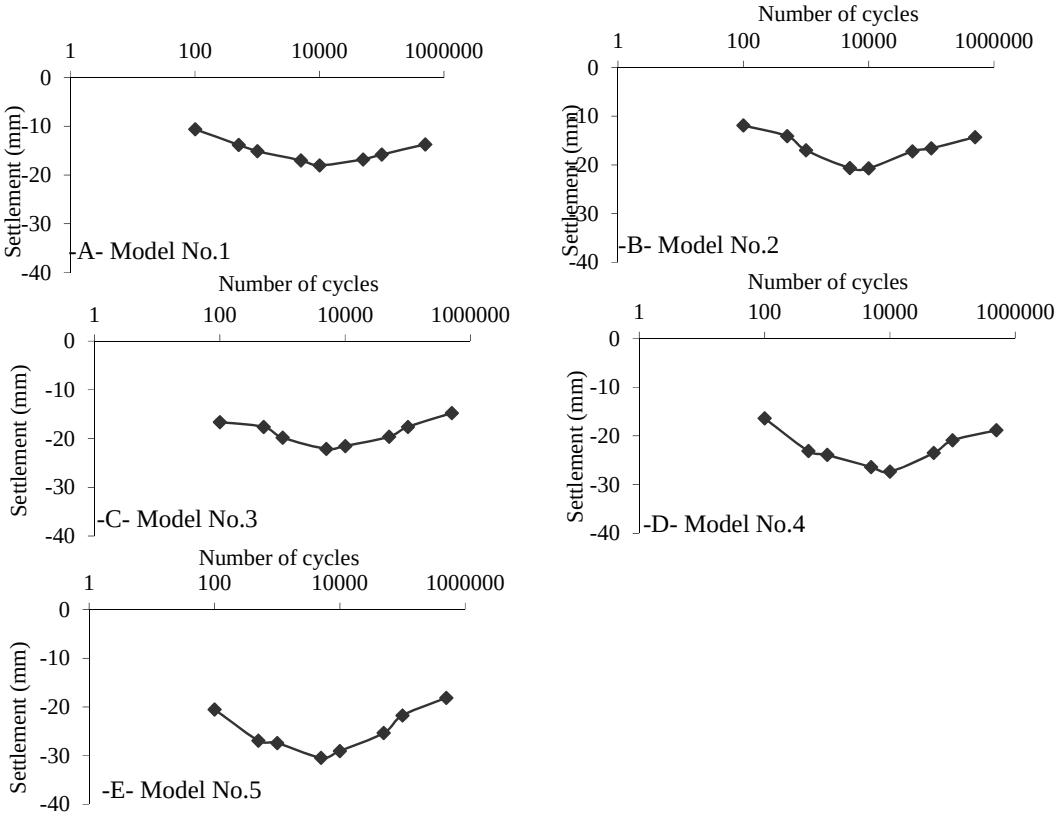

Figure 4 Modulus of Deformation Verses Cycles No. for Tested Ballast.

5. Repeated Loading Effect on Degradation of Ballast Particles

The degradation of particle size of the ballast particles at different locations in the model tests was studied (Al-saoudi and Shubber, 2013). The height of three selected section was divided into three horizontal parts, upper, middle and lower as shown in figure 5. figure 6 shows the percentage passing 25 mm sieve for each part shown in figure 5. The figure demonstrates that the central section, immediately underneath the sleeper, experienced high percentage of material passing sieve 25mm relating with high particle degradation. The right and left sections showed similar trend but with lower degradation level.

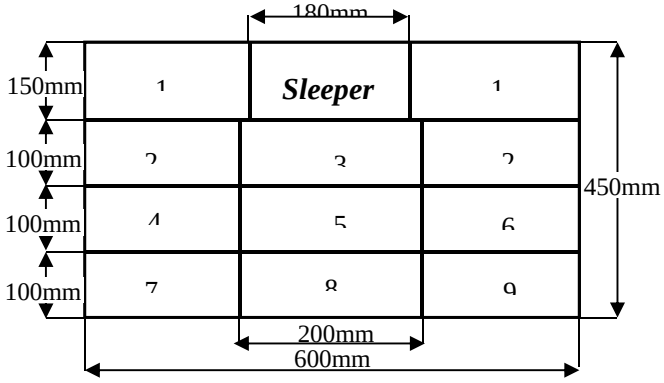

Figure 5 Removal Sections of Ballast from The Box.

-A- model No. 1

0.14	***Sleeper***	0.15
0.19	0.61	0.32
0.43	1.45	0.59
0.49	1.59	0.83

-B- model No. 2

0.37	***sleeper***	0.23
0.51	0.91	0.48
0.59	1.63	0.81
0.89	2.70	0.88

-C- model No.3

0.54	***Sleeper***	0.31
0.69	1.09	0.48
1.12	1.71	0.57
1.21	3.31	0.97

-D- model No. 4

0.54	***sleeper***	0.55
0.68	1.29	0.81
1.21	1.91	1.01
1.12	3.72	1.29

-E- model No. 5

0.70	***Sleeper***	0.71
0.89	1.39	0.94
1.39	2.49	1.29
1.37	4.09	1.89

Figure 6 Percentage Passing 25mm Sieve Increasing at Removal Section in Box.

For more focusing on breakage of ballast particles under different levels of repeated loads was investigated in term of "mean particle sized" given below:

$$d = 1/100 \Sigma P_i * d_i \quad \text{.....(2)}$$

where P_i is the percent between two adjacent sieves and d_i is the mean sieve size of them (Lindly, and Elsayed, 1998). The overall mass of the ballast was sieved then, linear relationship was obtained between the final mean diameter d_f and the applied load P as shown in figure 7. The relationship revealed the equation with $R^2 = 0.963$, shown below:

$$d_f = 39.489 - 0.0377 * P \quad \text{.....(3)}$$

Comparing between initial and final mean diameter values of the ballast particles does not demonstrated a clear picture about the fine fractions resulted from the broken ballast particle. As shown in figure 7, the slope of the line exhibits low sensitivity of applied load on final mean diameter. A better visualization of breakage of the ballast particles are established through two approaches explained below.

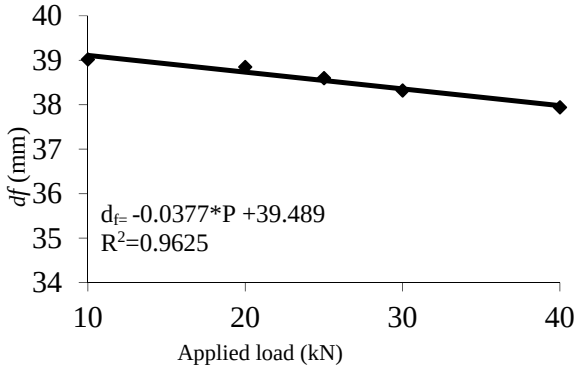

Figure 7 The Mean Particle Size (d_f) Verses Applied Loads.

6. Marsal's technique

Marsal's, 1967, 1973 proposed a technique for evaluating the breakage ability of rock fill material based on the difference in percentage retained on each sieve before and after the test denoted as (ΔW_k).

$$\Delta W_k = W_i - W_f \quad \text{.....(4)}$$

Where W_i is the percentage retained on a specific sieve before the test for the whole ballast material, W_f is the percentage retained on the same sieve after the test for the whole ballast material. The parameters ΔW_k for each model test are plotted against the sieve size (particle size) in figure 8. It is clear that the breakage of particles increases with increasing applied stress and large particles are more vulnerable to breakage than small particles. Marsal 1967 and1973 had also suggested the use of the term breakage index B_g defined in the equation below:

$$B_g = \Sigma \text{ positive values of } \Delta W_k \quad \text{.....(5)}$$

The breakage index was calculated and plotted versus the applied load as shown in figure 9. As shown in figure linearly increasing of breakage index with applied load. The best fit line exhibits the equation below with $R^2 = 0.921$.

$$B_g = 0.2628 * P + 0.132 \quad \text{.....(6)}$$

For comparison, table 1 illustrate breakage index and the mean diameters of the ballast particles before and after the model tests under effect of repeated load.

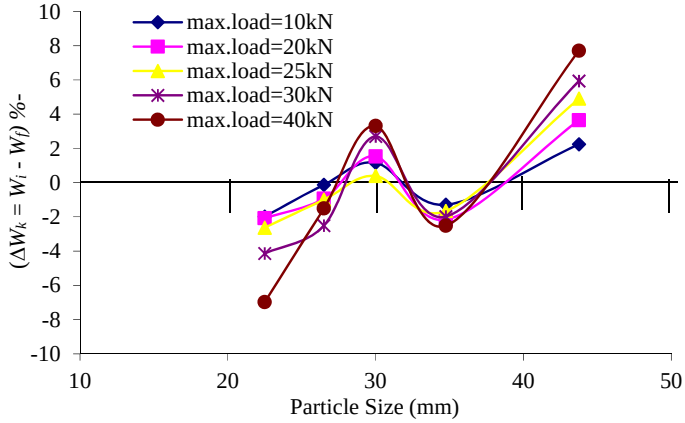

Figure 8 The Particle Breakage for Al-Qa'im Ballast.

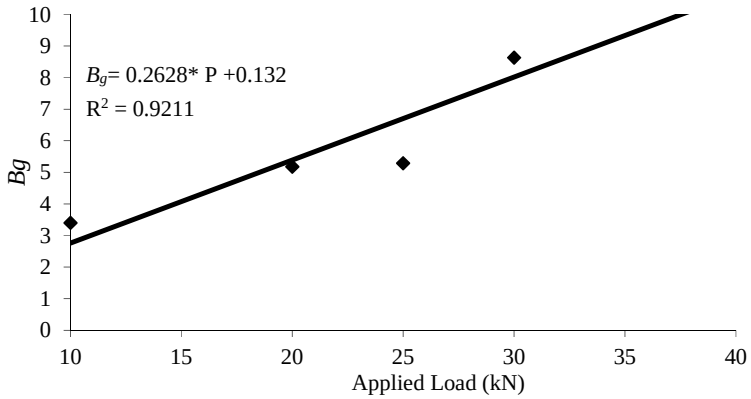

Figure 9 The Breakage Index (B_g) Verses Applied Loads.

Table 1 Breakage Index for Al-Qa'im Ballast.

Sample No.	Max. load kN	B_g	d_i (mm)	d_f (mm)
1	10	3.40	39.38	39.02
2	20	5.18	39.38	38.85
3	25	5.29	39.38	38.60
4	30	8.63	39.38	38.32
5	40	15.81	39.38	37.94

7. Hardin's technique

Hardin 1985, suggested soil particles breakage mean that, represent the third suggested method of particle degradation evaluation, when use the term total breakage factor B_t. "The evaluation of the breakage factor requires measuring the area swept out by particle size distribution "(Hardin 1985). This technique requires more analysis details, as a first step the breakage potential B_p must be determined by equation below:

$$B_p = \int_0^1 b_p * d_d \quad \text{.....(7)}$$

Where b_p is the breakage potential of a particle of a given size and d_d is the differential of percentage passing by mass divided by 100. The potential of breakage for granular soils of diameter D is given as:

$$b_p = \log_{10}\left[\frac{D}{0.063}\right] \text{for D} \geq 0.063\text{mm} \quad \text{.....(8)}$$

while the value of b_p equal to zero for (D < 0.063 mm). Harden suggested that 0.063 mm is the largest silt size; however 0.074 mm is the most likely to be considered as the border between fine and coarse grained particles. The total breakage B_t is defined as:

$$B_t = \int_0^1 (b_{po} - b_{pl}) * d_f \quad \text{.....(9)}$$

Where b_{po} is the original value of b_p and b_{pl} is the value of b_p after loading, thus the total breakage B_t is the area swept out by particle size distribution before and after the test. Based on particle size distribution before and after tests, the breakage factor was considered for the three sections, central underneath the sleeper, right section, and left section in addition to whole box. This results are shown in figure 10 and table 2 that, showing higher breakage factors for the ballast particles along the central section as compared to the right or left sections. The best fit equation for relationship representing total ballast breakage as a function of applied load for the whole ballast in box, also, shown in figure 10 concluding following linear equation with R^2=0.9589:

$$B_t = 0.0004P - 0.0014 \quad \text{.....(10)}$$

The breakage ability of the ballast particles is a sign of durability of the material under thousands or millions of repeated load cycles. The above three approaches commonly based on the results of grain size distribution before and after a certain number of repeated loading but differ in their outcome parameters. In spite of its importance less attention is paid for the breakage ability and no specification has yet been set or any criteria for accepted limits of breakage. The authors believe that it is time to rethink of this parameter by the authorized agencies and try to include it as part of the recommended specifications for selection of ballast material for railway constructions especially in Iraq.

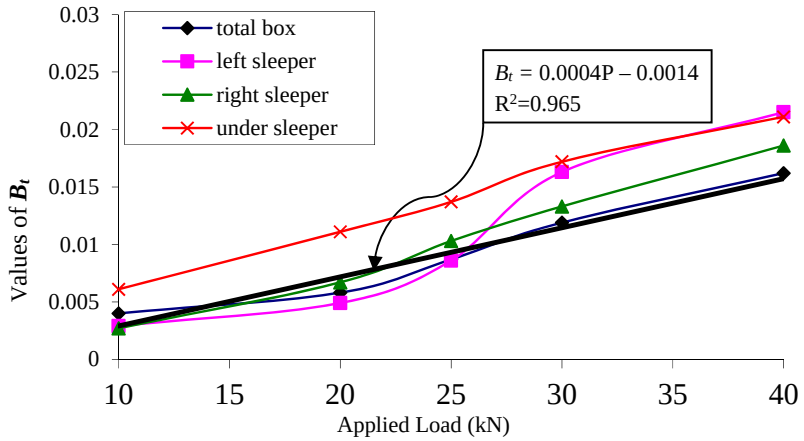

Figure 10 The Total Breakage Factor (B_t) Verses Applied Loads.

Table 2 (Bt) Values for The model Tests on Najaf-Sea Ballast.

Sample No.	Max.Load (Kn)	B_t Total box	B_t Left sleeper	B_t Under sleeper	B_t Right sleeper
1	10	0.0040	0.0029	0.0061	0.0027
2	20	0.0058	0.0049	0.0111	0.0067
3	25	0.0087	0.0086	0.0137	0.0103
4	30	0.0119	0.0163	0.0172	0.0133
5	40	0.0158	0.0215	0.0211	0.0186

8. Conclusions

The results of Al-Qa'im ballast behavior under repeated loading were analyzed in terms of generated settlement, modulus of deformation and degradation of the ballast particles and the following points are established:

1. The IRR specifications basically, depend on grain size distribution of ballast with shallow other requirements regarding breakage and abrasion of the particles. So, more interested should be take place, to extend IRR to cover other important parameters deeply.
2. Settlements reach its maximum values in first 10,000 cycle load or in other words, after the fifth tamping process, settlement began to reduce.
3. The modulus of deformation versus number of repeated load cycles, figure 4 exhibits a gradual decrease during the first five tamps followed by a gradual increase with increasing the number of load cycles and number of tamps.
4. Degradation of ballast particles was analyzed using three techniques. The first is based on the final mean diameter d_f related to the applied load P, equation 3 and figure 7. The second is Marsal's Technique relating the term breakage index to the applied load P, as shown in equation 6 and figure 8.The third is Hardin's technique introducing the term breakage potential as a function of the repeated load P as shown in equation 10 and figure 10
5. It is recommended to add degradation of the ballast particles in the specifications as an additional requirement for the suitability of ballast in rail track construction especially in Iraq.

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Sustainability of HMA by Using of Egg Shell Powder

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Abstract

It is estimated that huge tons of powder egg shell are generated throughout the world every year without realizing that it has many uses in other areas, perhaps most distinguishes the egg shell is fit on mineral salts such as calcium, phosphorus, manganese, molybdenum, iron, copper, chromium, fluorine, zinc. Since this additive proved effective in improving the concrete mixture in previous researches, it was decided to use it with the asphalt mixture in this study.

The road, whether rural or urban, is one of the important means of communication between cities, civilizations and commercial and industrial centers, thus an increasing the demand to expand this network to cope with the huge technological development , which in turn increase the need to pave the roads of this network . Since the flexible paving is widely used in this process, it is necessary to find additives to improve the performance of the mixture as well as reduce the cost. Therefore, considering the principle of sustainable and used waste recycling in the environment.

The practical aspect was to add different proportions of egg shell powder, which were (3, 5,7,10, and 15) % by the weight of asphalt and then perform some laboratory test approved at AASHTO to compared the results with virgin mix without additive. The following conclusions appears:

- the tests Recorded increases in penetration and increases in absolute viscosity
- valuable increases in flash point versus increasing percent of waste material but the softening point still satisfied specification requirement.
- (3-5)% from egg shell still give the mixture good ductility
- improved stability- flow results as increasing of egg shell percent
- improved the resistance to permanent deformation (rutting)
- reduced temperature susceptibility of the Egg Shell modified asphalt
- improving the performance of asphalt binder since the adding Egg shell reduce the high temperature deformation and rutting damage of asphalt pavement

Keywords: egg shell, hot mix asphalt, waste, physical properties, mechanical properties.

1. Introduction

During these years, appeared the urgent need to get rid of a hangover using eggs in the cooking which represented as hen shell by investigating the recycled methods in order to use in other areas, perhaps most distinguishes the eggshell is fit on mineral salts such as calcium, phosphorus, manganese, molybdenum, iron, copper, chromium, fluorine, zinc [Jayasankar,2010]. This research chose this study in order to investigate the effect of egg shells on bitumen as long as it's having an effect on chemically cement material.

Certain additives or blend of additives called as asphalt modifiers can improve properties of asphalt and asphalt concrete mixes.

2. Properties of asphalt

The desired properties of asphalt depends on the mix and type of construction. In general, asphalt should possess following desirable properties.

1. The asphalt should not be highly temperature susceptible: during the hottest weather the mix should not become too unstable or soft, and should not cause cracks because of excessive brittle during cold weather.
2. Its viscosity at the time of mixing and compaction should be adequate. This can be achieved by use of cutbacks or emulsions of suitable grades or by heating the asphalt and aggregates prior to mixing.

3. There should be adequate affinity and adhesion between the asphalt and aggregates used in the mix.

3. Aim of this study

The main objective of this project is working on the use of industrial waste as cement for cement in asphalt concrete and study their effect on the strength of concrete made with different cement replacement levels with admixtures.

- To try improving the efficiency of the asphalt
- To reduce the cost of the construction
- To compare the result with conventional asphalt

4. Literature Review

Egg shell waste in landfills attracts vermin due to attached membrane and causes problems associated with human health and environment. Few studies were done in civil engineering applications deal with the benefit for using eggshell waste. Amu et al., 2005 He studied the effect of eggshell powder to improve soil properties as a stabilizing material [Fajobi and Oke ,2005]. A. J. Olarewaju et al, 2011 deal with suitability of eggshell stabilized soil as subgrade material for road construction [Olarewaju, et al ,2011]. Apart from these studies, no other investigations were found in literature to use eggshells in civil engineering applications. This study was aimed to use egg shell powder (ESP) in bitumen. Although eggshell is calcium rich and analogous to limestone in chemical composition, it is a waste material [Sivakumar and Mahendran, 2014]. Therefore, in order to work on the inclusion of egg shells as an alternative to cement in mixtures as filler, the urgent need to understand asphalt properties made with eggshell powder were appeared. Thus, the primary objective of this study was to understand the possibilities of use of ESP in asphalt coarse layer. Investigations were systematically conducted on performance of ESP bitumen in terms of strength properties like compressive strength and indirect tensile strength. The control and ESP replaced asphalt were tested for 7 days. Based on the test results, the influence of ESP on the asphalt materials and asphalt mixtures properties were discussed.

5. Egg Shell Powder (ESP)

Egg shell consists of several mutually growing layers of CaCO3, the inner most layer-maxillary 3 layer grows on the outermost egg membrane and creates the base on which palisade layer constitutes the thickest part of the egg shell. The top layer is a vertical layer covered by the organic cuticle. The egg shell primarily contains calcium, magnesium carbonate (lime) and protein. In many other countries, it is the accepted practice for egg shell to be dried and use as a source of calcium in animal feeds. The quality of lime in egg shell waste is influenced greatly by the extent of exposure to sunlight, raw water and harsh weather conditions. It is the fine grained powder as appears in Figure (1) and Table (1), with suitable proportion which is sieved to the required size before use with asphalt binder.

Figure 1 Egg shell powder.

Table 1 Chemical composition of egg shell powder [Chirag et al.,2013].

Composition	EPS
CaO	47.49%
SiO_2	0.11%
Al_2O_3	Nill
Fe_2O_3	Traces
MgO	Nill
SO_3	0.38%
K_2O	Nill
Na_2O	0.14%

6. Test of asphalt

The tests below were done to assess the properties of asphalt materials [AASHTO,2004]

- Penetration test[D-5]
- Softening point test[D-36]
- Ductility test [D-113]
- Viscosity test[D-2171]
- Flash and Fire point test [D-92]
- Specific gravity test [D-70]
- Rheological Properties
- Temperature Sweep Test

7. Tests of asphalt concrete mixes

- Marshall Stability test [ASTM_D 1556]
- Marshall Flow test [ASTM_D 1556]
- Bulk density test [ASTM_D 1556]

8. Materials

All the materials used in this study are the currently local materials used in construction roads.

8.1 Asphalt Cement

One type of asphalt cement from Al-Daurah Refinery with (40-50) Penetration grade was used in this study.

8.2 Coarse Aggregate

Maximum size of 3/4 in. (19.0 mm) to No.4 sieve (4.75mm) was selected considering for asphalt surface later. The chemical composition and physical properties of the coarse aggregate are not be analyzing in this project.

8.3 Fine Aggregate

The fine aggregate is a combination of natural sand (river sand) which from Kerbala . The gradation of fine aggregate is passing sieve No.4 (4.75mm) and retained on sieve No.200 (0.075mm).

8.4 Additive

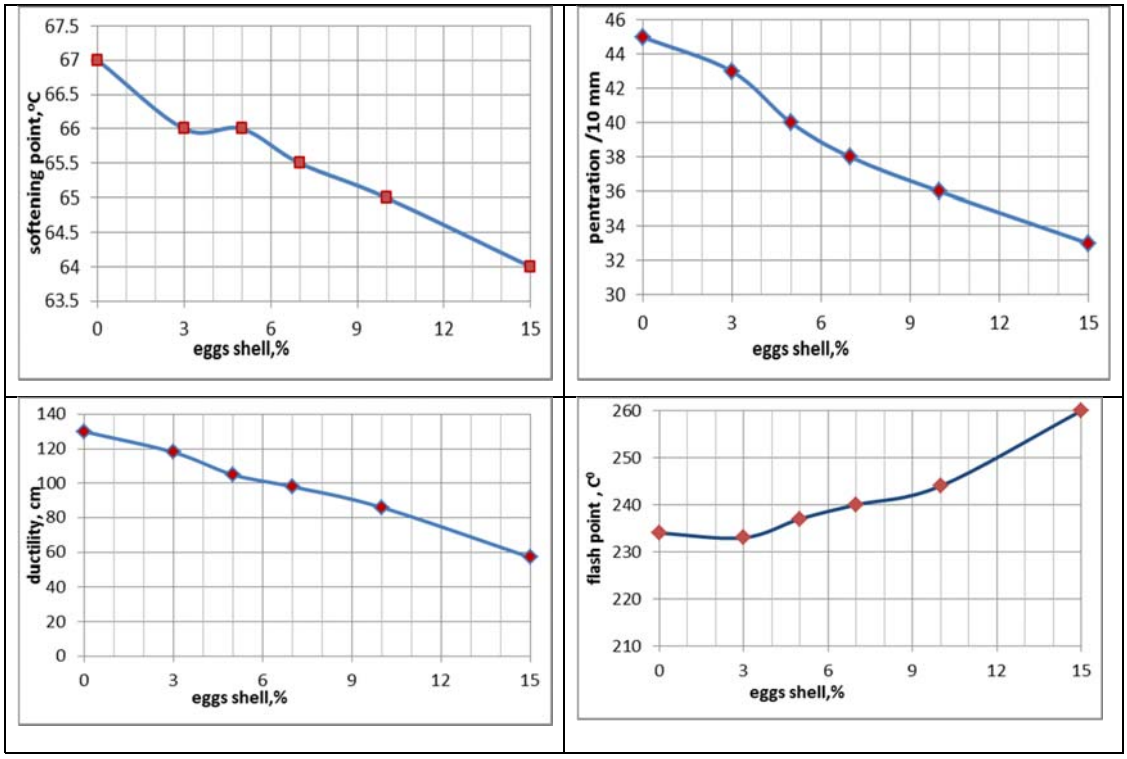
Egg shell powder is the fine grained powder with suitable proportion which is sieved to the required size before use with asphalt binder

9. Results and discussions

To identify some properties of asphalt after entering as a component of hot asphalt mixture, physical experimental tests (penetration , softening point , flash point ,and viscosity) were conducted using asphalt with penetration of (40-50) as a binder which is modified with eggshell of (3, 5, 7, 10, and 15)% by weight of the asphalt from to ensure they conform to the specifications in addition to study their behavior as additive or filler. All above result display in Table (2) and Figure (2). This represents first stage of project while the second stage has crystallized when test the modified hot asphalt mixture performance to Smooth riding quality surface and safety, only Marshall stability- flow test has conducted in this study.

Table 2 Asphalt cement properties.

Property	ASTM specification	Test results						
		Egg shell %						SCRB specification [SCRB,2004]
		0	3	5	7	10	15	
Penetration (25 C°, 100 gm, 5 sec, 0.1 mm)	D-5	45	43	40	38	36	33	40-50
Softening point , C°	D-36	67	66	66	65.5	65	64	…….
Flash point C°	D-92	234	233	237	240	244	260	Min limit 232 C0
Ductility, cm	D-113	130	118	105	98	86	57	>100
Absolute viscosity 60 ° C , poise	D-70	2520	3600	3960	4410	5580	5940	4000±800
Loss in weight ,% residue pent. Residue ductility	D-1754 D-5 D-113	0.346 48 78	0.521 48 64	0.411 51 42	0.571 53 44	0.586 53 35	0.778 59 31	0.75 +55 +25
Soluble in CCL4	D-2042-97	99.3	99.3	99.6	99.7	99.6	99.2	Min limit 99%



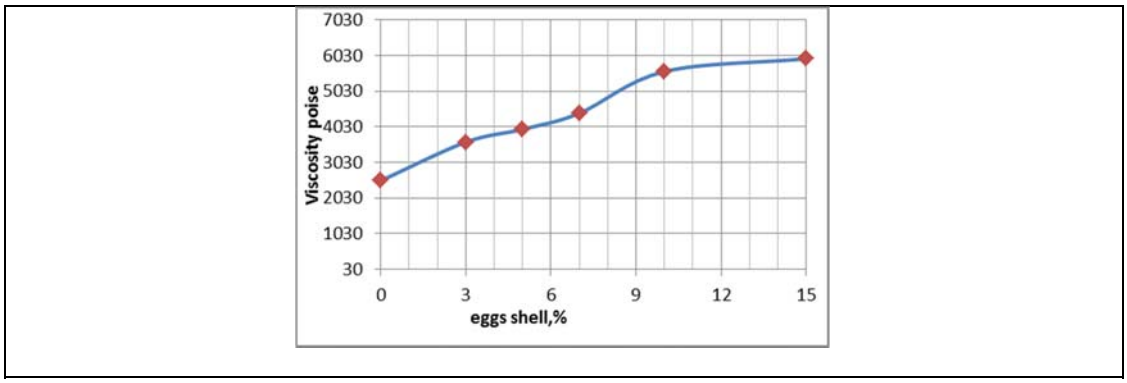


Figure 2 Asphalt properties tests.

10. Rheological Properties of Egg Shell Modified Asphalt Binder

The fundamental rheological properties of the un-aged and long term (PAV aged) asphalt binder, Egg Shell asphalt binder were measured in terms of complex modulus (G*), phase angle (δ), and temperature sweep test on un-aged state. Also, the Egg Shell asphalt binder was tested in fatigue performance on RTFO-aged specimens using dynamic shear rheometers (DSR).

11. Temperature Sweep Test at High Temperature

In this test G* (complex modulus) and δ (phase angle) of all un- aged Egg Shell modified binder at four different proportion was measured over a temperature range between 40°C and 82°C using DSR to investigate the effect of adding Egg Shell at four different durations in terms of rutting. Based on the Superpave specification, G*/sin δ represents the asphalt binder resistance to permanent deformation (rutting). A stiff and elastic binder could contribute better to rutting resistance therefore increasing G* or decreasing sinδ would lead to more rutting resistance. It is recommended a minimum value of 1.0 kPa for G*/sin δ to ensure that asphalt binder could resist well against permanent deformation at designed performance grade temperature. As a result 1.0 kPa was selected as failure temperature criteria in this test. Figure (3) shows failure temperature for Egg Shell Modified binder at four different durations.

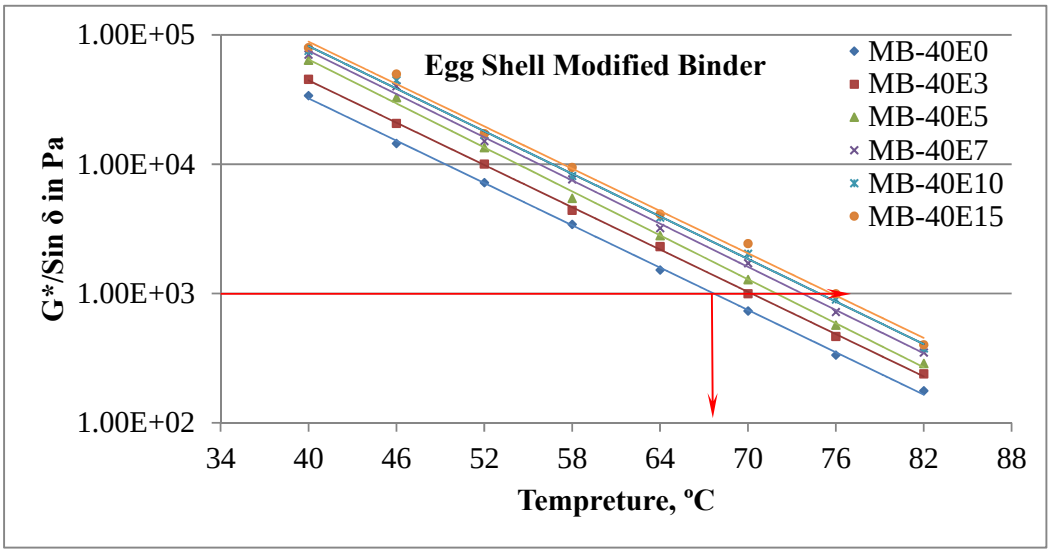


Figure 3 Temperature Sweep Test for 40-50 Asphalt Binder with Egg Shell Modified Binder.

Temperature sweep test on RTFO aged binder were carried out for Egg Shell modified binder at four different proportions as shown in Figure (4). It is recommended a minimum value of 2.2 kPa for /sin δ to ensure that asphalt binder could resist well against permanent deformation at designed performance grade temperature. As a result 2.2 kPa was selected as failure temperature criteria in this test.

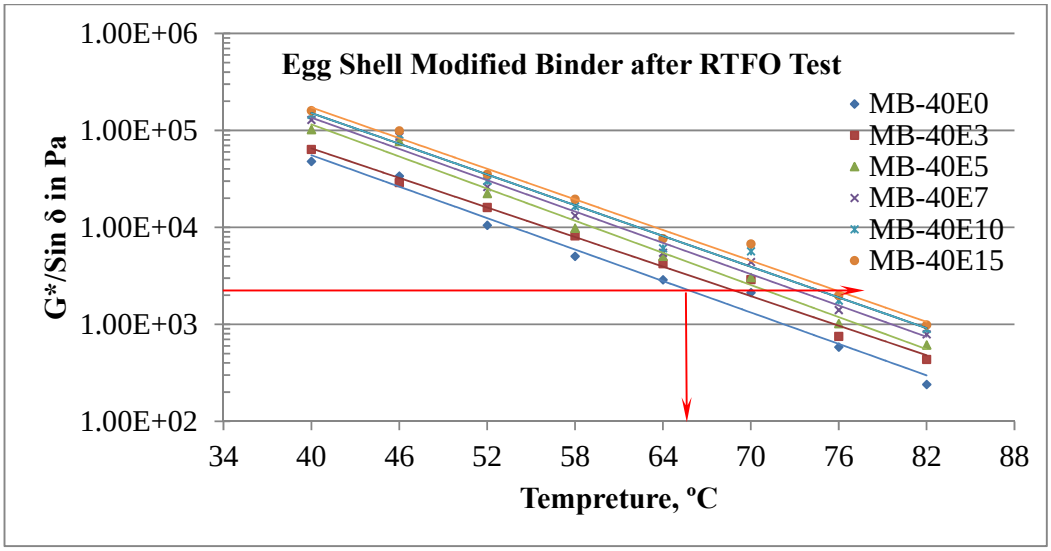


Figure 4 Temperature Sweep Test for 40-50 Asphalt Binder with Egg Shell Modified Binder after RTFO Test.

Figure (3) and (4) shows that, regardless aging state (un-aged or RTFO aged) the Egg Shell modified asphalt has the highest stiffness modulus (G* value) at the lower end of the temperature domain and a high stiffness modulus at higher temperatures compared to the neat asphalt. This indicates the improved (reduced) temperature susceptibility of the Egg Shell modified asphalt resulting in both increased flexibility at lower temperatures and increased hardness at high temperatures.

12. Sustenance Measurement of Original, Modified Asphalt Binder Using Time Sweep Test at Low Temperature

Time sweep test protocol was similar to asphalt fatigue testing method for the asphalt binder using DSR. This test was ideal to observe how asphalt binder changes over time. This test was carried out on RTFO aged samples with diameter of 8 mm and thickness of 2 mm. the requirement temperature was 20°C with the frequency of 10 Hz. The results of time sweep test are shown in Figure (5).

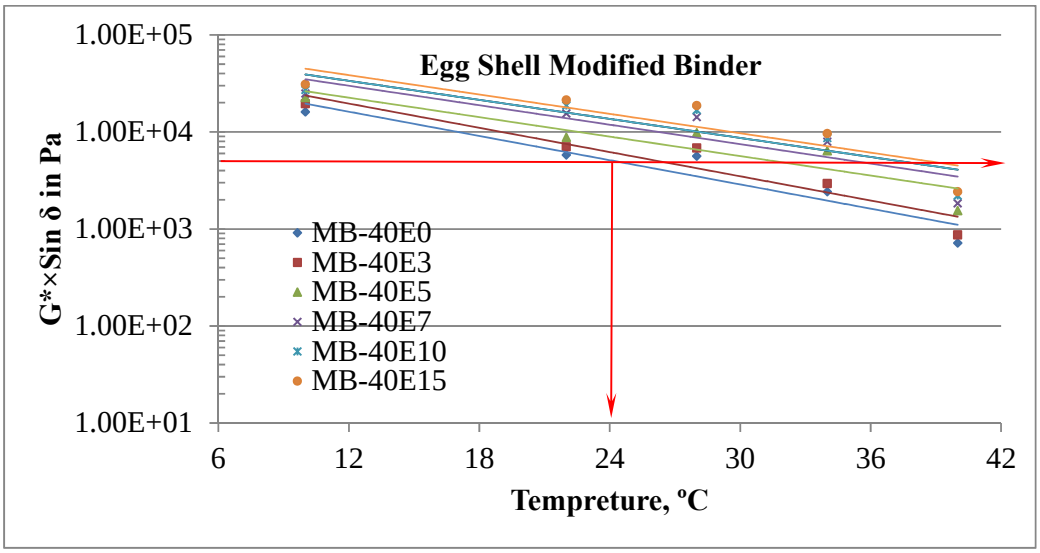


Figure 5 Time Sweep Test for 40-50 Asphalt Binder with Egg Shell Modified Binder.

The increment of failure temperature is very important to Table (3) shows the Failure Temperature and PG- Grading for Egg Shell Modified improving the high performance of asphalt binder. It will help to reduce the high temperature deformation and rutting damage of asphalt pavement. Binder at four different proportions.

Table 3 Failure Temperature and PG- Grading of Egg Shell Modified Asphalt Binder.

Binder Type	Failure Temperature (°C)			Temperature High and Low PG – Grading
	Un-aged	RTFO Aged	PAV Aged Long term aging	
MB-40E0	67.5	67.6	24.0	PG-64-25
MB-40E3	70.0	69.5	26.5	PG-64-28
MB-40E5	72.0	72.2	32.0	PG-70-33
MB-40E7	74.0	74.5	35.3	PG-70-37
MB-40E10	74.6	75.0	37.0	PG-70-39
MB-40E15	76	76.5	38.5	PG-76-39

13. Mix design properties

Three types of modified asphalt mixture Marshall stability - flow test have compared with corresponding virgin mixture so the results recorded in Table (4) indicates improved in mixture properties of modified asphalt with 7% egg shell than other portions and the latter mixtures than the virgin results as appears from Figure (6).

Table 4 Marshall Stability – Flow results*.

Additive	Asphalt Surface course type IIIB Asphalt penetration (40-50)				SCBR specification
Egg shell%	0	3	5	7	
Stability , KN	10.95	11.42	11.65	11.88	Min. limit 8
Flow, mm	3	3.1	3.1	3.3	2-4
Density, KN/m³	2.138	2.104	2.21	2.25	……

*ASTM-D_1559

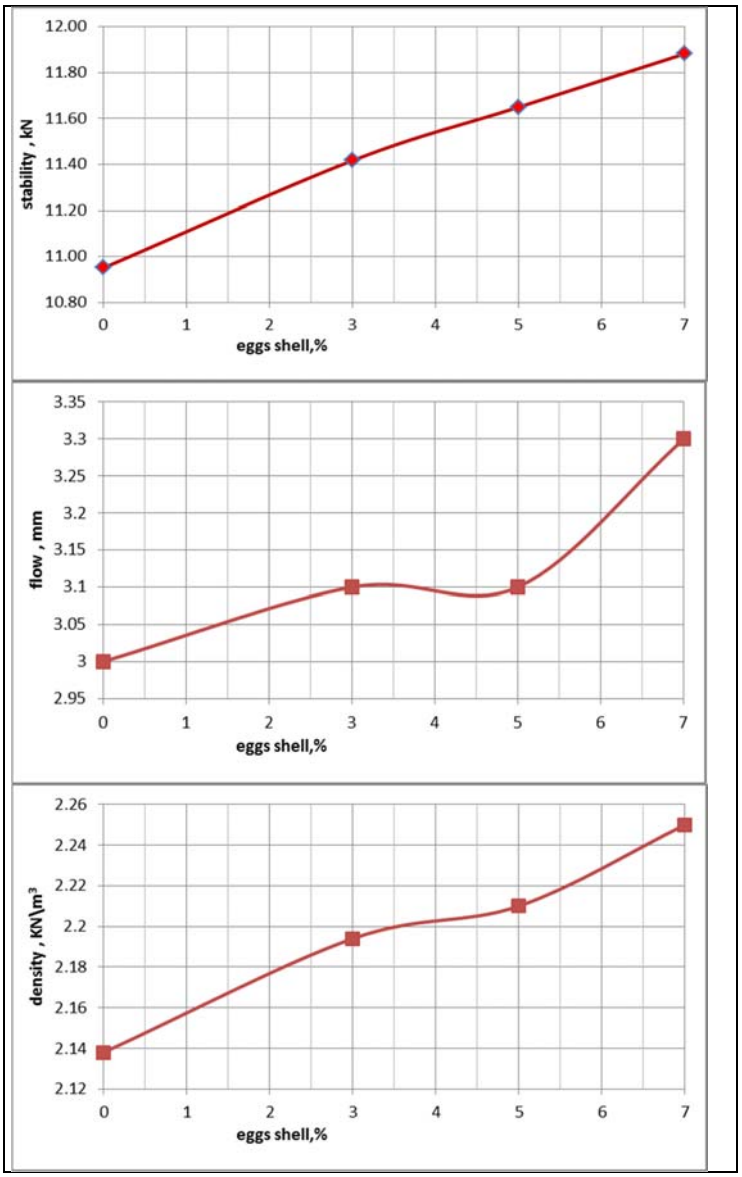


Figure 6 Marshall- Flow results.

To explain the effect of adding the egg shells to hot mix asphalt, Data has tabulated in Table (5) by comparing the results which has recorded with virgin mix has no additive. All of values have been obtained show improving in asphalt concrete characteristics.

14. Conclusions

After investigating the results has founded in this project, its conclude that:

1. Despite the apparent decline in the value of penetration, but significantly increased viscosity
2. Improved flash point temperature with increasing proportion of additive
3. the additive has no significant effect on the softening point temperature because of least difference values obtained
4. In general, the results recorded lead to the fact that the eggs shells classified as modified of asphalt mixture stability and their components interlocks.
5. Egg shells is modified asphalt binder material since it satisfy the Iraqi specification requirements.

6. 7% from eggshells as proportion from weight of asphalt, enhance HMA properties from the best results getting from in this study.
7. Adding Egg shell powder to the asphalt binder get it resistance to permanent deformation (rutting).
8. The increased flexibility at lower temperatures and increased hardness at high temperatures indicates improved (reduced) temperature susceptibility of the Egg Shell modified asphalt.
9. Improving the high performance of asphalt binder since Egg shell reduce the high temperature deformation and rutting damage of asphalt pavement.

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Section 5
Information Technology

Leadership for Knowledge Management Related Change Initiatives in the Kingdom of Saudi Arabia Public Sector Organisations

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Abstract

The Kingdom of Saudi Arabia (KSA) Government aims to reduce fiscal deficit by improving state efficiency, reducing costs, as well as its state subsidies. To address these issues and challenges, KSA public sector organisations have to modify and/or amend many strategic, structural, financial, and operational changes. As public sector organisations try to meet these complex challenges, they need to be innovative. This often calls for the creation, use and exploitation of new knowledge. Therefore, knowledge assets must be properly managed to provide an environment for well-informed decisions. The aim of this paper is to investigate the role of leadership for successful deployment of knowledge management (KM) related change initiatives in KSA public sector organisations. The qualitative approach of research was adopted to collect and analyse data. The qualitative results were derived from semi-structured interviews with 42 public sector directors and managers. It is evident from this study that there are many misconceptions of what leadership meant to them and their organisations. Seven key roles leadership plays in implementing KM related change initiatives. The most important key role of leadership for successful implementation of KM related change initiatives is creating culture for KM. The paper concludes that the leadership plays a key role in implementing KM related change initiatives in the KSA. Leadership is about preparing organisation with a KM vision and values that resonate with the team, all employees, and key stakeholders. Therefore, there is an urgent need to develop and deliver a bespoke training programme to address, improve and measure the effectiveness of leadership skills for implementing KM related change initiatives.

Keywords: Culture, Kingdom of Saudi Arabia, Knowledge Management, Leadership, Success Factors.

1. Introduction

The unfortunate convergence of increasing oil supply and weakening global demand has created an oversupplied market and caused a 55% decline in international crude oil prices (EY, 2017). The fall in crude prices has prompted the biggest leadership, economic and policy shake-up in the history of Kingdom of Saudi Arabia (KSA). The KSA Government has cut the public sector bonuses and benefits for the first time since the collapse in oil prices, in a move that underlines the depth of the fiscal crisis facing the kingdom. Since 2014, oil prices have fallen by more than fifty percent and this loss of revenue has caused the Saudi Government to draw down its foreign currency reserves, return to the capital markets to issue bonds, raise taxes, reduce spending and greatly reduce subsidies offered on energy. Collectively, these actions have had an adverse effect on the domestic economy, causing GDP growth to slow, share prices to fall, pressure to mount on the currency and inflation to rise (Fattouh and Sen, 2016). The Government aims to reduce fiscal deficit by improving state efficiency, reducing costs, as well as its state subsidies. Consequently, the KSA Government has announced an ambitious new strategy: Vision 2030 (Fattouh and Sen, 2016). The National Transformation Programme (NTP) is a detailed strategy to implement the broader Saudi's Vision 2030.

The NTP aims to reduce unemployment from 11.7% to 9% by 2020 and 7% over the following decade. Therefore, the KSA Government has the ambitious target of creating 450,000 private sector jobs by 2020 through the expansion of non-oil sectors. But at the same time it plans to decrease the civil service by 20%, as part of its aim of reducing the dominant role of the state. This is definitely a big challenge because Saudis have grown accustomed to working in the more

'relaxed' public sector environment. Furthermore, the demographic shift in the work place, whereby a large percentage of the working population will retire in the coming five to ten years. This has created unrest among the public sector organisations when their best employees depart. In addition to this, the climate change, the knowledge economy, and commitment to the principle of sustainability, pose profound strategic challenges for the public sector organisations in the KSA and beyond. Therefore, to address these issues and challenges, the KSA public sector organisations have to modify and/or amend many strategic, structural, financial, and operational changes.

As organisations try to meet these complex challenges, they need to be innovative. This often calls for the creation, use and exploitation of new knowledge. This calls for the KSA public sector organisations to institutionalise the tacit knowledge of the experienced civil servants who will soon be retiring, and passing that knowledge on to new staff through various training and mentoring programs. The management of knowledge is, therefore, increasingly considered an important source of sustainable competitive advantage (Hamel and Prahalad, 1994; Nonaka and Takeuchi, 1995). To take advantage of the opportunities that the knowledge based economy and society can bring, the public sector decision makers needs to take initiative and to identify the new techniques and technologies of the Knowledge Management (KM) and to adapt them to the public sector management particularities. Therefore, the KSA public sector organisations need to aware of the benefits of setting organisation-wide KM goals and strategies, which involve viewing knowledge as a "significant competitive differentiator and resource of wealth and value-creation" they will risk falling behind the dominant practices in the private sector (Riege and Lindsay, 2006). However, Sandhu et al., (2011) noted that the focus on public sector organisations seems to be relatively low as compared to private sector organisations. The common challenges faced by the public sector organisations are: handling workload with fewer workforces and building sound relations and collaboration with the stakeholders.

Sandhu et al., (2011) further noted that the key reason for this limited focus is because of the not-for-profit nature of the public sector organisations. However, it is important to take note that today the KSA public organisations, not only are regarded as knowledge-intensive organisations but also deal with excessive retirement and attrition due to policy changes. Therefore, it is of strategic importance to capture and share the knowledge of departing experienced employees. Zack (1999) noted that the greatest barrier to implementing KM was the lack of fit between an organisations strategy, its structure and culture. Seba et al. (2012) found that organisational structure, leadership, time allocation, and trust could be barriers for KM in the Dubai police force. Although there is no doubt that KM plays a greater role within public services, there is little research and few guidelines on how KSA public sector organisations can develop more effective KM strategies, policies, and programs.

Kingdom of Saudi Arabia has modernity and tradition moving together (Alatawi et al., 2012). The state functions on the basis of Islamic rules. Besides that many modern organisations are working which implement and share knowledge in order to grow. Furthermore, to improve the current KSA public service delivery and to achieve the Saudi's Vision 2030, the KSA needs to extend on KM strategies and programmes. Therefore, there is a great need for empirical research that can serve as a basis for further development of policy on KM among the KSA public sector decision makers. Henceforth, the present research aims to.

2. Research Methodology

The aim of this research is to investigate the role of leadership for successful deployment of KM related change initiatives in the KSA public sector organisations. In order to achieve this aim, a robust methodology was considered essential. Design of research methodology is a crucial and difficult step in the research process (Creswell, 2014). Methodology is the overall approach to the research process, from the theoretical underpinnings to the collection and analysis of data (Collis and Hussey, 2003). Therefore, the choice of research methodology is a crucial and difficult step in the research process.

Amaratunga et al. (2002) points out that qualitative research is conducted through an intense or prolonged contact with a field or life situation, with these situations typically banal or normal, reflective of the every life of individuals and organisations. Gable (1994) argued that an explorative qualitative approach is better suited to study a nascent research field and gain valuable initial insights, rather than large scale surveys. Therefore, given the complexity of KM

issues and the paucity of comparable research within the KSA public sector, qualitative research methodology was adopted. This research adopts the interpretivist terminology, in line with the philosophical paradigm.

Qualitative method relies on text and image data, has unique steps in data analysis and draws on diverse designs. Data tends to be collected in the field at the site where participants experience the issue or problem under study, usually gathering multiple forms of data (Creswell, 2014). Yin (2009) noted that a qualitative approach is one in which the inquirer often makes knowledge claims based primarily on constructivist perspectives or advocacy/ participatory perspectives or both. It utilises strategies of inquiry such as narratives, phenomenologies, ethnographies, grounded theory studies or case studies. Open ended, emerging data is collected with the primary intent of developing themes from the data.

In this study, primary data was collected through semi-structured interviews. Kvale (1996) stated that an interviews purpose is to gather descriptions of the life-world of the interviewee with respect to interpretation of the meaning of the described phenomena. To ensure greater dependability and transferability (Creswell, 2014), a total of 42 professionals were interviewed in the KSA public sector organisations. The sampling method used is purposive sampling, where the subjective judgements of the researcher are used in selecting the sample (Remenyi et al., 1998). In purposive sampling, participants are selected to meet a specific set of criteria. The study sample included directors, advisers and managers responsible for KM strategies implementation in their respective departments/organisations.

The interviews lasted between 20 and 90 minutes. The format of these interviews was face-to-face, and the transcripts were recorded and supplemented with field notes as appropriate. The analysis of the interviews was undertaken using Content Analysis. The purpose of content analysis is to provide knowledge and understanding of the phenomenon (Downe-Wamboldt, 1992). Hsieh and Shannon (2005) noted that a Content Analysis is a method of research for subjective interpretation of the context of text through a process of system classification of coding and identification of themes or patterns. In the study, coding of the transcribed documents involved open coding of meaning units, that is, words, phrases, sentences, paragraphs, which essentially involved labelling concepts. The emerging concepts were mapped into themes. Threats to validity were minimised through triangulation of data collection methods (interviews, internal and external documents) and verification of the initial thematic codes by participants, where they judged the accuracy of data collected, though not its conclusions. The unit of analysis adopted for this study was the KSA public sector, and the embedded unit of assessment was the 'individual employee'.

3. The role of leadership for successful deployment of KM related change initiatives in the KSA public sector organisations

In this study, during face-to-face interviews, interviewees were asked about the role of leadership for successful implementation of KM related change initiatives in their organisations. Table 1 presents seven key roles leadership plays in implementing KM related change initiatives as revealed by those interviewed in this study. From Table 1, it is evident that the most important key role of leadership for successful implementation of KM related change initiatives is creating culture for KM. This is closely followed by developing vision and mission for KM; mapping key knowledge sources; developing knowledge capture strategies; developing knowledge sharing strategies; identifying and deploying effective KM tools; and stakeholder engagement. Each of these roles is discussed in detail below.

Table 1 The roles of leadership for successful implementation of KM related change initiatives in the KSA public sector organisations.

Roles of leadership	Percentage of interviewees cited (N=42)
Creating culture for KM	95%
Developing vision and mission for KM	88%
Mapping key knowledge sources	81%
Developing knowledge capture strategies	71%
Developing knowledge sharing strategies	65%
Identifying and deploying effective KM tools	60%
Stakeholder engagement	55%

3.1 Creating culture for KM

Overwhelmingly, 95% (40 of the 42) of the interviewees noted that creating culture for KM is most important leadership role in implementing KM related change initiatives in their organisations. There has been growing research linking successful knowledge management practices to the leadership process (Chuang et al., 2013). Leadership helps the change process to get going. The focus of change is not only on organisational process and structure systems, but also organisational cultural systems (Whittington*, et al.*, 1999). These systems are usually a part of a broader set of systems to evaluate the performance of the organisation, its various units, and individuals. Cultural changes occur through leadership and vision rather than directives. In general, leaders play a key role in maintaining and transmitting the culture. They use a number of powerful mechanisms including what they pay attention to, measure, control, how they react to a range of crises, and whom they recruit, promote and reward. All these mechanisms send important messages about the kind of organisation the leaders are running.

In this study many interviewees noted that the main causes of knowledge hoarding in their organisations include: people believe that knowledge is power; people are insecure about the value of their knowledge; people do not trust each other's; employees are afraid of negative consequences (insights and opinions are ridiculed, criticised or ignored); people work for other people who do not tell what they know; people lack time; people forget to share; people do not want additional work and responsibilities; people do not see the connection between sharing knowledge and the business purpose; and fear of being 'downsized'. How quickly this knowledge hording culture will change to one supportive of organisational learning and KM in great part depends on leadership in any organisation. Yukl (2013) view leadership in terms of group process, traits, behaviours, and as an instrument of goal achievement. In summary, leadership is a dynamic process of influencing the activities of a group in order to achieve unit and organisational goals while facilitating individual and collective efforts to learn and accomplish shared goals in organisations. Leadership for KM is about standing up for beliefs, challenging norms and pushing for what is right; the leader's job in making this happen is in providing the inspiration, creating culture, the permission and demonstration that principle-based working is worthwhile.

3.2 Developing vision and mission for KM

In this study, 88% (37 of the 42) of the interviewees noted that developing a long-term vision and mission for KM is most important roles of leadership in implementing KM related change initiatives in their organisations. For the successful development of KM initiatives, it is suggested that the development of vision and mission is the basis for organisational alignment, coordination and teamwork. The mission statement describes an organisation's basic purpose.

The mission and vision give direction to an organisation, and they function as a compass and a road map, leading to better performance (Ramparsad, 2001). Translating the organisation's vision and mission into a knowledge vision and mission is essential for KM implementation.

According to Roche (2013), leadership must articulate a clear KM vision of the future "ideal" organisation in order to successfully implement change initiatives. Once the KM vision is established, leadership must establish and create understanding and commitment among organisation members to share the vision of the ideal identity – and the actions that are necessary to achieve it. A vision and mission aligned KM strategy is hard to challenge. It has also been suggested that organisation leaders have roles to play in order to implement a clear vision, separate from the past, create a sense of urgency, develop enabling structures, communicate, involve people and be honest, reinforce and institutionalise change (Kanter, 1999).

If a leader does not think ahead, beyond a quarterly or even a year focus, he or she cannot readily assess the full impact of KM on his/her organisation. The role of leaders and leadership cannot be overestimated in creating a culture of change; no amount of words, mission or vision statement can make up for a failure to demonstrate and support the behaviours that are needed. While leadership may too often be the role solely of senior people in an organisation, managers hear phrases such as 'we are going through a period of change' – or worse, they displace responsibility and use phrases such as 'they need to change'. It is a manager's job to lead his or her team through change and help them understand that change is an organic, ongoing process that never stops.

3.3 Mapping key knowledge sources

In this study, 81% (34 of the 42) of the interviewees asserted that mapping knowledge sources is another important leadership role in implementing KM related change initiatives. In this study, most often cited roles leadership plays in implementing knowledge mapping initiatives include: identifying internal and external sources of knowledge; creating ICT infrastructure; developing training programme to promote knowledge mapping initiatives; creating new job roles and positions; developing reward systems to promote knowledge mapping initiatives.

Knowledge mapping confers benefits such as improved ability to locate knowledge in processes, people, repositories and context; and improved awareness of islands of expertise and evaluation of intellectual and intangible assets, improved decision making and problem solving by providing applicable information, and effective knowledge sharing associated with knowledge exploitation in organisations (Eppler, 2003; Bentaleb and Zouhdi, 2017).

Conducting 'knowledge auditing' would show how organisation currently creates new knowledge, stores, access, use and share the knowledge that they need to do their jobs. According to Burnett, *et al.,* (2004) a successful audit should effectively reflect the organisation knowledge assets and how it flows. It also shows key internal and external sources of knowledge that organisations are using for solving day-to-day business problems.

3.4 Developing knowledge capture strategies

In this study, 71% (30 of the 42) of the interviewees asserted that developing knowledge capture strategies is another important leadership role in implementing KM related change initiatives in their organisations. In this study, most often cited roles leadership plays in implementing knowledge capture initiatives include: identifying and capturing knowledge from external sources (e.g. academic institutes, non-government organisations), developing a knowledge capture policy, encouraging employees to participate in project teams, dedication of resources for knowledge capture, creating IT infrastructure, developing and deploying knowledge capture training programmes and reward systems to promote knowledge capture initiatives.

Today's most pervasive initiatives related to capturing knowledge is a result from the constant movement of people from project to project inside organisations, as well as the changing fiscal/regulatory measures. Employee's especially new hires are facing steeper, longer learning curves at the same time that employers are looking for faster revenues and higher productivity (Kluge*, et al.*, 2001; Aggestam, et al., 2014). Knowledge loss and time to build new competency issues for new hires have fuelled organisations to implement initiatives related to capturing knowledge.

Capturing key lessons learned by others as well as good work practices helps to prevent firms from repeating errors while allowing new project teams to build on the work of their predecessors (Dixon, 2000). Therefore, leadership should decide how best to cope with this problem such that as much knowledge as possible is retained within organisational boundaries.

3.5 Developing knowledge sharing strategies

In this study, 65% (27 of the 42) of the interviewees asserted that developing knowledge sharing strategies is another important leadership role in implementing KM related change initiatives in their organisations. In this study, most often cited roles leadership plays in implementing knowledge sharing initiatives include: developing knowledge sharing policy statement; developing reward systems; developing training programmes; and creating new job roles and positions (e.g., KM officer). A lack of knowledge sharing may inhibit or hinder KM (Roche, 2013; Ipe, 2003). Although knowledge exists at different levels of an organisation, for instance, at the individual, team, and organisation levels, sharing of knowledge at the individual level is critical to an organisation.

Knowledge sharing is the voluntary dissemination of acquired skills and experience to the rest of the organisation (Davenport, 1997). Some define internal knowledge sharing as the beliefs or routines for disseminating knowledge and experience across the units of an organisation (Calantone*, et al.*, 2002). The acts of sharing are very important since an individual's knowledge will not have much impact on the organisation unless it is made available to other individuals (Nonaka and Takeuchi, 1995).

3.6 Identifying and deploying effective KM tools

Massingham (2014) asserts that KM tools are able to amass data from various sources and classify, integrate and codify these data. In addition, Massingham (2014) suggests that these tools make it possible to retrieve and reveal knowledge and can also be employed in order to disseminate knowledge among staff. In this study, 60% (25 of the 42) of the interviewees noted that identifying and deploying effective KM tools is another important leadership role in implementing KM. It is believed that KM technologies can provide many benefits. Technology can enhance the sharing of knowledge by reducing the restrictions pertaining to distance and time. The application of electronic mail, internet, collaboration technologies, bulletin boards, newsgroups can support the distribution of knowledge throughout an organisation. Technology also can provide a forum for employees to debate, discuss and interpret knowledge via multiple perspectives. Most often used KM techniques and technologies in the interviewed organisations include: mentoring; after-action-review; internet; process map; newsletters; exit interviews; audio recording; intranet; and corporate yellow pages.

There are several issues with the current use of technologies in the interest of KM. The challenge for technology is to facilitate a dynamic process of knowledge creation and representation, not a static process of information management. Current ICT based KM technologies focuses only on explicit knowledge, which can be expressed in words and numbers and easily shared, and fails to deal with tacit knowledge. Most KM technologies are designed to extract profits through knowledge economies of scale by combining or reusing existing knowledge, not to create new knowledge (Dierkes*, et al.*, 2001).

To gain competitive advantage, it is necessary for leadership to recognise and use a blend of ICT and non-ICT based KM techniques and technologies. It is advisable to recognise and use conventional, simple, low cost, and easy to use with minimum training needs KM techniques and technologies. It should note that KM techniques and technologies roles are not mutually exclusive and organisations may adopt any combination of them to tackle their particular issues or support particular motives. For instance, if the prime reason for KM is minimising the risk of losing valuable knowledge, the response may involve identifying and capturing knowledge that an organisation has. Thus, risk minimisation is closely related to KM techniques and technologies specifically aimed at locating and capturing existing valuable knowledge.

3.7 Stakeholder engagement

In order to develop a shared understanding of KM related change initiatives approaches and expectations, it is important to engage with key stakeholders in their own right and not only

with investors with short-term financial interests. Stakeholder engagement means more than just entering into dialogue. It has to produce real learning effects that lead to product and process improvement or innovation. Engagement with internal and external stakeholders as well as with sectoral and multi-stakeholder initiatives supports the learning process and increases credibility, commitment and innovation.

In this study, 55% (23 of the 42) of the interviewees noted that stakeholder engagement is another important leadership role in implementing KM related change initiatives in their organisations. Strong stakeholder's relationship is a focal point for change. Leadership skills that support KM activities include the ability to think across a myriad of boundaries, across disciplines, establish new relationships, working across organisations, and value chains. Such people must be excellent communicators and have the capacity to develop and maintain broad networks. Through establishing a wide range of relationships, they recognise the need to collaborate. Other related skills include the ability to be flexible and adaptive with regard to people and relationships.

4. Conclusions

It is not simply enough for knowledge to reside within an organisation as knowledge that is not effectively utilised is essentially a wasted resource, instead knowledge needs to be actively managed. There are several mechanisms that can be used to manage public sector or private sector organisational knowledge. However, the challenge of managing knowledge is a daunting task for any organisation. An organisation's knowledge resources are complex and multifaceted, ranging from tacit components to knowledge that is explicitly represented. The ultimate key to organisations successfully embracing KM initiatives into daily operation is leadership. Effective leadership requires a particular set of attributes that enables to extract ideas and knowledge from stakeholders and transfer this knowledge into organisational assets. This study revealed, seven key roles leadership plays in implementing KM related change initiatives. The most important key role of leadership for successful implementation of KM related change initiatives is creating culture for KM. This is closely followed by developing vision and mission for KM; mapping key knowledge sources; developing knowledge capture strategies; developing knowledge sharing strategies; identifying and deploying effective KM tools; and stakeholder engagement.

The paper concludes that the leadership plays a key role in implementing KM related change initiatives in the KSA. Leadership is about preparing organisation with a KM vision and values that resonate with the team, all employees, and key stakeholders. The lack of leadership skills is one of the most important challenges KSA public sector organisations face in implementing KM related change initiatives. Therefore, there is an urgent need to develop and deliver a bespoke training framework to address, improve and measure the effectiveness of leadership skills for implementing KM related change initiatives in the KSA public sector organisations.

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Facilities Management: Granularity of Information for a Digital Information Platform

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Abstract

The data landscape in facilities management ranges from an un-catalogued, siloed, analogue base of data to an integrated digital landscape, often running in parallel. The dynamics of information requirements for service delivery in facilities management suggests there is an information disparity between CAPEX and OPEX teams, each have limited understanding of their respective information needs. Additionally OPEX teams have limited experience of using the complex inter-related digital information schema. Analysis of owner/user client profile organisations, Employer's Information Requirements [EIR] and pre-contract BIM Execution Plans [BEP] is used to assess the respective effectiveness. The research method adopted involved a review of the relevant literature about information requirements for digital information modelling and the analysis of archive pre-contract EIR's and BEP's that offer data on current practice. Recent examples of EIR's and BEP's were sought from organisations.

This research identifies the adaptations made to the BIMSmart EIR template and the Cpix Bep template by organisations. Recommendations are for generation of revised free standardised contractual templates together with a framework for generation of a suite of information requirements for Facilities Management [FM] with guidance and adaptations for FM to be included in the appropriate standards and process.

This research adds to the limited knowledge regarding how owner/user clients generate a comprehensive suite of information requirements [IR] based on an Operations and Maintenance [O&M] viewpoint through the assessment and use of pre-contract EIR's and BEP's in procurement for large owner/user clients.

Keywords: Information Requirements, IR, BIM, Building Information Modelling, Facilities Management, FM, Asset Management, Employers Information Requirements, EIR, BIM Execution Plan, BEP.

1. Introduction

The current paradigm for BIM FM is the use of BIM resources that are developed for design and construction (Ashworth, Tucker, & Druhmann, 2017). Facilities management work with information based on systems and design and construction deliver information based on assemblies, a dichotomy of approach to information (McGraw Hill Construction, 2014). There is limited research that looks at BIM FM implementation needs and how the information requested through EIR's. Our view is that EIR models have been created, facilitated and generated by designers and contractors, based on their understanding of the information needs of O&M, rather than through engagement with clients and O&M delivery teams. Therefore, the aim of this research is to investigate legacy estate information requirements and how to transition to a digitalised platform by identifying the efficacy of data requirements contained in EIR's that deliver the data streams to FM teams for service delivery. Key research objectives include: the identification of enablers of information requirements for the client; the identification of possible impacts that this capability can have for delivery of facilities management; and the identification of the dynamics of information requirements on service delivery for facilities management.

The research method included a literature review of EIR's, BEP's, BIM for facilities management, information management, standards, guidelines, processes and big data & data analytics. Additionally, EIR and BEP exemplars were sourced from large owner/client organisations based in the UK. Each organisational EIR was compared to the BIMSmart [2013] exemplar EIR template and BEP's were compared to the Cpix BEP [2013] template to determine a range of adaptations. Elements of comparative analysis were used to identify emerging trends

within categories, identifying variables and emphasis of use (Cragun et al., 2015). Investigating EIR's against the BIMSmart template and the efficacy of BEP's to respond to EIR's to determine the use profile of the BIMSmart template. This was done by using the BIMSmart template as a baseline and identifying the total number of clauses within each EIR and how many clauses have been added comparatively. The EIR samples compared are detailed in Table 1.

Table 1 EIR & BEP Research Sample Profile.

Organisation	Description	Year
00	EIR, BIMSmart Template	2013
01	EIR, Large Higher Education Facility – UK	2016
02	EIR, Medium Local Government – UK	2016
03	EIR, Medium Local Government – UK	2016
04	EIR, Large Higher Education Facility – UK	2016
05	EIR, Large Government Department – UK	2016
06	BEP, Large Higher Education Facility – UK	2016
07	BEP, Large Government Department – UK	2016
08	BEP, Large Higher Education Facility – UK	2016

2. Background

2.1 The Information Landscape

Digital information modelling is an essential element of UK Government digital strategy, Construction 2025 and Digital Britain 2050 which aims to reduce built-asset costs by 33 per cent, and time and carbon by 50 per cent through the implementation of real time efficiency, increased utilisation and reductions in energy use (Cabinet Office, 2014). This target relates to UK Government as a client, however there are concurrent beneficial impacts for organisations with large legacy estate portfolios that operate as owners/users to implement a digital information modelling landscape.

A new paradigm of digital information modelling present opportunities for organisations to leverage information for service delivery, improving productivity, reliability and the multiple use profile of information. This transformational aspect of digital information modelling implementation for FM operates at a department and organisational level, it also has the capacity to be disruptive (Reinhardt & Gurtner, 2015). As digital expertise develops, within an organisation, the increasing sophistication of data management increases the feasibility for the integration of data leading to the potential to use Big Data; which suggests organisations will be increasingly agile and responsive to market trends that are relevant to the organisation. Information requirements for physical assets are significant and increasing in volume due to global reduction strategies for carbon reduction, budget reductions, economic climates and the serial changes due to increasing visualisation requirements for FM service delivery models. Currently, a significant proportion of data used by FM teams is contained in information silos which limits the use profile of data for FM service delivery through a lack of integrated data (Codinhoto & Kiviniemi, 2014). Therefore to improve FM service delivery, the integration of silos and a platform for integrated digital data are necessary to support effective management of assets.

2.2 Sustainable Data

In practice, the management of assets continue to use fragmented data-sets, despite guidance indicating the importance of integrated information (Bilal et al., 2016). More recent approaches that are delivering a sustainable model continue to value data that is delivered through the multiple reuse of data for different purposes, regardless of the primary motivation for the collection of the data (Batra, 2014). In addition, the UK Government also regard the digitalisation of OPEX activities as a key element in delivering reductions in carbon emissions (Crown, 2013). Despite the guidance and research outputs, change is slow and while there is engagement in the debate by FM teams, the status quo continues with isolated pots of data (Bilal et al., 2016).

Park and Tanger (2012) state that analytics as applied to sustainability can reduce operating costs i.e. energy costs and carbon emissions, materials and water use; generate insight into supply chain performance, resource efficiencies and support informed decision-making. Additionally, emerging risks can be identified and mitigation strategies can be devised in anticipation; performance and sustainability strategies can have an enhanced response to economic, social and environmental factors (Park & Tanger, 2012). These data driven strategies deliver a proactive approach to performance and sustainability and unlock hidden value, achieving a resilient organisation.

Digitalisation, as a process presents specific challenges for construction, an industry that operates on 4-6% margins which means that the organisational benefits of new investment need to be robust (Bilal et al., 2016). Barton and Court (2012) indicate using data analytics, delivers productivity improvements an increase of 5% and budget savings of 6%, Liu (2015) also suggests an 8% improvement. There are issues of data ownership, data security, data quality and the complexity of the technology and analytics environment that FM teams need to resolve. Isolated digitalisation is not the solution, but an integrated approach to improve process and workflows, increasing transparency in the data and accessibility to the data deliver a platform to use analytics as a predictor of the future (Bilal et al., 2016). Data analytics and the associated technology are recognised as the drivers for innovation (Côrte-Real, Oliveira, & Ruivo, 2017). A result of enabling the use of integrated big data is it becomes a major differentiator between organisations, this develops organisations to be proactive in devising strategies to future-proof their organisation (Wamba et al., 2017).

3. Granularity of Information in FM

3.1 Clients

Construction clients critically under estimate their role in changing the construction sector (Crown, 2013). Eastman et al., (2011) state '*... many owners accept the current status quo and may not perceive their ability to change or control how a building is delivered*.' The lack of definition by clients of the information, documentation and deliverables required throughout design and construction and handover are problematic (Beck, 2012; Cotts, Roper, & Payant, 2010). This is as a result of the multiplicity of choices, the complexity of processes, BIM guides and BIM standards together with the data use profiles of multiple users (Giel, Mayo, & Issa, 2015), and the lack of specificity for FM within all these resources. Giel et al. (2015) outlines a pragmatic model for transitioning to a digital landscape through the connection of digital information, not necessarily requiring highly developed geometric modelling expertise from the outset. An additional constraint concerns the construction supply chain, which are not very experienced in delivering digital information modelling for FM but are regarded as the primary change agents to develop the expertise of clients accessing the construction market (Philp & Thompson, 2014). Giel et al. (2015) with a limited survey indicates that 47% of client respondents do not have their BIM information requirements in place for FM. There are good examples of developing FM practice, in Manchester Town Hall the BIM FM implementation was driven by the client. The FM team as client at the Manchester Library Project, sought BIM education and experienced the difficulties of changing the status quo at a time when the benefits of BIM for FM were unknown and unproven. This demonstrates the importance of internal BIM champions able to drive change and validate the benefits of implementation (Codinhoto, 2017).

Performance of information management within FM can be enhanced by taking a 'lean' perspective. Jylhä and Suvanto (2015) identified that improvements to the quality of information for FM service delivery minimises the additional time required for data validation and reliability checks. Missing data as a result of data atrophy and omitted data is reduced and productivity is increased. Problem solutions are achieved in a shorter timescale because data is transparent, visible and easily available, as demonstrated in 'Lessons-learned' within the BIM task group website. Ventilation motor replacement was reduced from 4 weeks and 14 work hours to 1 day and 3 working hours, also reducing costs by £286 and disruption by 27 days. Implementation of digital information modelling and geometric modelling within an FM environment will lead to value creation (Jylhä & Suvanto, 2015). Giel et al. (2015) confirms that owners are recognising the benefits of a digitalised information platform in an abstract way, but are overwhelmed by the change management required. In addition, they do not have

the time or expertise to generate the complex suite of information requirements as required for a digitalised IR landscape (Ashworth et al., 2017).

3.2 The Data Continuum

The data stream in construction and FM is increasing in volume and complexity. The transition to digitised data for FM adds to the intricacy of the working environment and the potential for data overload (Irizarry, Gheisari, Williams, & Walker, 2013). Isolated database queries and spreadsheets are challenging tools to use for delivering insight and identifying patterns in collected data (Berinato, 2016). In general, FM teams are managing two information platforms in parallel, a set of historic text and 2D drawings together with a digital based information platform received from recent CAPEX BIM projects. This 'Data Continuum' increases complexity in FM teams, for managing the different data streams, see Figure 1. The transition of FM teams to a digital landscape, that is accessible and interactive within a real-world view, increases efficiencies, improves decision making and reduces time required to address issues (Irizarry et al., 2013).

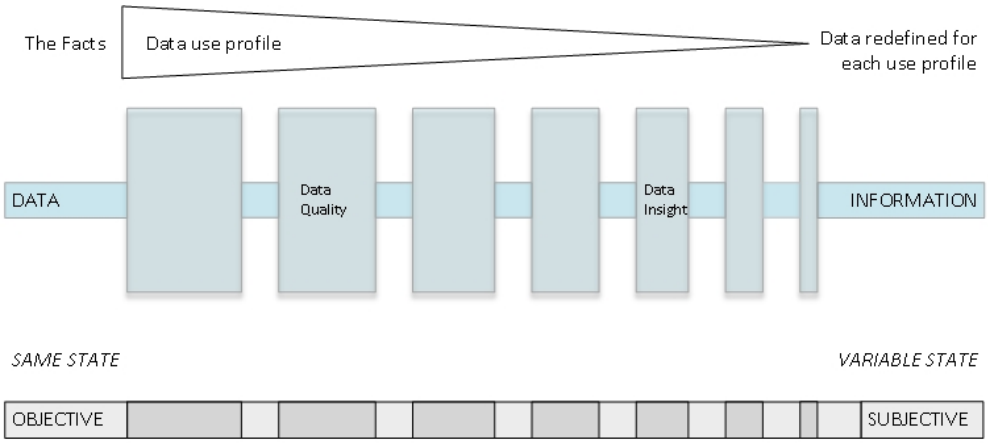


Figure 1 The Data Continuum adapted from (Harris, 2009).

The integration of legacy estate FM information within a digital information modelling platform is under developed worldwide, despite the application of digital information modelling processes, work flow, information sharing and technology for existing built assets, having the potential to create added value for organisations (Crown, 2013). Giel et al. (2015) conducted a limited survey with FM professionals and found that the key benefits of digitalised information are in the potential for asset management, building systems analysis, ease of transfer of data to computerized maintenance management system [CMMS], space management and control, scheduling of maintenance, GPS/GIS integration, disaster planning. The Ministry of Justice (UK) and Sydney Opera House continue to develop and publicise strategies to transition and operate digitally modelled information for FM, and report gains of improved accessibility to information, resource utilisation and increased productivity (Linning, 2015).

The management of information requirements and their data demands, adds a layer of complexity to O&M service delivery that is generally unquantifiable. However, it is known that successful implementation which is focussed on how to capture and use data; and is appropriate to the organisation, assists with improved decision making and achieves an increasingly flexible team, able to respond to changing organisational requirements (Barton & Court, 2012). Refining the resolution of the granularity of information required to map data requirements for digitalised information requirements of organisations necessitates a data audit of the existing situation to understand the inefficiencies and identify the development needs.

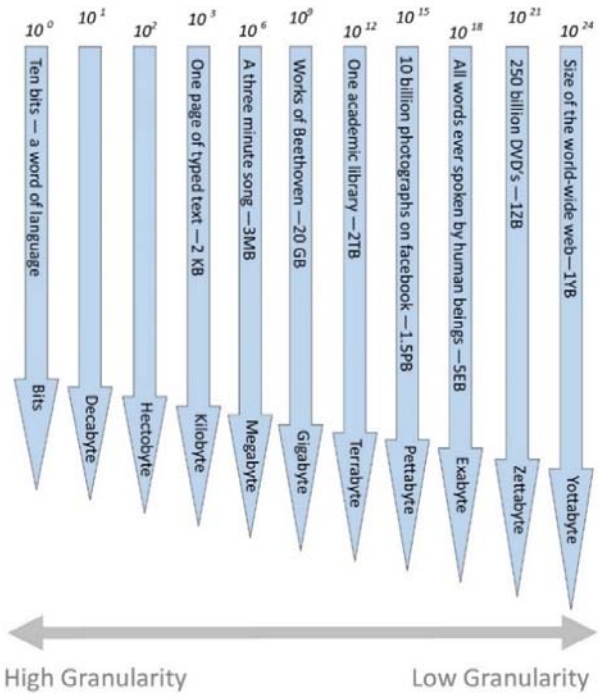


Figure 2 Data Granularity

The data collection needs identified should be sufficient to deliver FM and not a catchall of JIC [just in case] information, also known as 'data bloat'. Figure 2 shows how high granularity is as bad as too low, each model of granularity having their own issues. In the case of being 'unknowing' about digital data then there is a tendency to request everything, a 'low granularity' of data, which presents significant storage issues and incurred costs and does not address the issues facing FM (Bilal et al., 2016). Individual design professional BIM models on average of 100Mb, a single construction project with the potential range in models, visualisations, analytical models, AIM model and data, has significant data storage and maintenance needs. The granularity of data, resolved as quantification of how much fine data is required (low granularity) and strategic level data (high granularity) has significant cost implications.

3.3 The Standard Effect

Hart (2016), BIM Task Group, Innovate UK said:

'The use of the UK developed BIM standards is transforming the $10 trillion global construction sector towards improved productivity, competitiveness and efficiency and providing growth for UK small businesses at the forefront of this technology'.

BIM Standards such as ISO/TS 12911:2012, ISO 29481-1:2010, BSi PAS1192:3, etc., aim to achieve the quality, validity and reliability of data and information; this approach to standardisation reduces variability, atrophy, replication and redundancy in the data (Corrocher, 2013). Standards reduce technical uncertainty and complexity and are the result of innovation and knowledge sharing between an extensive range of experts and specialists (Corrocher, 2013). Compliance with the UK BIM standards has seen the commensurate development of the IFC standard to deliver interoperability for BIM tools. However, the IFC standard is under constant revision to meet the needs of the industry, which has effected the information requirements of clients where all file types are required, due, in part to a lack of confidence in Ifc data (Giel et al., 2015). The use of standards in the digital construction platform ensures consistent information is issued and released in appropriate formats, achieving good levels of efficiency for information exchange and compatibility (Giel et al., 2015).

Roles and responsibilities require clear definition together with key deliverables and processes for managing the quality and timing of data exchanges (Biddle et al., 2012).

BIM standards and guidelines currently available, apply in the main to new build CAPEX projects. PAS 1192-3: 2016 and BS 8536-1-2015 are specifically for facilities management however, legacy estate is not explicit within these standards. BS EN 19650-2 & BS EN 19650-2, are international standards under development, due Spring 2018 that will also be relevant to facilities management (BSI, 2017). These proposed ISO standards engage with BIM for the whole life cycle of a built asset and may be applied irrespective of procurement strategy, organisation typology and size, however, the standards are aimed at CAPEX projects i.e. refurbishment and does not address digital data for an existing built environment. Currently the standards are acting as an enabler and as a '… engine of innovation', primarily for design, construction and refurbishment. The current standards are unbalanced, at the present, as they do not engage with legacy estate (Corrocher, 2013). A situation that has not significantly changed, there is no framework for 'how' large client/owners could migrate their legacy estate to a BIM platform.

For clients to achieve the level of information required by the FM team to operate and maintain their buildings, the information requirements of the client should be sufficiently detailed to receive useful information from the supply chain that meets the current state and the projected future state and meet BS 8536:2015 - FM briefing for design & construction. Overall, FM teams are engaging with the highly complex paradigm of digital information modelling, with all its intricacies without the support of fully developed guidance, standards and templates that will assist in an easier transition to a digitalised landscape.

3.4 The Complexity of Information Modelling

The starting point for a construction contracting client within the BIM standard environment is to identify the Organisational Information requirements [OIR] and Asset Information Requirements [AIR] based on BS ISO 55000 series (BSI, 2014) and then develop an Employer Information Requirement [EIR] on this basis. An EIR should contain sufficient detail to ensure that clients' information needs are met to deliver a construction project together with data for operations and maintenance activities (BSI, 2013). The generation of these documents are generally left until a CAPEX project is due. The optimal solution would be the generation of a connected set of OIR, AIR and EIR, that is able to deliver information requirements regardless of the starting point, i.e. initiated as a capital build or initiated by FM. The EIR supplied to the supply chain at tender requires a response document, received in the form of a pre-contract BIM Execution Plan [BEP], the client then reviews this against the issued EIR, negotiations occur and the tender is awarded. The issue for clients is achieving the range of documentation prior to commissioning a delivery team, it is not unusual to prepare EIR in isolation from the suite of documentation.

The key factors to improve digitalised information modelling in facilities management is development of a model that is pragmatic i.e. not overly complex, and one that uses data relationships that are understood by user groups and management alike (Rothberg & Erickson, 2017). Forns-Samso, Bogus, and Migliaccio (2011) identifies a correlation to successful building information modelling [BIM] implementation for facilities management [FM] if an organisation has experience of BIM for design and construction together with a correlation between the size of organisation and a rise in implementation rates of BIM FM. A significant issue is the different emphasis placed on 3D geometric models, which are highly valued in the design and construction phase, however, for FM teams they operate in a very data centric environment. Improvements required to develop FM service delivery would focus on accessibility, transparency and reliability of data (McGraw Hill Construction, 2014).

4. Results

All the organisations made significant adaptations to the EIR template, as shown in Figure 3, clause 1.2.10 which was significantly adapted, organisations 01 & 03 added, *'Contractor to devise a strategy for capture and processing of as built information to populate attributes, information to be efficiently accessed during operations.'* Table 2 gives further detail on the adaptation percentage as a result of the comparison of template clauses against additional

clauses included by the EIR generating organisations. A significant outlier is clause 1.3.2 Client Strategic Purpose which has 17 additions compared to the one contained within the clause. The BIMSmart EIR template had no additions in two clauses out of twenty-two, 1.3.3 B & C therefore the remaining clauses all had additions to meet the organisational information requirements. Organisation 05 demonstrated the most similarity in content to the BIMSmart EIR template.

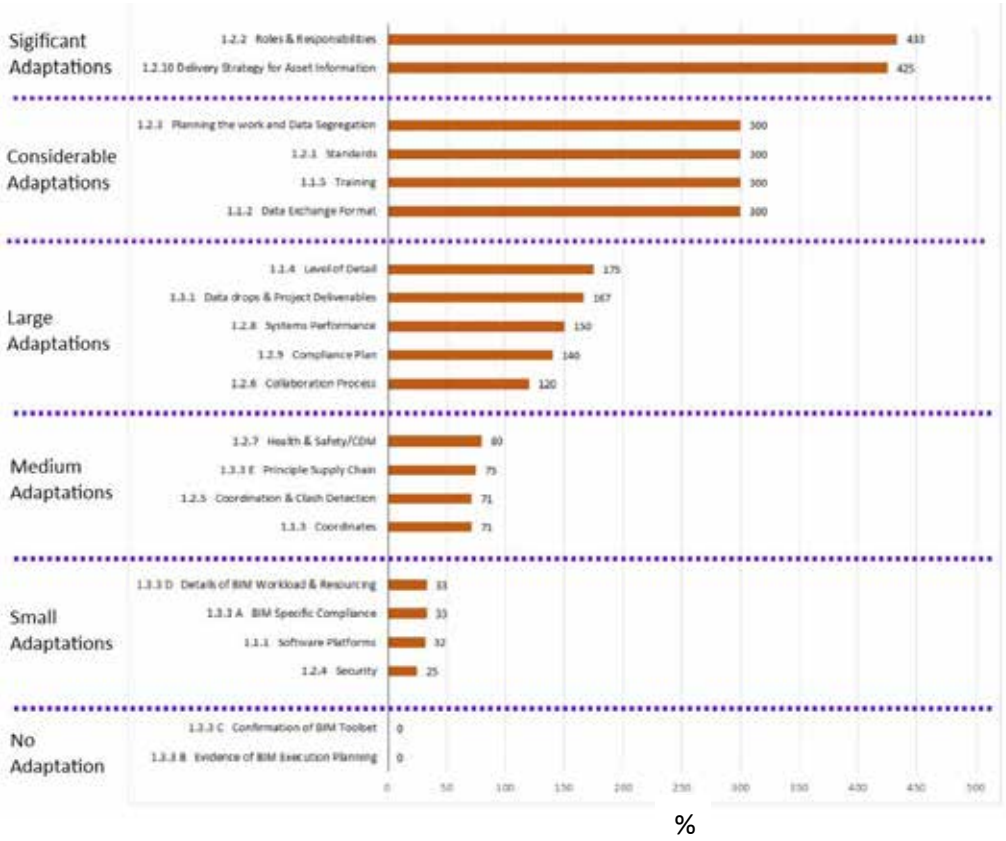


Figure 3 EIR - Level of Adaptation

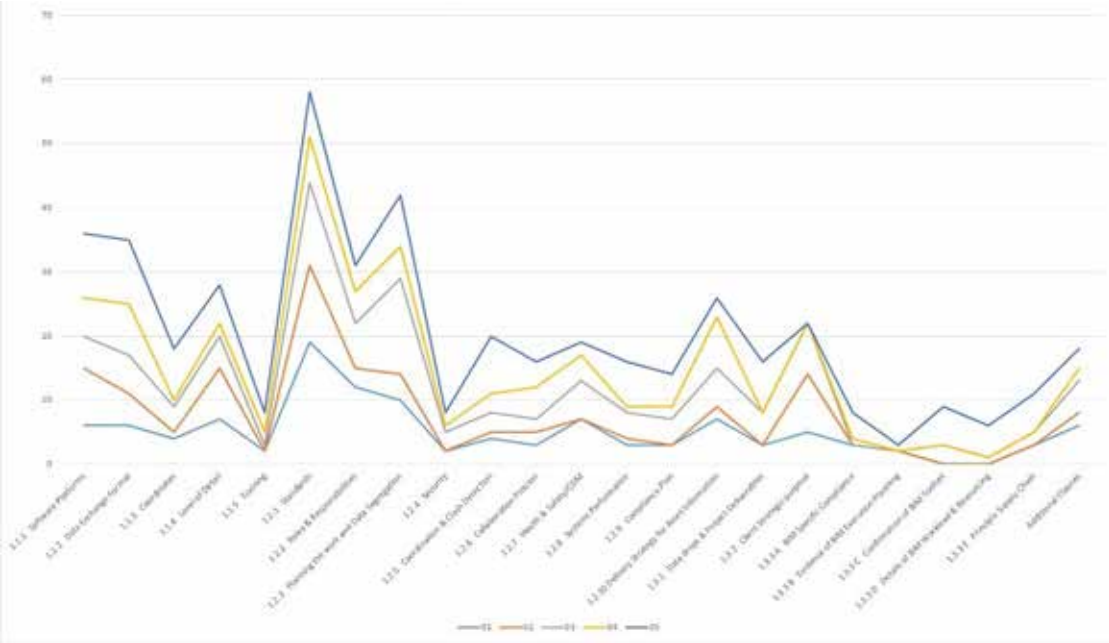
Organisation 02 did not generate requirements for software requirements, in particular, and left the content to be specified in the pre-contract BEP by the supply chain. This organisation additionally specified some information in sections where the EIR did not specify requirements i.e. clause 1.1.2 *'Import design & construction data to CAFM software, defined by the Employer'*. Organisation 05 moved *'The ability of the bidder to work with these platforms should be made clear in the response.'* which is in clause 1.3.3 A & D, to the 'Technical' section. Organisation 04 omitted the 'Commercial' section entirely. 1.2.4, which has a small number of additions may indicate consensus, however, security issues were found within alternate sections of the EIR for Organisation 05.

Organisation 05 required the use of a pre-contract BEP template bespoke to their organisation for the supply chain response and organisation 01 require a BEP *'... with responses directly correlating to the section references within this document [EIR] and guided response BEP headings.'*.

Table 2 EIR Clauses, Additions and Percentage Increase in clauses

Clause Ref:	Description	No. of Clauses	No. of Additions	%
1.1.1	Software Platforms	22	7	32
1.1.2	Data Exchange Format	4	12	300
1.1.3	Coordinates	7	5	71
1.1.4	Level of Detail	4	7	175
1.1.5	Training	1	3	300
1.2.1	Standards	7	21	300
1.2.2	Roles & Responsibilities	3	13	433
1.2.3	Planning the Work & Data Segregation	6	18	300
1.2.4	Security	4	1	25
1.2.5	Coordination & Clash Detection	7	5	71
1.2.6	Collaboration Process	5	6	120
1.2.7	Health & Safety/CDM	5	4	80
1.2.8	Systems Performance	4	6	150
1.2.9	Compliance Plan	5	7	140
1.2.10	Delivery Strategy for Asset Information	4	17	425
1.3.1	Data Drops & Project Deliverables	6	10	167
1.3.2	Client Strategic Purposes	1	18	1700
1.3.3 A	BIM Specific Compliance	3	1	33
1.3.3 B	Evidence of BIM Execution Planning	3	0	0
1.3.3 C	Confirmation of BIM Toolset	7	0	0
1.3.3 D	Details of BIM Workload & Resourcing	3	1	33
1.3.3 E	Principle Supply Chain	4	3	75

The comparative analysis revealed that each organisational EIR, generated in 2016, is presented in a range of formats and layouts when compared with the BIMSmart EIR template (2013). The content is largely present with different nuances that are organisation specific as seen in Graph 1. 1.2.1 Standards, 1.2.2 Roles & Responsibilities and 1.2.3 planning the work and data segregation are three clauses that have a high level of saturation that closely adhere to the template. 1.1.4 Level of detail and 1.2.10 Delivery Strategy for Asset Information also have a good frequency of use. Overall, organisation 01 and 05 have a high level of clarity and identified deliverables, with built-in flexibility, as it is stated *'... good ideas/alternates to be discussed'*. All clients do not supply a comprehensive EIR that ensures delivery of the digital information relevant to their organisational objectives, particularly ensuring the appropriate data for FM activities.



Graph 1 EIR Clause Comparison between organisational samples.

The layout and format of each pre-contract BEP was different to the Cpix template which is free for use and different to the EIR format and layout that the supply chain received. Organisation 06 and 07 prescribed the format of the pre-contract BEP, which directly correlates to the EIR in layout, format and organisation.

5. Discussion

Results shows that a "just in case" approach is adopted by clients, demonstrated through the range of file types requested as information exchange requirements. This conflicts with existing recommendations where an EIR should contain only sufficient detail to ensure that clients' information needs are met and the supply chain are able to deliver without extraneous work due to unclear specifics (BSI, 2013). A highly prescriptive EIR is also inadvisable and this is likely to incur higher fees from the supply chain due to the level of work required. An EIR that is specific to achieve organisational requirements and encourages the supply chain to offer innovative solutions as well would be an optimal solution, as recommended by (Rothberg & Erickson, 2017), however this consistent approach is not widely disseminated.

Giel et al. (2015) and (Ashworth et al., 2017) views were confirmed in the research. It is apparent that FM teams are overwhelmed by the complexity of the data required to manage O&M activities and tend to request information in every file format available, another example requests an 'AIM' absenting themselves from specifying what they want and leaving the content of the AIM up to the supply chain. Adding to this complexity is the reducing capacity in FM teams over the last 5 years. The results of this research contradicts the findings of Forns-Samso et al. (2011), with regard to experience of BIM in the CAPEX phase will have a beneficial impact on FM implementation. This is due to a range of other significant influencing variables such as team capacity to deliver FM while in a change management process.

6. Conclusion

The generation of a suite of information requirements is not supported as a holistic process at present. The current approach of using standards and guidance derived for application and use in design & construction and then adapting these for FM is limiting the implementation for FM due to the lack of data granularity relevant for FM working practices. The standards (Giel et al., 2015) are not sufficiently holistic to contain information sets appropriate for FM. Limitations of the research were in accessing corresponding BEP's to the EIR's, due, in part to the commercial nature of the information.

Dissolution of 'silos of data' and achieving the seamless interconnectivity of digital data are a priority. Information modelling standards, guidance, templates and workflows designed specifically for facilities management are required. Engagement with the FM community and their expertise, is likely to improve BIM FM implementation rates and help FM team's transition to a digital landscape. Finding the wide range of adaptations in the sample EIRs shows that the BIMSMart standardised template requires revision. This research shows that a certain amount of content is likely to be standard across most organisations engaging with digital information modelling. Therefore, a standardised BEP response template, based on the EIR should be issued and contracting teams, are required to complete the template (EU BIM Taskgroup, 2017).

7. Future work

Freely available standards, documentation and guidance documentation are required that incorporate FM and digitalisation of legacy estate data. A suite of documents that are adapted and relevant to FM working practices together with a system for validation and verification that assists client organisations achieve a comprehensive, holistic range of information requirements.

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Optimising Communication among Nigerian Building Professionals through BIM: A Pre-emptive Approach towards Achieving Sustainable Building Delivery

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Abstract

Building projects are usually born out of concerted efforts of different professionals engaged by the client for their delivery. These professionals include the architects, quantity surveyors, as well as the structural and services engineers who are statutorily licensed to practice as a team. Researches have shown that effective communication among team members is fundamental to the attainment of set goals such as sustainable building delivery. A Sustainable development meets the present needs without negatively impairing those of future generation. Limited, fragmented project data, disjointed and ineffective communication among building professionals, and deficiencies of existing framework for quick project delivery have been identified as some of the problems bedevilling the building industry in Nigeria. Building Information Modelling (BIM); a revolutionary development that is quickly reshaping the Architecture-Engineering-Construction (AEC) industry around the world. BIM is a technology and process which enables project key players visualise, collaborate and communicate effectively on a common platform with a view to making collective decision on a design before actual construction. To what extent have Nigerian building professionals utilised BIM as a platform for collaboration and communication towards achieving sustainable building delivery? This study adopted a survey method to seek the opinions of some of the professionals on this question. The study revealed that while some professionals utilise BIM, a number of them still stick to the traditional disjointed way of communication. The study concluded by recommending the adoption of BIM to engender optimised communication among the professionals for sustainable building delivery in Nigeria.

Keywords: Building Information Modelling, Communication, Professionals, Sustainability.

1. Introduction

Key players in different social-economic sectors and professional undertakings embark on diverse tasks and activities, in which communications and information management remain the prime pivotal element that can determine failure or success of such activities. If viewed as a fundamentally social activity, communication activities should include engaging in conversations, listening to colleagues, networking, collecting information, directing subordinates, writing letters or transferring information through electronic devices such as telephones and computers.

In the Architecture, Engineering and Construction (AEC) industry, usually a set of team of professionals from various disciplines are employed to deliver and operate a building project and information exchange is crucial factor for the project success (Saeed, 2014; Vanlande et al., 2008). All construction projects execution requires communication between professionals in all the different stages of construction. Project team members traditionally access the required data via reports, blueprints, work schedules and periodic meetings; getting the information in this way is time consuming and needs human effort. Traditional methods also fall short in accurately monitoring life cycle of building projects. Luka et al (2014: 49) corroborate with Foley (2005:19) that as a project unfolds and the design is realised, information in the form of drawings, specifications and construction methods must be communicated from one expert to another. They also contend that when communication is

poorly managed, this will lead to a workforce poorly motivated, design errors, slowdown in the entire job and failure in production. Therefore, putting in place an appropriate communication management system to ensure effective communication is essential and central to the successful design and construction of a building project.

Thus, a change and shift from the traditional communication channels among professionals particularly in heavy construction projects has become inevitable. Such a change cannot be ensured by a single unit; it is rather a transition that requires participation from the building clients, designers, builders and product manufacturers. Successful completion of building projects requires collaboration of numerous multidisciplinary and sometimes geographically separated team members (Becerik-Gerber and Rice, 2010: 185).

In the wake of the information and digital revolution, the AEC industry is contending with a paradigm shift in the use of Building Information Modelling (BIM) and Integrated Design and Delivery Solutions (IDDS) (Owen et al., 2009) aiming to increase productivity, efficiency, value, quality and sustainability, and to reduce life cycle costs (Arayici et al., 2011: 20-22). Some of the benefits of BIM technologies are the provision of an efficient communication and data exchange system (Nederveen et al, 2010: 28-40), auto quantification, improved collaboration, coordination of construction documents, improved visualisation of design (Olatunji, et al, 2010: 137-151), clash detection and cost reduction (Eastman et al; 2011). In

Consequently, it becomes imperative for the Nigerian AEC industry, which has been described as a 'sleeping giant' and having no capacity to deliver due to inefficiency and poor service delivery among other problems attributed to it (Kolo and Ibrahim, 2010:653; Mohammed, 2012:63) to exploit the widely affirmed and recognized benefits of BIM in order to achieve continuous improvement needed by its core players.

The potentials and documented benefits, not much has been done regarding BIM implementation in the Nigerian AEC industry. Having realized the importance of effective communication management system in the Nigerian construction project delivery and the need to engender state of art in sustainable project delivery technique in her built environment, this research focused on unveiling essentiality of effective communication among Nigerian building professionals. It thus showcased the untapped potentials of building information modelling as it relates to collaboration and information management throughout the life cycle of a building project.

1.1 Research rationale and objectives

Although several earlier researches were done surveying the impact of the information technology in the Nigerian AEC industries, they mostly focused on either its impact on education (Ogunsote et al., 2008), or towards integrating it to the architectural curricular (Ajufoh and Inusa, 2012). Copious researches had also been done on the level of awareness and adoption of BIM in Nigerian AEC. Nonetheless, research gap exists in practical approach to advocacy for BIM adoption as it relates to imminent way-out; BIM could offer one of the foremost challenges confronting Nigeria building industry and her.

Among the foremost challenges is ineffective communication and collaboration among building professionals. Communication barriers among project teams had been found to be contributing to the construction team failure in their duties to successfully implement project design (Cheng et al., 2010: 245-266; ElGohary and El-Diraby, 2010: 316-328). The establishment of effective communication system for group of construction professionals thus becomes imperative for the actualisation of sustainable construction.

The research aim is to evaluate the significance of communication among Nigerian building professionals in construction projects and documents the barriers to BIM adoption for effective communication and collaboration with a view to showcasing what BIM offers in this regard for better sustainable and efficient project delivery.

In the view of this, the research objectives are to:

- Discuss briefly Nigerian Building Industry;
- Enumerate the negative effects of ineffective communication on sustainable project delivery in Nigeria; and
- Identify the major factors hindering effective communication and serving as barriers to collaboration among professionals in the building industry.

2. Research Methodology

Extensive literature review was carried out on the state of Nigerian building industry, importance of communication among project stakeholders for sustainable building delivery, BIM maturity levels, and BIM approach to collaboration and communication. Ten (10) factors affecting BIM adoption for collaboration and communication were identified from the literature. This was followed by an online questionnaire survey to test the relative importance of these factors. A structure questionnaire was administered on professionals in the AEC industry: architects, quantity surveyors, engineers and builders. Four hundred (400) questionnaires were sent out through SurveyMonkey. 102 were returned with some rendered invalid because the respondents only answered question one due to poor understanding of the software. However, sixty-nine (69) was found valid for this research representing 68% of the responses. Relative Significance Index (RSI) was used for ranking the factors. The respondents were required to mark their answers on a five-point Likert scales, 1 for strongly agree, 2 for agree, 3 for uncertain, 4 for disagree and 5 for strongly disagree.

3. Literature review

3.1 Nigerian Building Industry

Luka et al (2014: 49) quoted Gorse (2002) that 'organised construction contracting in Nigeria began in the 1940s with few foreign companies coming into operation'. In Nigeria, the construction professionals regularly engaged in the industry are architects, quantity surveyors, structural engineers, and Service Engineers (Aibinu, and Jagboro, 2002: 593-599). Nigeria contractors can be categorised into two, namely national (indigenous) and multi-national firm (Kasimu, et al, 2013: 120-129). The operations of indigenous firms are limited to Nigeria while the multi-national firms operate in Nigeria and other countries.

In the past three to four decades, construction projects in Nigeria had suffered delay largely due to cash flow problems, insufficient communication, design errors, improper planning and scheduling mistrust and political instability (especially for government projects) among others. Beside projects' delay, several cases of building failures and collapses have been incessant, concomitant with loss of lives as well as properties. Professional integrity of building consultants has suffered immeasurably.

3.2 Importance of Professionals' Communication in Building Industry

Like other building industries, professionals in Nigeria collaborate as consultants at different stages of project from inception to operation. Communication is very essential in project execution. Olaniran (2015: 129) and Mehra (2009) posit that communication plays a vital role in all stages of construction such as design production, organisation and management. Statistics have shown that over 50% of projects in Nigeria are unsuccessful due to inappropriate communication method (Kasimu, and Usman, 2013: 120-129). Various professionals in the construction industry must communicate effectively for any given project to be successful. (Mehra, 2009).

Luka et al (2014: 49) emphasized that the need for construction professionals to communicate throughout all the stages of construction is inevitable. A successful project demand that professionals involved are experienced, appropriate, have the same mindset, are team players with complementary skill sets and are managed to bring out their best to meet the vision and goals of the project. Further, communication between these professionals is an integral part of the construction process in any successful project. Given that construction is such a fragmented, dynamic and disparate sector, effective communication becomes essential "for the successful delivery of performance goals (productivity, profitability and repeat working opportunities" (Dainty et.al, 2006). Scope of work and details of construction are communicated by means of drawings, contract documents, addenda and specifications (Mehra, 2009). Therefore, the need for professionals in the construction industry to effectively communicate with each other in order to accomplish their production and social functions cannot be overemphasised and the effects of communication and communication management have a pertinent impact on any project delivery (Luka et al 49: 2014).

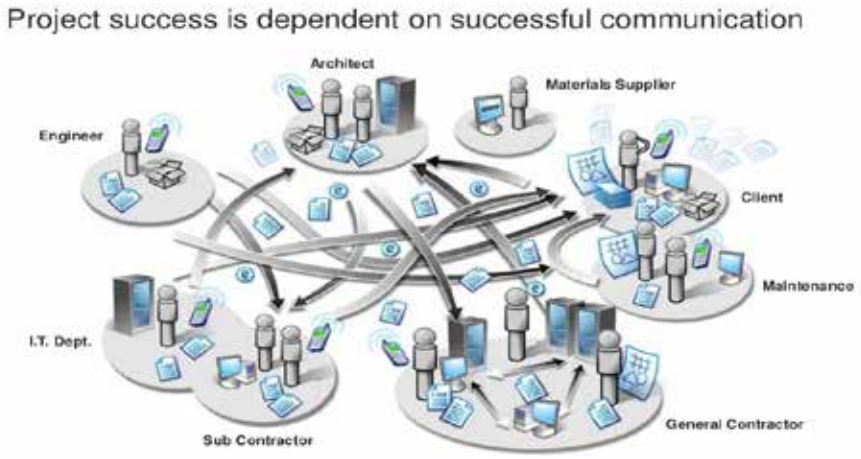

Figure 1 Project success is dependent on successful communication

Stempfle and Badke-Schaub (2002: 473-496) proposed that communication allows for the thinking and problem-solving process of the design team through two methods, synchronous and asynchronous. Synchronous communication is when individuals or groups such as design teams communicate face to face through interactive dialogue by telephone, in meetings or with video conferencing. This method is cited as being essential for problem-solving, developing trust and exploring values amongst the design team stakeholders (Emmitt and Ruikar, 2013).

To underscore the pivotal role communication plays in the construction industry Olaniran (2015: 129-130) enumerated some areas where proper information management or otherwise would affect project delivery:

- Poor and distorted information;
- Unclear channels of information;
- Inadequate regular Site meeting;
- Late dissemination of instruction;
- Non-review and adjustment of communication plans;
- Inappropriate communication media for specific purposes; and
- Non-comprehensive project annual report.

3.3 Why Effective Communication for Sustainable Building Delivery

The concept of sustainable construction (a subset of sustainable development) concerns the responsibility of the construction sector of creating the built environment in a sustainable manner (Pearce et al, 2012). This should be in a way that is environmentally friendly, socially responsible and economically supportive. As communication cuts across all phases of project life cycle, the principles of sustainable construction should be well-applied throughout the entire life cycle of the construction from planning to deconstruction. In the light of this, since project consultants, contractors and clients are drivers of construction sustainability, it thus imply that engendering effective communication among them would be effort exerted in the right direction.

3.4 The BIM Paradigm

There are different definitions of BIM, and debate as to whether BIM is 'Building Information Management' or 'Building Information Modelling. According to National Building Report (2016), BIM is a process for creating and managing information on a construction project across its life cycle. One of the key outputs of this process is the building information model, the digital description of every aspect of the built asset. This model draws on information assembled collaboratively and updated at key stages of a project. Creating a digital building

information model enables those who interacted with the building to optimise their actions, resulting in a greater whole life value for the asset.

BIM is not just a tool or a solution (BIFM, 2012), but rather value-creating collaboration, underpinned by 3D models (figure 2) and intelligent structured data (BIM Industry Working Group, 2011). BIM is regarded as a critical factor in fulfilling integrated project delivery. This inevitably leads to the restructuring of project organisations and communication processes. Current project management also needs to be changed to facilitate BIM implementation.

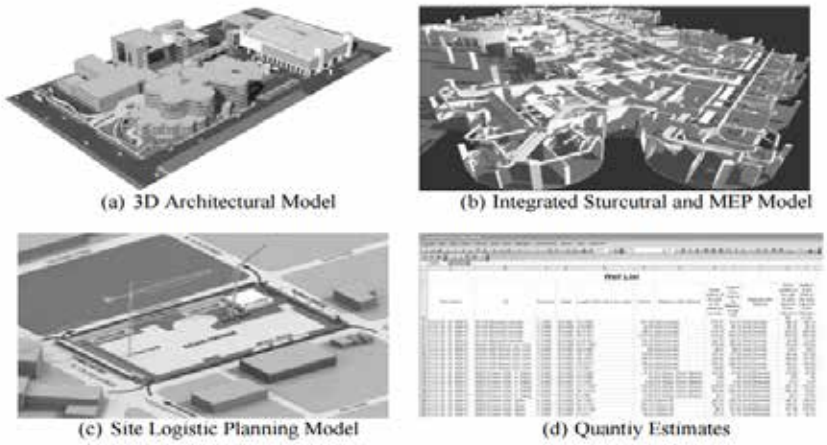

Figure 2 Samples of Building Information Models.

3.5 BIM Approach to Building Professionals' Collaboration and Communication

Project design team collaboration is achieved through a coalition of multi-disciplined, multi-skilled individuals with different values, attitudes and goals to deliver a project (Emmitt and Ruikar, 2013). Teams of individuals or organisations working together can address problems and deliver outcomes not effectively achieved by working alone or in silos. Since Building Information Modelling (BIM) is a shared source of information about a building (Ward, 2013: 101-109) it encourages the design team to collaborate. BIM enhances collaboration and information sharing unlike traditional construction processes. It is linked to higher level of efficiency in terms of communication and collaboration (Bryde et al. 2013).

Gerber et al. (2012: 22) highlighted BIM collaboration benefits as follows:

- **Enabling concurrent collaboration**—compared to sequential workflows of information generation and analysis;
- **Integrating separate tasks**— a shared 3D model can incorporate estimating, scheduling and spatial coordination tasks more effectively;
- **Improving separate tasks**—the direct use of a 3D model facilitates tasks such as estimating, scheduling, and spatial coordination."

The current literature presents BIM (Building Information Modelling) related technologies and processes as the ideal solution for poor information management processes within the construction project network. There appears to be a tendency to depict BIM based models and related technologies as eliminating this information conundrum easily by:

- Centralising and managing neatly the huge and complex information flow;
- Eliminating repetition, and
- Avoiding redundancies without loss or alteration of project information by the collaborating members when using and sharing a BIM platform.

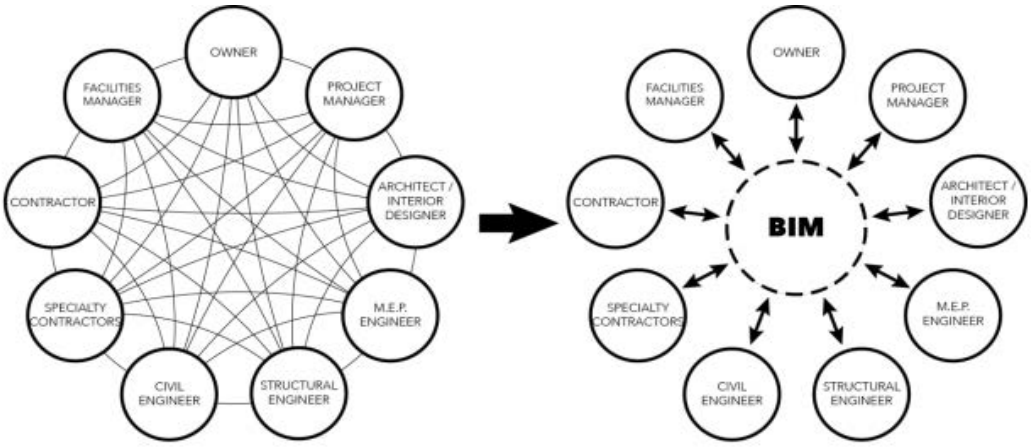

Figure 3 Illustration of BIM Project Team Collaboration.

BIM is an efficient visualisation tool which provides a three dimensional virtual representation of a building. This ability in BIM greatly improves communication and collaboration amongst the project members whereas traditionally the primary causes of the construction's poor performance was due to ineffective communication practices (Dainty et al., 2006; Emmerson, 1962). The efficiency of business process depends on the quality of communication and improvement in the communication can reduce failure (Thomas et al., 1998). Moreover, effective communication by use of BIM in early stages positively influences the quality of project delivery (Brow, 2001; Barret and Baldry, 2009). Visualization promotes planning and sequencing the construction components.

The essence of BIM implementation is collaborative working process in construction work. Therefore project participants could generate the maximum benefit of collaborative arrangements increasing efficiency and effectiveness (Succar 2009: 65-103). The process allows project team members to work effectively, particularly when identifying potential problems before they start to build on site. Effective communication allows stakeholders to exchange accurate, update and clarified information for decision makers to form a reliable decision. American Institute of Architects (AIA 2007) also identifies that "BIM is a shared digital representation founded on open standards for interoperability". A successful BIM project highly relies on effective collaboration among project participants including owners. BIM becomes one way to cope with the cooperation, integration and coordination of challenges faced in construction.

3.6 Barriers to BIM Adoption

A number of factors have been identified as barriers to the full adoption and implementation of BIM despite the promised benefits. The NBS national BIM Report (2014) identified five top reasons given by organisations (essentially small sizes firms) that are yet to adopt BIM into practice as: '*No client demand, BIM is not always relevant to projects they worked on, high cost of taking off, projects they are working on are perceived as to small to warrant BIM adoption, and lack of in-house expertise'* (Lymath, 2014).

Liu et al. (2015) also identified five categories of barriers to BIM adoption in the construction industry after a thorough review of the literature. These include: lack of a national standard, high cost of application, lack of skilled personnel, organisational issues, and legal issues.

The findings of a research conducted by Zahrizan et al (2013) within Malaysian construction industry ranked factors that constitute barriers to BIM implementation. In order of rank, the result revealed the barriers to include:

1. Lack of knowledge about BIM,
2. Clients do not request/enforce BIM,
3. Reluctance from client, contractors or consultant to implement BIM,
4. BIM is not required by other team members,
5. Lack of data of return on investment of BIM.

3.7 BIM Maturity Levels

A concept of 'BIM levels' is used to define criteria required to be deemed BIM-compliant, by seeing the adoption process as the next steps in a journey that has taken the industry from the drawing board to the computer and, ultimately, into the digital age. UK government has recognised that the process to 'full' collaborative working will be progressive, defined in form of 'levels'. Levels are: Level 0 BIM to 4D BIM and beyond.

Level 0 BIM – Effectively no collaboration. 2D CAD drafting only is used for Production Information. Output and distribution is via paper or electronic prints, or both.

Level 1 BIM – Comprises of a mixture of 3D CAD for concept work, and 2D for drafting of statutory approval documentation and Production Information. No collaboration between different disciplines – each publishes and maintain its own data.

Level 2 BIM – Distinguished by collaborative working – all parties use their own 3D CAD models, but not necessarily working on a single, shared model. Design information is shared though a common file format where organisation are able to combine data with their own in order to make a federated BIM model, and carry out interrogative checks on it. This is minimum target set by UK government for all work on public-sector by 2016.

Level 3 BIM – This represents full collaboration between all disciplines by means of using a single, shared project model which is held in a centralised repository. All parties can access and modify that same model. It removes the final layer of risk for conflicting information. This is known as 'Open BIM'.

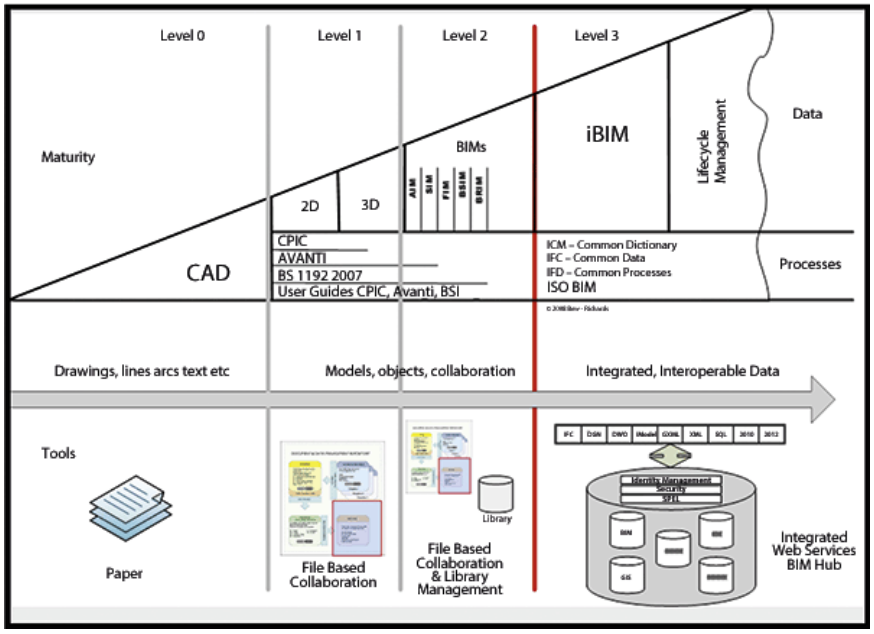

Figure 4 Illustration of BIM Project Team.

4. Results and findings

4.1 Respondents Characteristics

Table 1 shows respondents characteristics in terms of profession, qualification and years of experience. 35 of the respondents are architects, 20 engineers, 8 quantity surveyors and 6 builders. The architects have the highest number of respondents followed by the engineers implying that architects and engineers are more used to the BIM software. In terms of qualifications, 4 of the respondents are HND holders, 20 have degree, 28 have masters, 11 have PhD and 6 have others. 57 (82%) of the respondents possess maximum of 10 years of

experience BIM tools experience which indicates that majority of these professionals using BIM are fresh graduates.

Table 1 Respondents' Characteristics.

Field of specialization	**Frequency**	**Percentage**
Architecture	35	51
Quantity Surveying	8	12
Engineering	20	29
Building	6	8
Total	69	100
Level of Education		
Qualification	**Frequency**	**Percentage**
HND	4	6
Degree	20	29
Masters	28	41
PhD	11	16
Others	6	8
Total	69	100
Years of Experience		
Number of Years	**Frequency**	**Percentage**
0-5	32	46
6-10	25	36
11-15	8	12
16-20	4	6
Over 20 years	0	0
Total	69	100

4.2 BIM Software Adoption and Proficiency

As shown ion table 2, Autodesk, Revit architecture and ArchiCAD are the most commonly used software among the respondents. These are design software indicating that BIM tools are essentially used for 2D or 3D. In terms of level of BIM competence, 48 of the respondents (70%) are either using the BIM software foe 2D drawing and 3D modelling. These levels are, at best, equivalent of UK level 2 BIM maturity level.

Table 2 Level of BIM adoption.

BIM software used by Respondents		
Software	**Frequency**	**Percentage**
Revit architecture	16	23
ArchiCAD	13	19
Revit structure	4	6
Bentley architecture	3	4
Vector works	3	4
Autodesk	20	29
Cost X	4	6
Revit MEP	2	3
Navisworks	4	6
Total	69	100
Level of BIM Competence		
Rating	**Frequency**	**Percentage**
Level 0 (Paper drawing presentation)	12	17
Level 1 (2D CAD drawings without collaboration)	24	35
Level 2 (3D CAD Model with intra-discipline collaboration)	24	35
Level 3 (Model with all stakeholders' integration)	9	13
Total	69	100

4.3 Factors Hindering Effective Communication among Nigerian Professionals

The factors hindering effective communication among Nigerian professionals in the AEC industry are presented in table 3. It shows that the majority of respondents agreed that lack of delegated authority to field personnel ranked first (RSI = 0.635), followed by lack of project pre-planning (RSI = 0.564, Rank = 2), and then uncertainty or lack of clarity concerning project process integration (RSI = 0.565, Rank = 3). Centralised decision-making Rank the least among the factors (RSI = 0.539).

Table 3 Factors hindering effective communication among project team.

	SA	A	N	D	SD	R.S.I	Rank
Lack of project pre-planning	25	8	1	0	35	0.565	2
Uncertainty or lack of clarity concerning project process integration	15	10	12	3	29	0.539	3
Centralised decision-making	12	13	13	13	18	0.441	4
Lack of delegated authority to field personnel	17	14	14	12	12	0.635	1

4.4 Barriers to Adoption BIM for Effective Collaboration among Project Team

The Barriers to adoption BIM for effective collaboration among project team in the AEC industry in Nigeria are presented in table 4. It shows that, majority of the respondents agreed that 'Resistance to change existing work practice and ignorance of BIM benefits' ranked first (RSI = 0.852), followed by 'Problem of integration and interoperability between the architects and engineers (RSI = 0.661), and the 'Cost of BIM software and resources' (RSI = 0.661).

Table 4 Barriers to adoption BIM for effective collaboration among project team.

	SA	A	N	D	SD	R.S.I	Rank
Lack of basic training required for high-end hardware resources and networking facilities to run BIM applications and tools efficiently	27	12	2	3	25	0.646	4
Lack of tools for early design phases and conceptualization	14	16	11	10	18	0.594	5
Resistance to change existing work practice and ignorance	18	51	0	0	0	0.852	1
Problem of integration and interoperability between architects and engineers	12	10	39	3	5	0.661	2
Technical defects (i.e. compatibility of BIM software with other software presents)	13	13	16	7	20	0.577	6
Lack of clarity on roles and responsibilities of project team members	13	14	8	5	29	0.5333	7
Cost of BIM software and resources	24	14	0	14	18	0.661	3

5. Conclusion and Recommendations

Utilization of BIM has been shown to be invaluable to construction projects. Gains are accomplished through operative collaboration of team members during design and construction through the usage of BIM. Assessing the extent to which Nigerian building professionals have utilized BIM as a platform for collaboration and communication towards achieving sustainable building delivery, this study concludes that despite its numerous merits, BIM has not attained a sufficient level of adoption amongst Nigerian building professionals.

The study identified the major barriers to adopting BIM for effective collaboration among project team in the AEC industry in Nigeria to be resistance to changing existing work practice and ignorance. Other associated challenges include problem of integration and

interoperability between architects and engineers, cost of BIM software and resources, lack of basic training required for high-end hardware resources and networking facilities to run BIM applications and tools efficiently. This study also observed that the larger percentages of professionals using BIM in the AEC industry are fresh graduates, with proficiency in design software like Autodesk suites, Revit Architecture and ArchiCAD.

This paper recommends that the major barriers to BIM adoption should be mitigate and factors hindering effective communication removed in order for BIM to engender optimized communication among the professionals for sustainable building delivery in Nigeria.

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Building Information Model for Construction Management and Planning

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Abstract

Construction planning plays a vast part within the construction industry, however achieving the right construction plan can be a problem. The construction industry is highly reliant on the planning process of the whole job as the right planning strategy can save costs and increase productivity. For many people being able to visualize what is to be carried out helps in understanding the steps of the process and the timescale, this is where 4D BIM comes in. The Building Information model can be used to gain a number of benefits within the construction industry from clash detection to visualization. 4D simulations can be very useful for planners as it provides a number of benefits for the planners. Having a 4D model can also help with the communication between the planners and the onsite team as the onsite team can fully benefit from the program as they can visualize the work plan and understand the timescales.

Keywords: Building Information Model; 4D; Planning; Construction Management

1. Introduction

In the construction industry performance is key as it determines deadlines being met and allows construction firms to win work for the future. Achieving a good performance record depends on a variety of measures however planning works is an important factor in attaining top performance. The construction industry in the UK is looking to improve the market activity over the next few years and achieving top performance would prove valuable for the industry (Davis, 2015). Improving planning procedures within the industry would boost the industry's performance and by using BIM it would be possible.

The Building Information Model is mostly thought of as a 3D model, however it is much more than that. BIM is a process which aims to improve productivity and reduce costs and can be utilized at any stage of the constructions process from planning to asset management. Most planners would ask how BIM is going to assist with the planning procedure as it is just a 3D model, this is where 4D planning comes in. the BIM process does not just produce a 3D model but it is capable of much more.

In this paper an investigation on what difficulties the planning teams mainly face was carried out and solutions with the utilization of BIM were explored. A few studies have shown positive reviews with the utilization of 4D planning, in addition with a 3D model being produced even before works start with the process of BIM, planning can be a lot easier and cost effective increasing productivity.

2. Overview of the Planning Process

Construction planning is quite a challenging process which involves the selection of technology, the explanation of the work tasks, which resources are required and the timescales for the individual tasks (Hendrickson, 2008). Achieving a good construction plan is a critical aspect within the management of construction as it develops the foundation of the working budget and schedule for works.

A famous military adage from the British army once said (Nalumansi, 2015):
"Proper Planning and Preparation Prevents Poor Performance"

There are a number of different disciplines involved within construction and each has to be involved into the planning process and having proper planning ensures the construction process to be a lot more efficient and also enables the organisation to achieve good performance where as poor planning can result in the delay of the project completion.

The planning stage of construction is not an easy process, activities to be undertaken need to be analysed and choosing the wrong way to perform an activity could potentially affect the project budget and time scales and cost and schedule controls are to be in effect. Most projects require the consideration of the cost and scheduling of the project over time the planning and monitoring of the works records must reflect on all both aspects.

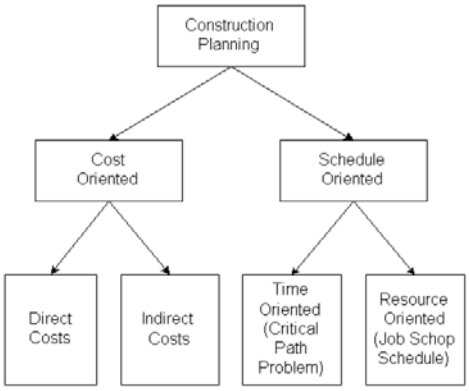

Figure 1 Emphasis of Construction Planning (Hendrickson, 2008).

3. Introduction to BIM

The Building Information Model is a 3D model, some would say it is a process. With BIM becoming more popular over the past 10 years, it has been made mandatory in the UK that all projects are to use atleast BIM level 2 as part of their constructionprocess.

BIM being a 3D model, it is an ideal standard for examining the relations between a number of features of the project and also evaluating their compatibility with the local topography. The 3D model can prove efficient and cost effective by exploring different situations which can be taken down into the detailing of each element so therefore being efficient throughout the design process.

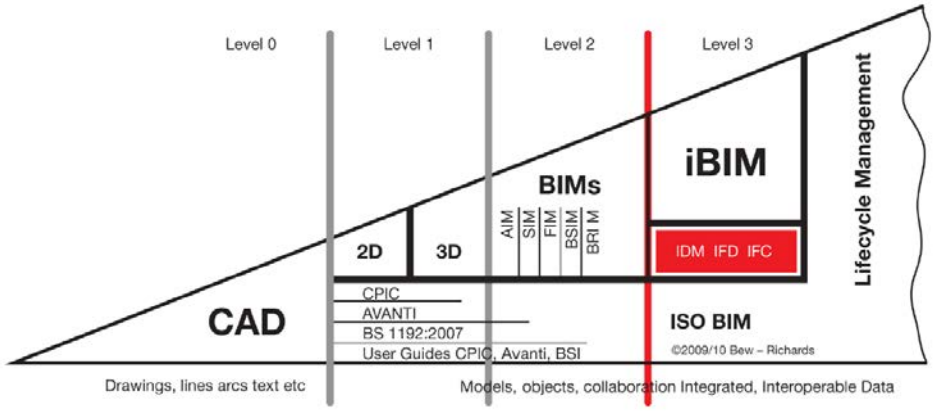

Figure 2 BIM Levels, (Simmonds, 2015).

Level 0 BIM
Level 0 BIM consists of converting regullar paper drawings to 2D CAD drawings and the output is simply dispersed along the organisation by ellectronically or by paper (NBS, 2014).

Level 1 BIM
Level 1 is a combination of 3D CAD models for concept work and 2D for drafting documents and information about the product. Models are managed with BS 1192:2007 and the data share electronically is achieved by the common data environment (CDE) which is to be managed by the contractor (NBS, 2014). This level is the most common level at present although it does not contain the collaborative aspects.

Level 2 BIM
Level 2 BIM is the level which is was made mandatory by the UK government in 2016. It is operated by collaborative practices, all parties work on their own 3D model which is not necessarily a shared model however the design information shared through the same file format allowing the organisations to be able to input data and all check on it. Each party using the CAD software should be able to access the file formats through IFC (Industry Foundation Class) or COBie (Construction Operations Building Information Exchange (NBS, 2014).

Level 3 BIM
Level 3 BIM uses a single shared model and it is a fully collaborative process. All of the parties involved and use the same model accessing and changing it if required, this allows the risks to be reduced by reducing the conflict of information. This level is the governments' requirement by 2019 (NBS, 2014).

3.1 Dimensions of BIM

There are three different dimentions of BIM illustrated in Figure 3

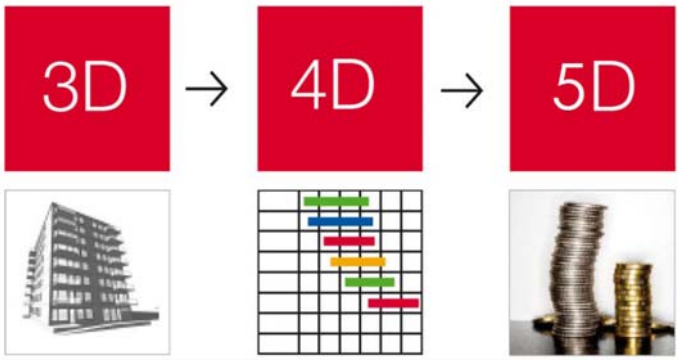

Figure 3 Dimensions of BIM (Dang, 2012).

3.1.1 3D BIM

With 3D BIM, all the components contain spatial relationships,, the have all the geometry and geographical information for exampli height of the building components. With the use of a 3D model, errors can be identified and eliminated before the works commence (Dang, 2012).

3.1.2 4D BIM

4D BIM involves the construction plan being linked to the 3D model which allows the both the construction team and planners to visualise how the site would look at any specific time and also allows visual communication (Dang, 2012).
This allows for alternatives for work processes to be tested out highlighting the best way to carry out an activity.

3.1.3 5D BIM

5D BIM involves cos along with time and the 3D model. This allows the tracking of the projects costs throughout the phases of works. 5D BIM is mostly helpful during the eary stages of the construction, the cost data outputed from the 5D model can also be used to measure the finantial performance of the project throught all stages of construction (Dang, 2012).

4. 4D Simulation and its benefits to the planning process

4D modelling can be used as a visualization tool which also enables better communication between the different disciplines within an organization, it gives all parties a better understanding of the planning process and project milestones. It can also assist in finding potential problems before the commencement of construction activities which can be resolved saving future extra costs (Autodesk University, 2014). 4D models can be used a number of ways to assist with the planning process.

4.1 Site Utilization Planning

In the construction industry, temporary works and structures are a vast part of the whole construction process, using the normal planning outputs such as Gantt charts usually do not account for the temporary works to be undertaken and structures to be worked on (Sardari, 2016).

With the utilization of 3D models, linking the planning program to the construction activity appropriate would enable the sequencing to be visualized, this would allow sequencing requirements to be determined. In addition to visualization, additional information required can be linked into the project model such as the description of equipment locations and material staging areas which can assist the site management team in making decisions for all phases of the construction activity.

4.2 Coordination and clash detection

With the use of a 4D model, time-based clashes can be detected which would allow planners to gain insight on potential clashes for activities while the coordinate the trades materials and equipment needed for the works activity. With the use of clash detection, temporary items within the works which have been linked to the construction planning models can be combined with the overall project model to check for potential clashes that are time based.

4.3 Materials Planning and Management

With the model being linked to the program, materials, building elements within the model can be monitored. This will allow planners to be able to understand how much material would be needed for a specific task and what elements are needed on site for the installation.

There are numerous advantages of 4D simulation when it comes to planning, from figuring out potential issues prior to the commencement of works which is a which essential as it would save time and cost of having to do reworks to fix the issues. Scheduling methods which are traditionally used do not outline the construction activities as they are usually words on a Gantt chart, with the use of a 4D model, the onsite team can visualize how the works is to be carried out giving them a better understanding and also allowing them to markup potential issues or concerns (University, 2014).

5. Issues with 4D planning and schedueling

4D simulation has its benefits with the planning process however there are some disadvantages that come with using 4D simulation for planning purposes (Eastman, 2011), below are a few:

5.1 Level of Detail

By allocating time to a model, the level of detail is directly affected, for example if a wall with rebar was to be built, architects apply many components to it in order to support the rendering for different materials, however in the contractors case, the wall would just be looked as a single component, hence in the 4D model, the wall would appear missing out the minor components. In this case planners would have to apply multiple activities to one component (Eastman, 2011).

5.2 Reorganization

When creating a 4D model, the scheduler modeling the model can create custom groupings and move them around in order to suit the planning process. This is the most vital feature for the planners as components to activities are usually not organized appropriately by architects and designers.

For instance a designer ma group all columns for more than one structure for the sole purpose of making it easier to make changes or duplicating, however these components will be split into zones to align with the sequence of work from the planners and with the items being grouped, the model sequence would have trouble recognizing the different columns for different bridges (Eastman, 2011).

5.3 Schedule Properties

4D models usually use exagerated start and finish dates making them both earlier than anticipated, however with construction, nothing is certain as projects can be delayed for a number of reasons which is why other dates may be need to be explored such as later start and finish dates to review the effect of the times scales being changed (Eastman, 2011).

6. Research Methodology

During this research information was collected through case studies and interviews. The planning process knowledge was expanded on by reading through journals and also speaking to planners on constructions site before going ahead with the interviews to get an insight on the planning activities.

Once the background research was done, case studies and qualitative interviews were undertaken with a few planners. There are three types of qualitative interview:

6.1 Structured interviews

These are mainly verbally administrated questionnaires which a list of question would be provided with a little or no variation of the responses. These are fairly quick and easy to execute and may be able to clear up questions that are both literacy and numeracy problems. However these provide limited responses therefore a minimum use of depth can be obtained (Gill, 2008).

6.2 Semi-structured interviews

These generally consist of a variation of key questions that would assist in defining the areas of the topic that is of interest, it also at the same time allows the interviewer to pursue the answer in more detail which would be useful. The answers obtained from the responder are not limited hence more detail can be explored (Gill, 2008).

6.3 Unstructured

Unstructured interview do not reflect any ideas put into the research. These are generally very time consuming and are difficult to manage and participate. Lack of questions provided can prove difficult to explore the topic and subjects to talk about (Gill, 2008).

For this research, semi-structured interviews were undertaken to gain as much knowledge and insight from the respondents. Questions about certain issues within the planning process and how 4D simulation can assist to better those issues were asked. The main questions for this research are as follows:

- What difficulties to planners face on a day to day basis (with onsite team and scheduling?)
- Is it easy communicating the work plan to onsite staff?
- How often does the program change and is it easy to change the schedules?
- Have they used 4D simulation during the planning process before?
- Do they think 4D simulation is beneficial to the planning process?

The interviews undertaken within this research were conducted face to face with the respondents. The interviews were recorded by writing for reference.

7. Findings

Case studies and interviews were undertaken to explore the difficulties being faced with planners during the planning process and how 4D simulation can assist with that, the findings are as follows:

Firstly interviews were conducted with a few planners to gather information about the issues planners face and how 4D BIM can assist with them. The first issue highlighted was gaining access to site as planners are not able to see works areas and gather insight on how the work plan would be carried out and if it is achievable. With a 4D model, planners can visualize the site without having to go on site and also try out different ways in which an activity can be carried out choosing the best method for it. This saves time and also increases productivity as with different scenarios being tested a fast and cheap approach can be chosen.

Below is an example of a 4D model showing the process of installing a typical verge detail which on of the interviewee's have used within their project. This was to show the onsite team how to construct the typical verge detail with a planning sequence attached to it showing at what stage they should be daily.

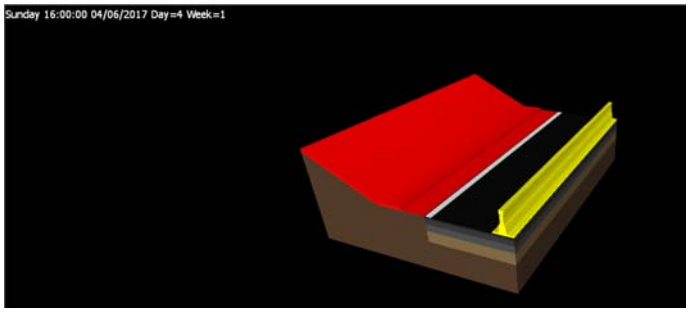

Figure 4 Typical Verge Detail at Day 4.

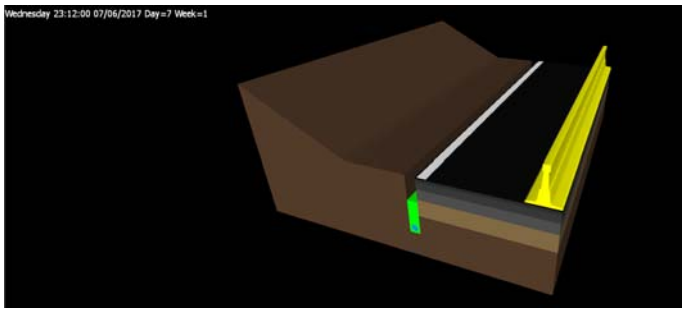

Figure 5 Typical Verge Detail at Day 7.

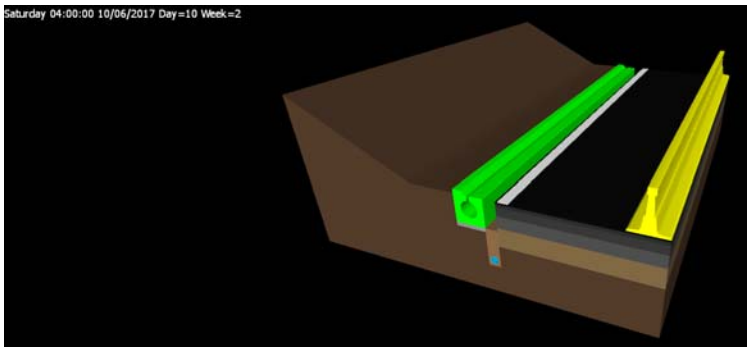

Figure 6 Typical Verge Detail at day 10.

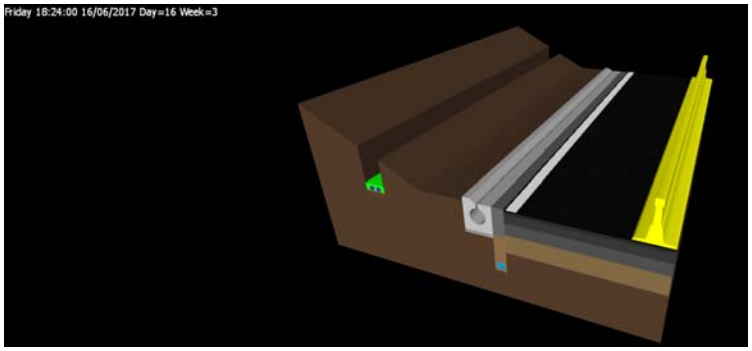

Figure 7 Typical Verge Detail at day 16.

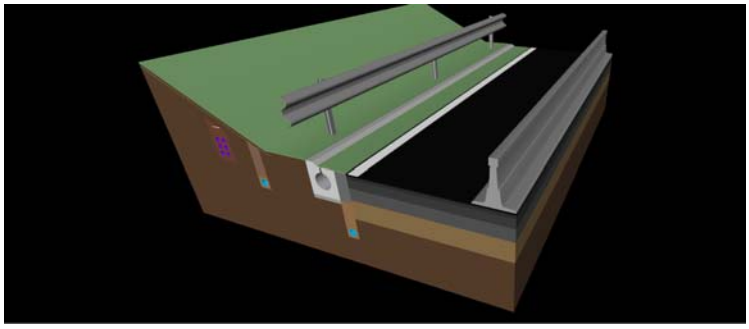

Figure 8 Typical Verge Detail (Finished).

Communication is a massive part of the construction industry, and communicating the work plan with Gantt charts can be difficult, one of the interviewees who has used a 4D model at one of their previous projects said showing the onsite team how the excavations were to be carried out and the installation of the bridge afterwards, they found this very useful as it enhanced communication between them and the onsite team having a visual representation of the work plan. Another interviewee also had the same views as they have said that various mechanisms were tested to see what was the best way to communicate the work plan to the onsite team and they found that visual aids were the best tool along with the schematics to show the geography of the site showing if there is enough work space to execute the work plan.

Obtaining information from the production team was also one of the issues highlighted, if a 4D model is used, with it being fully collaborative, the production team are able to update the model at any time which the planner can benefit from as all information required by them would be on the model and they can access it at any time obtaining the updated information required.

Uncertainty is one the planners struggle with, as once the work plan is agreed on, it does not always go to plan. These constant changes are very difficult to track which makes it difficult for planners to change the work plan.

Sequencing is a difficult process within the planning stage, the planner's interview found that using a 4D model made considering the sequence a lot easier. Looking at the constraints and also considering alternative routes and more efficient ways of constructing the elements of work with the support of a 4D model, to enable visualization, rather that approaching every activity with the mentality that the activity can be completed with previous methods worked very well as it saved time of re-doing works which would cost more money and extend the time period that the activity was to be completed.

Not a lot of planners have used 4D planning that I have interviews however the use of 4D simulations sounds like a good idea to them. Planners find that visual communication would be effective and would enable the site staff to be able to engage with them and understand the processes a lot faster. Using 4D sequencing would allow planners to have it easier as it would allow them to be able to consider alternative methods which could prove more efficient rather than approaching every activity like if would be possible to build it that way they have done previously.

8. Conclusion

Planners have a difficult time planning out activities as they have an important role which enables people to carry out activities on site. Finding an efficient work plan which can be finished according to schedule can be very difficult and the work plan can determine whether the project has a late finish or early finish.

Planners face a lot of difficulty through trying to explain the work schedule to the onsite team and creating a good work plan that is where 4D planning comes in. With a 4D model, a visual aid representing the schedules can be utilized to find alternative solutions and choosing the more efficient route of executing the activity. Using a 4D model during the planning stage can assist the planning process in a number of ways, such as clash detection, for example if there is minimal workspace on a site the 4D model can show how much space is available and if the work plan would be possible with the restriction on site.

The 4D model can also assist with material takeoffs as the materials can be monitored through the model allowing planners to be able to monitor how much material is being used on site.

4D planning does have its disadvantages such as level of detail as some components will be missed out on the model, however based on my research after speaking to a number of planners 4D modelling is a promising idea for them as with most of the difficulties they face, using a 4D model would help them in a number of ways from visualization to scheduling, so 4D modelling is a promising tool to be used during the planning process.

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A Systematic Review for the Challenges Related to the Implementation of Building Information Modelling, Big Data Analytics and Internet of Things (BBI) in the Construction Sector

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Abstract

Under scrutiny for the past several years, the adoption of Building Information Modelling (BIM), Big Data Analytics (BDA) and Internet of Things (IoT) (together also known as BBI) is yet to grow significantly in the construction industry. The industry itself is realising the complexity and challenges which admittedly inhibit BBI implementation. The identification of these challenges is an imperative precondition for successful implementation of BBI. Even though there is a paucity of empirical data in this area, a notable body of research has reported such challenges which are the target consideration of this paper. However, no study has comprehensively reviewed, and synthesized existing research on the basis of treating BBI implementation as an integrated process and viewing these challenges as the cause for laggard manifestations, which underpins the originality and value of this study. To bridge this gap in literature, this paper primarily undertakes a critical systematic review of research around challenges related to BBI implementation. It emphasises a variety of important challenges inter-alia, skills and training needs, level of interoperability, infrastructure associated costs, data security, privacy, data ownership and supply chain concerns. This synthesis shows that BBI implementation is complex and challenging, and suggests that the industry as a whole need to take immediate actions. The need for more concerted research efforts to bridge the gaps are also identified. Finally, the paper proffers recommendations for managers and workers, which have social, technological, and economic capability and capacity dimensions.

Keywords: big data analytics, building information modelling, challenges, internet of things, systematic review.

1. Introduction

As remarked in seminal construction industry reports, inefficiencies in processes, less collaboration and innovation deficiency have caused entrenching and persistent UK construction industry problems of fragmentation, less productivity and poor delivery. Moreover, the industry has long been subjected to criticism for not being able to meet target costs. There are delays, time and cost overruns, deep-rooted adversarial culture, poor risk management, fragmentation, improper standards for safety and quality, lack of consideration given to life cycle sustainability, high energy consumptions and high waste generation (Bryde *et al.*, 2013; Liu *et al.*, 2015; Davies and Harty, 2012). The mainstream literature has identified 'technology' as one possible solution for overcoming these challenges and uplifting the contemporary status of the industry. To that end, Building Information Modelling (BIM) is advocated as being a technological driver in addressing 'the lack of innovative adoptions' (Navendren et al. 2014).

BIM is defined as a collaborative platform (consisting of set of technologies, processes and policies) that integrates all the stakeholders in designing, constructing and operating a facility (Qadir et al. 2016). Internet of Things (IoT) makes devices (smart phones, remote controllers, sensors, actuators) capable of interconnecting and communicating with each other over the Internet. The increase in population and billions of devices used in businesses that communicate with each other, results in enormous amount of Big Data. Big Data Analytics (BDA) is required to manage these big data to form a sort of understandable information, knowledge and valuable insights (Bilal et al. 2016). Data generated from BIM can be analysed

and managed by BDA and can be used for insightful decisions through IoT. This is the concept of BBI.

2. BBI Implementation: An Old but New Concept

BIM, BDA and IoT have long been buzzwords associated with innovation, often representing an improved quality of life with digitalisation. Nevertheless, the concept of BBI: considering all three domains as an integrated process is still at a pristine state. This emerging concept targets transforming the way products and services are delivered with the best value by achieving sustainable competitive advantage goals. Figure 1 summarises the practical application of BBI as an integrated process.

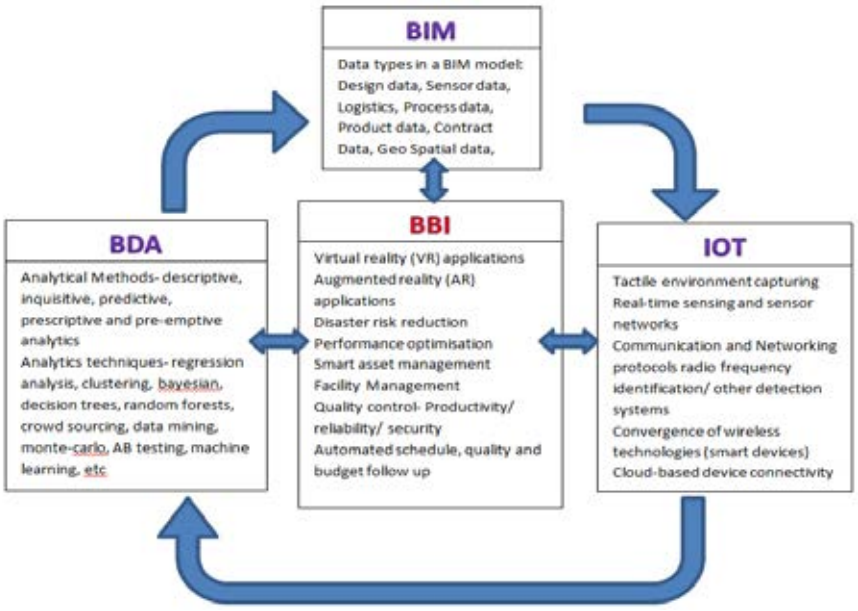

Figure 1 Application of BIM, BDA and IoT in construction.

BBI implementation involves a set of activities undertaken by an organisation to prepare for, deploy or improve its deliverables (products) and affected work flows (processes). BBI implementation process can be described, with reference to the BIM implementation model suggested by Succar and Kassem (2015), as a three-phased approach segregating an organisation's readiness to adopt; capability to perform; and its performance maturity. The point of adoption is where organisational readiness transforms into organisational capability and maturity. In order to make a successful BBI implementation, a clear understanding of what prevents readiness, capability and maturity is imperative. Hence, this paper is specifically focused on the contemporary challenges of BBI implementation.

3. Research Methodology and Methods

In order to identify the challenges related to BBI implementation, the paper predominantly follows Tranfield *et al.'s* (2003) systematic review approach; for a systematic review has the potential to inform both practice and scholarship of the gaps existing in the literature. For practitioners, a systematic review can assist in their decision making process for managerial challenges as the review itself provides some reliable knowledge bases through a range of findings. For scholars, a systematic review sheds a light in perceiving the robustness and rigour in research methodology for the given area as well as an idea generator for future research. The systematic review manifests its richness in twofold; firstly, interrogating the strength of the research evidence found in past (peer-reviewed) studies and secondly, consequently identify fresh, interesting research questions that peer scholars can take forward as separate research.

This method offered the advantage of being extremely specific on the scope: 'challenges' and the logical steps required to be followed in order to select the articles.

In terms of theory, the study has demonstrated that the idea behind the concept of BBI is not entirely new, analysing BBI separately (with each domain) in the context of construction sector provided in the literature. However, these remain little or no studies that have considered the three concepts together. The study has explained the academic interest in BBI in relation to organisational strategic development. To this end, the paper itself proffers significant managerial implications related to BBI implementation to help managers understand and grasp these implications as well as suggestions provided for future research to help upcoming scholars.

A systematic literature review has to be systematic (organized according to a process designed to address the review questions), transparent (explicitly stated), reproducible, updatable, and synthesized (summarizes the evidence relating to the review question) (Briner & Denyer 2012). The steps employed for the systematic review is one suggested by Tranfield et al. (2003) and Briner and Denyer (2012). This included (1) Identify the review question, (2) Locate the study, (3) Study selection and evaluation, and (4) Analyse and synthesise the findings from the studies and (5) Disseminate the review findings.

3.1 Step 1 - Question Formulation

The paper firstly provides an overview of the contributions to 'challenges in BBI' by analysing all the documents retrieved from the systematic review in order to answer the following review question: 'how BBI is positioned in the existing literature, in terms of challenges for implementation?'

3.2 Step 2 - Locate the study

The review has taken in to account all available published and unpublished (journal articles, conference articles, conference proceedings, monographs, report chapters, report reviews, editorial material, theses and working papers) studies as evidences based on best quality contributions using 'search strings' (Denyer & Tranfield 2009)**.** The key words used were 'BIM', 'Big Data Analytics', 'Internet of Things', 'Challenges' and 'implementation' with search strings (AND/OR) in major AEC research databases in all fields (subject, title, abstract, keywords, full text, etc.), from 2006-2016. The search also expanded in to grey literature in google scholar and basic google searches because of the paucity of empirical data available to date. The study excluded data received for year 2017 as at, the date that the review is consulted; half of the year does not represent the year as a whole. Insignificant number of articles was found covering all three domains, while some have addressed more than one domain and some were specifically focused on a single domain**.**

3.3 Step 3 - Study selection and evaluation

The output of the comprehensive search offered a list of studies (Table 1) which helped to address the above review question and the list of documents were stored in a citation management software package, 'Mendeley'. Table 1 gives an overview of the raw data extracted from each database including duplicates, as documents could be retrieved from more than one databases.

Table 1 Initially selected articles that address the review question.

Consultation date: 27/06/2017; Data set (2006-2016) Key theme: Challenges for Implementation								Total
AEC Database	Singleton			Twinned			Triplet	
	BIM only	BDA only	IoT only	BIM+BDA	BIM+IOT	BDA+IOT	BIM+BDA+IOT	
Emerald	95	67	31	4	6	5	0	208
Web of Science	68	14	9	3	2	4	0	100
Elsevier	38	24	6	1	2	4	0	75
Scopus	93	58	21	6	7	5	0	190
ITCON	14	6	10	4	4	4	0	42
Google scholar	86	26	12	7	7	8	2	148
Other unpublished	27	15	16	13	15	14	6	106
Total								**869**

The initial selection was then further sorted with two successive steps: elimination of duplicates/ irrelevant documents and verification. The filtered list was then subjected to classification into four distinct categories (A-primary subject, B-secondary subject, C-anecdotal, D-others. The final sample was composed of 121 pieces to review (Table 2).

Table 2 Document categorisation.

Category	Attributes - (*BIM* 'OR' *BDA* 'OR' *IOT):*	Number of documents
A- Primary subject	Are the main topic	12
B- Secondary subject	Are not the main topic, but the concept is detailed discussed with a strong link to the main topic	36
C- Anecdotal	Are only mentioned (often as a future research avenue)	27
D- Others	Are mentioned but not in the sense of a broader concept specifically related to AEC sectors	46
Total		**121**

3.4 Step 4 - Analyse and Synthesise the Findings from the Studies

The aim of the analysis is to break down each article content in to constituent parts (in terms of challenges identified) and describe how each relates to the other while synthesis makes associations between the parts identified in each study (Denyer & Tranfield 2009) . The synthesis is a generation of knowledge out of all the information collected which is not apparent from reading each individual paper alone. In order to organise the findings, it is expedient to build an analytical framework (Mishra et al. 2016) which was built using 48 articles from the A and B categories (see Table 2) and extracted the key challenges associated with BBI implementation separately for each domain based on a 'manual content analysis'. Table 3 summarises this framework. Out of the selected 48 articles nearly 75% were descriptive while the rest 25% were prescriptive. The articles were approximately equally distributed among conceptual (theory based) and practical (case study based) papers.

4. Challenges Related to BBI Implementation

The articles analysed (document types A and B) revealed 63, 68 and 73 challenges for BIM, BDA and IoT respectively (See Table 3). Araciyi et al. (2012) in their systematic survey and

interviews confirm that the practitioners need clear guidance, training and technical support for BIM implementation in practice as they are not knowledgeable and experienced about BIM. Supporting the same argument, many authors (Davies and Harty, 2012; Merschbrock and Munkvold, 2012; Bryde *et al.*, 2013) claim that skills and training needs are on the top among barriers for implementation of BDA and IoT. Considering the consensus that has been reached in the literature, reluctance to initiate new strategies, benefits not being tangible to warrant its use, lack of capital investments, and unfamiliarity of use are some of the other challenges common for all three domains (Vrijhoef and De Ridder, 2007; Azhar, 2011; Singh *et al.*, 2011).

Table 3 Analytical framework for challenges.

C No	Category of Challenges	Number of Challenges		
		BIM	BDA	IoT
C1	Design-specific	9	4	5
C2	Project-related	12	13	13
C3	Industry-related	11	12	11
C4	Organisational/ strategy attributed	9	10	13
C5	Technological	10	17	15
C6	Environmental	12	12	16
	Total Number of challenges	***63***	***68***	***73***

Table 4 encapsulates the variety of challenges that were discussed in the literature for BIM, BDA and IoT. Out of all the challenges identified, only 15 challenges (from each domain) were taken for evidence demonstration. Please note that all the authors who have identified the challenges in their papers are not cited here- instead few of the authors who have mentioned the challenges as 'most critical' and evidences which belong to '*category A- Primary Subject'* are only included here. The category that each challenge belongs to (According to Table 3) is mentioned in front of each category as from C1-C6.

Interestingly, many industry/ project/organisation/environmental related challenges were common to all three domains while design specific and technological challenges were distinctive to each domain (See Figure 2).

Figure 2 Relationship between common challenges for BBI implementation.

Out of the number of challenges mentioned in Table 4, only 6 key challenges (one to represent each category and two to represents each domain) are discussed in this paper. The remaining challenges will be addressed by a subsequent publication to this. The 6 challenges were selected on the basis of frequency of citation as mentioned in Table 4, through manual content analysis in light of 'mostly cited' challenges. Thus, first two challenges of each domain are selected (See Figure 5).

Table 4 Most cited challenges for BBI implementation.

Domain		Challenges \ Authors	Arayici et al., 2011	Miglinskasa et al., 2013	Mogk, 2017	Navendren et al., 2014	Newton and Chileshe, 2012	Singh et al., 2011	Succar and Kassem, 2015	Davies and Harty, 2012	Merschbrock and Munkvold,	Bryde et al., 2013	Liu et al., 2015	Vrijhoef and De Ridder, 2007	Azhar, 2011	Total
BIM	1	Education and training costs- C4	•	•		•	•	•	•	•	•		•	•	•	11
	2	Lack of interoperability-C5	•		•	•	•				•		•		•	7
	3	lack of integration and effective communication-C2	•			•	•				•		•			5
	4	start- up costs-C4	•		•	•	•						•			5
	5	Changing the way companies do business-C4				•	•		•					•	•	5
	6	Lack of understanding about BIM-C3				•	•			•		•				4
	7	legal issues regarding data ownership, copyright, data protection and licensing issues-C6	•			•	•								•	4
	8	Data inaccuracies-C2			•	•						•		•		4
	9	Resistance to change, and getting people to understand the potential and the value of BIM over traditional approaches-C4	•	•		•							•			4
	10	Adapting existing workflows to lean-orlented processes-C4				•		•						•		3
	11	organisational learning curve, lack of senior support-C4	•						•						•	3
	12	Control, supervision and authority over usage in such integrated environments-C2				•				•		•				3
	13	scalability and capacity constraints; accessibility and security of data-C1	•			•		•				•				3
	14	lack of high-end hardware resources and networking facilities-C5				•		•					•			3
	15	lack of standardised BIM processes with defined guidelines-C6			•	•							•			3

		Challenge \ Authors	Sivarajah et al., 2017	Fayet, 2015	Spiegel, 2015	Arikar, 2015	Crouch, 2016	Wang et al., 2014	Quadir et al., 2016	Martinko et al., 2016	Giandomi et al., 2015	Bilal et al., 2016	Usmani, 2015			Total
BDA	1	Infrastructure high costs and operational expenditures-C3	•	•		•		•		•	•	•	•			8
	2	Data security- ethical consideration/ownership and privacy-C3	•		•	•	•		•			•				6
	3	inadequate infrastructure and insignificant data warehouse architecture C5	•				•			•			•			4
	4	Keep the data quality in the output-C2			•			•			•	•				4
	5	lack of skilled personal and sufficient resources-C4	•	•	•		•									4
	6	Identifying the right data, accessibility and connectivity-C1		•			•					•				3
	7	change management-C4		•	•				•							3
	8	analytics maturity and using the insights gained to transfor your operations and impactful decisions- value creation-C4			•		•					•				3
	9	Reliability of analytics-C2		•												2
	10	chosing the right technology-C5		•					•							2
	11	Lack of proper understanding and often confusion-C3		•					•							2
	12	data integration complexities-C1	•										•			2
	13	synchronising large data and integration with existing systems- Data governance-C1	•										•			2
	14	Storage of large amount of data-C5	•				•									2
	15	Extreme- fastly evolving data landscape-C6	•													1

		Challenge \ Authors	Chapin et al., 2015	Borgia, 2014	Banafa, 2017	Linderoth et al., 2010	Roussey, 2016	Byfield, 2016	Sarkhel, 2016	Mitchell , 2015	Lima, 2015	McCauley, 2016	Gaura et al., 2015	Dutton, 2014	Mishra et al., 2016	Total
IoT	1	Legal, regulatory and rights-C6	•	•	•	•	•	•	•	•	•		•	•	•	12
	2	Supply chain concerns-C3	•		•	•	•	•	•	•		•	•	•	•	11
	3	Security-C5	•		•	•	•	•	•	•		•			•	9
	4	Privacy-C5	•		•	•	•		•	•					•	7
	5	Interoperability standards-C1	•			•	•		•	•						5
	6	Emerging economy and development issues-C6			•		•		•	•						4
	7	Networking, connectivity and gateway access issues-C5		•	•		•					•				4
	8	Compatibility and longevity-C2			•				•		•					3
	9	Intelligent analysis and action-C1			•						•		•			3
	10	Slow adoption of new technologies-C4			•						•			•		3
	11	Lack of understanding or education by consumers-C3		•		•	•									3
	12	Implmentation is expensive and take time and resources-C4			•							•		•		3
	13	Sensing a complex environemnt-C1							•					•		2
	14	Criticality of power and energy- Battery life-C1						•			•					2
	15	Data manageemnt and Storage issues-C5						•			•					2

Table 5 Refined most cited challenges for BBI implementation.

	Three Domains		
	BIM	**BDA**	**IoT**
Challenges	1.Education and training costs for upskilling staff (C4)	3.Infrastructure's high costs (C2)	5.Legal Regulatory and Rights issues (ownership) (C6)
	2.Inter-operability standard issues (C1)	4.Data security- ethical consideration and privacy (C5)	6.Supply Chain Concerns (C3)

These challenges are not at the same gravity- one which is most challenging for BIM is regarded as least challenging for IoT. Hence the challenges can be 'moving' in-parallel with the technology development over time.

5. Discussion

5.1 Challenge-1 (BIM)

Khosrowshahi and Arayici (2011) have described the need of organisational upskilling for successful BBI implementation and how it can be positioned via training and education protocols. However, the authors also claim that this relates to the potential lack of marginal utility and risk weighted business benefits to be realised by BIM adoption. Bringing out the same opinion, Bryde et al., (2013) highlight the need for providing education and specific support services to those who practically trigger the implementation process.

Some positions may need certified standards of education and training. Mastering a particular area with proper education and training eventually would prevent employees fear/ reluctance to change and promote embracing the change in a positive way. Moreover, upskilling through training must target all the tiers of an organisation (See Figure 3).

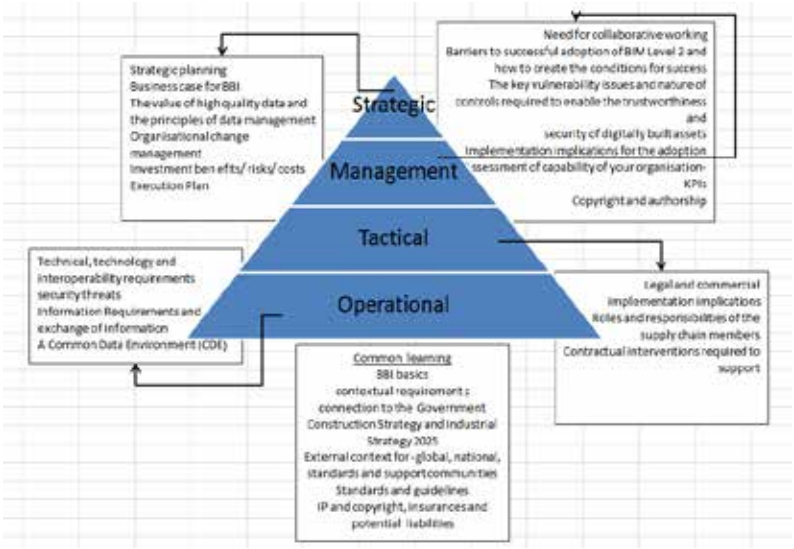

Figure 3 Dimensions for organisational skills and training needs.

5.2 Challenge-2 (BIM)

The high expectation of information sharing requires organisational interoperability, which is often associated with legal requirements in ambiguity about data ownership, copyright and data protection (Newton & Chileshe 2012). In a collaborative environment, design data exchange should take place between all the interconnected IoT devices. But the actual complex

scenario of these interconnected devices seriously inhibits the design data flow in responses to the incompatibility of data. Bringing an array of different perspectives, Singh *et al.* (2011) affirm that the problems around interoperability often occur due to lack of standardised approaches to sharing data across diverse proprietary information systems and software; and inability of organisations to share or integrate information across heterogeneous information systems. Not only the lack, but also the non-existence of interoperability itself often emanates from legally handled disputes because of the ambiguity of data ownership, copy right, data protection and confusion of who shares the risks and benefits (Mogk 2017). A collaborative platform, arguably, allows access to all the involved individuals. In addition, computer systems or software offers the opportunity to exchange and make use of information grounded in the common platform. Therefore, adoption of 'open BIM' concept is regarded as one best solution for 'common data environment' related issues. A systematic licencing procedure could also help to protect the ownership of data where guidance could come from standardised professional bodies.

5.3 Challenge-3 (BDA)

Wang and Wiebe (2014) highlight infrastructure associated costs as one big problem for BDA implementation. Even though the cloud computing technologies have now reached an improved level of maturity, the hardware equipment is still very expensive. This sometimes cost more for the organisations. Supporting the same argument, Gandomi and Haider (2015) emphasise the potentials of using BDA as 'endless' but restricted by the cost of technologies, tools and skills. Most organisations are therefore reluctant to invest in such, as benefits are not tangible enough to warrant its use and the benefits do not outweigh the costs to implement it.

Many managers claim that the BDA investment costs are way too high (Usmani 2015). Small businesses compare their profit with their investments, costs, and claim BDA is not for them. In a significant work, Mahamadu, *et al.* (2014) suggest organisations need to be convinced that investing in BDA, is a worthwhile long term investment. Undertaking a SWOT analysis to assess the current and future competitive advantages and 'action planning' for BDA could help to determine whether to go ahead or not (See Figure 4).

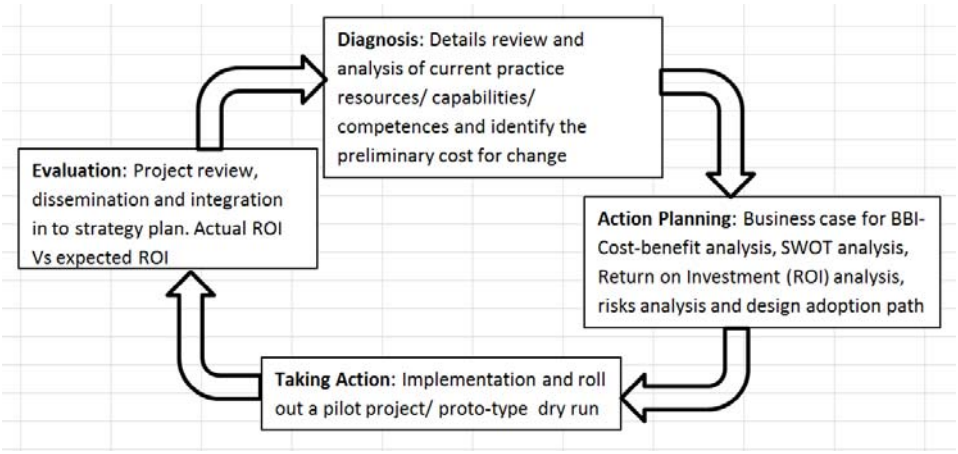

Figure 4 Action planning for costs. Adopted and revised from; (Arayici et al. 2011)

5.4 Challenge-4 (BDA)

Issues of data security, ownership, privacy and ethical considerations relevant to data mining (Jacobsson and Linderoth, 2010; Fayet, 2015; Spiegel, 2015; Ariker, 2014; Crouch, 2016) are some of the major reasons why organisations stop halfway through their big data journey. In an era where protecting privacy in the digital age is a prime challenge, organisations are more concerned with streamlining the processes. The threat of location-based information being collected by BD applications and transferred over networks, where city is smartly connected with strong IoT power, results in higher risk of privacy. It is increasing the case that the more data sources become ubiquitous, the more the threat to data privacy and security. In terms of security, systems that are vulnerable to malware attacks are commonly known as a threat to

data security. It has been identified that, inadequate security controls to ensure information is securely locked up and no third party is able to hack in to the system is one major cause of this. Consequently, third parties receive endless opportunities to access the network flows/ system. The need for forensics and intrusion detection has been a major concern in the prevailing digital age; however this is not entirely addressed.

5.5 Challenge-5 (IoT)

As long as real time data is shared over connected socially embedded devises, the ownership is at a high risk (Roussey, 2016; Byfield, 2016; Dutton, 2014; Gaura *et al.*, 2015; Lima, 2015; McCauley, 2016; Mitchell, 2015; Sarkhel, 2016). It is generally perceived that the receiver/user and the producer/ sender own the IoT data. On the contrary, Sivarajah *et al.*, (2017) argue that this ideology is very ambiguous and still needs to be settled, for the ownership gives the right for some party to control and ensure the accuracy of information. Once the ownership becomes unclear, the information accuracy and maintenance / control also become weak. Extreme sensitive data transferred through IoT without well-defined ownership results in mounting errors and may further lead to inconsistent data where misinterpretations are made. Ownership often categorised as a 'deep social issue' (Migilinskasa *et al.*, 2013) as the creators always expect an acknowledgement for their effort.

5.6 Challenge-6 (IoT)

Since functionality is not the only concern, cost and industrial reliability also play a major part in early adopters to encourage IoT implementation. It is therefore vital to maintain the integrity of the supply chains (Chapin et al. 2015; Banafa 2017). Borgia (2014) emphasises the fact that, IoT elements that are used within critical infrastructures need direct concern with respect to politics, public opinion, and other industrial perspectives. To this end, it is important that organisations must consider how they can maximize transparency and standardisation in their contribution to supply chain. The potential source of resistance can be maximised by creating devices according to an open standard that is agreed by the supply chain partners. This can then be evaluated as progress, to make sure that only the approved and agreed application techniques/ hardware/ software is employed.

6. Conclusion Recommendation and Future Research

There are number of challenges in the implementation of BIM, Big Data Analytics and Internet of Things in AEC sector. The study deployed a systematic review approach to critically reviewing existing literature around key challenges for BBI implementation. Out of all challenges identified in 6 different categories, only 6 key challenges were taken (two to represent each domain) for the discussion in this paper. These are: Education and training costs for upskilling staff, Inter-operability standard issues, Infrastructure's high costs, Data security- ethical consideration and privacy, Legal Regulatory and Rights issues (ownership) and Supply Chain Concerns. The challenges take economic, technological and social perspectives as well as significant managerial implications. There is also an ample scope for research to investigate motivational constructs, and business case positioning that promotes BBI implementation. Being destined to intensify over the years, BBI requires to be ensured that this practice is thoroughly studied to help organisations for successful implementation.

6.1 Social Dimensions

During an innovation transition period, support from the top management is crucial in formulating strategies and directing people. The need for a participative, democratic style leadership which encourages subordinates to be involved in implementation decisions encourages creativity and to feel able to suggest novel ideas without fear of disapproval is recommended for the social/ cultural well-being.
As underlined by Martinko *et al.* (2014), changing people's behaviours to handle new tools is one of the biggest reasons for people being reluctant to adopt new technologies. Therefore, getting people to understand the potential and the value of BBI over traditional approaches and adapting existing workflows to lean-oriented processes need to be a key concern in

implementation process. Further, according to J-curve as suggested by RICS BIM adoption guide, the stages of any implementation often involves an actual steep fall from current status than expected in order to reach the desired outcome, where the value creation is born. This is an important fact that the managers need to bare in their mind in strategic planning.

6.2 Technological Dimensions

As technology become more pervasive and integrated into our daily lives, it is crucial to ensure that the users trust IoT devices and BDA services to be secured from vulnerabilities. As a matter of principle, developers/vendors and users both are collaboratively obliged to ensure their protection against security and privacy threats. In order to seize the benefits, strategies will need to be placed to respect individual privacy choices, ownership and data protection while fostering innovation in new technology services. On the other hand, even though full interoperability across products and services is not always feasible, there are still options that can beat fragmentation. Appropriate, generic and open standards, policies and regulatory structures will greater user benefits and innovation opportunities.

6.3 Economic Dimensions

The BBI concept has a major potential for use in construction life cycle management, providing a central focus on the collaboration between parties involved, in which saving are made in cost, time and quality. Moreover, the potential value of BIM, BDA and IoT could be gauged, when the analytical information is leveraged to the drive decision-making process. Many research studies have evidently proven that BBI is capable of adding substantial value and competitive advantage for organisations by taking corrective and effective decisions based on systematically analysed data. To that end, managers must make long term strategic plans to gain real value over cost.

6.4 Avenues for future research

The review has led to the following research suggestions:

- Highlight the importance of IP and copyright, insurances and potential liabilities, contractual and regulatory legal aspects behind BBI implementation
- Improve the identification of the risks associated with BBI implementation in order to help organisations successfully trigger their innovative strategy in this regard;
- Further explore knowledge, skills and training protocols and process mapping to address the 'skills and training needs';
- Consider different financing options for the organisations who substantially strive towards BBI adoption
- Defining a more firm-perspective organisational cultural aspects that support BBI implementation

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Building Information Management (BIM) Education in the Dominican Republic: An Empirical Study

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Abstract

Building Information Management (BIM) education is par excellence the best solution to overcome the lack of BIM knowledge and BIM skilled professionals that affect the implementation of BIM in the Architecture, Engineering, and Construction (AEC) industry. Moreover, BIM education is vital to drive the implementation and evolution of BIM in the AEC industry. However, its provision can be a difficult task, more for BIM infant countries such as the Dominican Republic (DR). By adopting a qualitative approach, using semi-structured interviews with nine professionals involved in BIM education, this study aims to explore the presence of BIM education in the DR. The data gathered was analysed with the method of content analysis. The findings mainly indicated: a shortage of BIM experts; lack of BIM education, as there is currently provided only BIM training based on software; and the dissemination of BIM knowledge through educational activities and BIM communities. However, the provision of BIM education is likely to expand. Most of the current training providers are eager to continue with their work and get into further areas, and there is also evidence of the first plan of inserting BIM in a university curriculum. These results infer that, for an infant country, BIM education seems to be heading in the right direction in the DR. The implementation of BIM is likely to increase, along with the provision and demand of BIM education in the country. This research may be beneficial to professional and policy makers interested in BIM education in BIM infant countries.

Keywords: BIM education, BIM infant country, BIM training

1. Introduction

The AEC industry has extensively explored methods to reduce project cost, enhance efficiency and quality and decrease project delivery team and is believed that Building Information Management (BIM) provides the potential to attain these purposes (Azhar 2011). BIM is defined as "*the process of creating, storing, managing, exchanging and sharing building information in an interoperable way and reusable way."* It demands the creation and use of a computer-generated model to represent the planning, design, construction and operational stages of projects (Eadie *et al*. 2013). As one of the most significant technological advances in the building design and construction industry, BIM has been capturing the attention of the worldwide AEC industry (Liu *et al.* 2015). The increment of BIM Government initiatives has motivated the professionals of the AEC industry worldwide to opt for its implementation. This boost of BIM adoption has generated the need for BIM skilled professionals (Suwal *et al.* 2013). However, this requirement has been difficult to fulfil as the lack of BIM skilled professionals is a challenge to the universal adoption of BIM in the AEC industry (Gardner *et al*. 2014; Macdonald 2012; Suwal *et al*. 2013).

BIM education is considered as the solution to speed up the BIM learning curve hence companies can employ ready-made BIM professionals when students finish their studies (Wu and Issa 2013). There are several stakeholders involved in the delivery of BIM education: Academia, Industry, software companies, local chapters of diverse type of associations, vocational training institutions and BIM learners (AIA-CA 2012; CIC 2013; Rooney 2017). Academia is the primary provider of BIM education while the other stakeholders provide BIM training, which is a complementing part of the process of BIM education.

It is believed that the essential education needed to overcome the lack of BIM skilled personnel needs to come from higher education institutions (Miller *et al.* 2013). Currently, there is a growing number of universities worldwide that are either researching about BIM or have enthusiastically started the integration of BIM in the multidisciplinary curriculum at

undergraduate and graduate levels (AIA 2012). However, they have been criticized for their deficiency in introducing BIM into an existing or future curricula, and numerous academic programs have not been able to meet industry and student's expectations (Wu and Issa 2013). For a successful integration of BIM in academia, the alliance of academia and the industry has been suggested as well as the creation of frameworks to direct and assist this process (AIA 2012; Byrne 2015; Macdonald & Granroth 2013; Macdonald 2012; Macdonald & Mills 2011).

The present study explores the status of BIM education in the DR, and it is part of the on-going research study entitled "Decision support toolkit to implement BIM in the DR."

2. Contextualisation of the Dominican Republic

The AEC industry is one of the sectors that more contributes to the economy's growth of the DR (Soler *et al.* 2013). According to Banco Central de la República Dominicana (2015), the sector registered an annual growth of 13.8% in 2014 driven by both private and public investment. As per Soler *et al*. (2013), despite showing a sustainable and continuous growth, the Dominican AEC industry is lacking, in many cases, of a qualified workforce and innovative and efficient construction techniques. Recommendations for the enhancement of the sector include the necessity of implementing technologies to improve the communication among construction parties; have better control of the different disciplines involved in a construction project; reduce the response time and get precise and reliable data, and facilitate and make construction processes more efficient and sustainable. In the presence of these needs, this research suggests the adoption of BIM as the solution to improve the Dominican AEC industry.

Currently, the status of BIM implementation in the DR is unknown. There is a paucity of research about the implementation of BIM in the DR construction industry. Therefore, this research aims to bridge this research gap.

3. Research methodology

The research process undertaken comprehended a literature review which pointed out the scarcity of information about the AEC industry and the implementation of BIM in the country. A qualitative approach was adopted to explore these unknown aspects of the country (Creswell and Poth 2017). It was considered to collect this data through the experience and perspective of professionals of the Dominican construction industry. As per Alshenqeeti (2014), interviews are methods where people can share their insight and interpretation of a given topic. Therefore, they were the selected as the research strategy for collecting data. The interviews were especially semi-structured. The data has been collected in two phases namely: the preliminary study and the main study.

3.1 Preliminary study

The preliminary study was conducted to explore the Dominican AEC industry and inquire about the BIM implementation in the country before undertaking the main study. Data was collected in January 2016 by interviewing 17 professionals from 12 construction organisations. The study presented patterns of the way of work in the Dominican AEC industry. Concerning BIM, it gave an outlook on aspects such as the levels of BIM awareness and BIM implementation; interest in BIM; and challenges to implementing BIM in the country. In general, the findings categorised the DR as a BIM infant country which is defined by Rogers *et al.* (2015) as a country whose AEC industry does not develop any project that is BIM; however, it is interested in implementing BIM in future.

Furthermore, BIM education was an important theme that arose in the preliminary study. First, it was brought up through the lack of BIM skilled personnel, which was identified as a significant challenge to implementing BIM in the country. Regarding importance, the barrier was ranked as high by 27% of the participants, as medium by 45%, and as low by 9%. Secondly, there were identified positive BIM education indications for a BIM infant country: a training centre teaching some aspects of BIM in their software courses and the interest of integrating BIM into a university curriculum.

These results suggested investigating the presence of BIM education in the country further. As stated earlier, BIM education is the solution to the lack of BIM skilled professionals in the AEC industry. Moreover, Smith (2014) points out that BIM education, training and research are

vital practices to propel the implementation and evolution of BIM in the industry. Therefore, the theme of BIM education is considered an essential aspect to be included in the toolkit, which is the projected outcome of the research.

3.2 Main study

After the preliminary study, a theoretical BIM education framework was conceived from reviewing the literature about BIM education, which is intended to be part of the toolkit of the research (Silverio *et al*. 2016). Then, the main study was carried out following the same lines of the preliminary study but with a deeper approach and a larger sampling. Besides exploring construction organisations to identify their working pattern and levels of BIM awareness and implementation, the main study considered the theme of BIM education, as suggested by the preliminary study. For that, it was undertaken an ongoing investigation to explore the presence of BIM education in the country and professionals related somehow to the delivery of BIM education in the country were contacted and interviewed.

3.2.1 Investigation of BIM education in the country and selection of participants

As previously mentioned, the first manifestations of BIM education in the country were identified in the preliminary study: The *Training Centre A* that delivers a sort of BIM seminar in the last stage of a software course and the intentions of integrating BIM in the Civil Engineering curriculum of *University B*.

Table 1 Results of the online search about BIM education.

Key words combination	Results
BIM + Educacion + Republica + Dominicana	BIM Diploma course and BIM informative in *University A*
	Conference dedicated to BIM and IPD in *University B*
BIM + Diplomado + Republica + Dominicana	BIM Diploma course in *University B*
	Three Revit courses and one ArchiCAD course
BIM + Cursos + Republica + Dominicana	Webpage of an Architect dedicated to the dissemination of BIM knowledge
BIM + Universidad + Republica + Dominicana; BIM + Formacion + Republica + Dominicana	No results

After the analysis of the preliminary study, an investigation about BIM education was conducted to explore more manifestations of BIM education in the country and look for potential participants that could be interviewed in the main study. The investigation consisted in an online search using combinations of key words (in Spanish) related to BIM education and training. As presented in Table 1, the results were mainly about training. There were found two Diploma courses, a conference, BIM software courses and an Architect dedicated to the dissemination of BIM knowledge. Secondly, websites of universities that offer careers related to construction were searched, and the same combinations of key words were used to search in the social networking *LinkedIn;* however, none of the searches provided new results.

Table 2 Profile of the participants of the study.

Interviewee	Profile
A	Civil Engineer and MSc in BIM.
B	Non-graduate. He was a student of Architecture.
C	Civil Engineer. Professor and Researcher at *University A*.
D	Architect. Founder member of *Training Centre C*.
E	Architect. Director of the Continuing Education Department of the Headquarters of *Professional Body A*.

F	Architect. Professor at *University C*, CEO of *Training Centre A,* and exclusive Vectorworks provider
G	Freelance Architect.
H	Civil Engineer. Professor at *University A.*
I	Architect.

From this online search, could only be contacted a representative (*Interviewee C)* from *University A* and the Architect mentioned above *(Interviewee G).* Furthermore, a representative *(Interviewee E)* of a Professional Body *(Professional Body A)* was contacted due to a BIM talk that was hosted by this institution and conducted by *Interviewee G*. The rest of participants were identified by references, through the snowball sampling strategy (Atkinson & Flint 2001). This paper presents the data analysed so far in the study. In Table 2 are describe the profile of the participants.

3.2.2 Design of the interviews

The interviews were intended to examine the involvement of the interviewees with BIM education by inquiring how they got interested in BIM, how they acquired knowledge about BIM, how they started to get involved with BIM education and the manners in which they are related to BIM education. Other topics that the interview aimed to explore were: their projects concerning BIM education; practical experience of implementing BIM; points of view of the implementation of BIM in the country; challenges they perceive; and the actions they consider necessary to propel the implementation of BIM in the country.

3.2.3 Analysis of the interviews

The interviews were conducted in Spanish, audio recorded, and subsequently transcribed and translated into English. Data were analysed with content analysis, a methodical coding and categorisation method that determines the tendency and patterns of the words, their frequency, their relationships and compositions, contexts and dialogues of communication (Grbich 2012). The analysis of the study focused on coding the data to identify themes and relationships among the interviews. The data was managed and coded with the software NVivo.

4. Findings

This study will present four key findings of BIM education in the DR: *Shortage of BIM experts*, *Lack of BIM education (Presence of training)*, *Dissemination of BIM knowledge*, and *Future strategies as to BIM education*.

4.1 Shortage of BIM experts

The shortage of BIM experts is a common challenge in the provision of BIM education. Gardner *et al.* (2014) indicate that there is a small group of educators dedicated to spreading BIM knowledge across the industry because BIM is relatively new and its implementation in the sector is still progressing. Therefore, it was not a surprise to see the same scenario in the DR. First, it was hard to identify people related to BIM education in the country. Furthermore, from the nine participants presented in this paper, three are not BIM experts and do not deliver any BIM knowledge themselves (Interviewees *C, D and E*). They are just supporters of the dissemination of BIM knowledge (Refer to Table 3).

4.2 Lack of BIM education (Presence of training)

In the same manner, the study could confirm the lack of BIM education in the country identified in the preliminary study. Thus far, BIM education is not provided in academia. There is only presence of BIM training focused on software. Training is delivered in the form of software courses and diploma courses. Companies are demanding in-house software training and consultancies to implement BIM in their practices. Moreover, BIM knowledge is currently being disseminated in the country through educational activities and BIM communities.

The lack of BIM education in the country affects not only the AEC industry but also the stakeholders involved in the delivery of BIM training/knowledge. As presented in Table 3, many of the interviewees are autodidacts in the subject of BIM. Only interviewees *A, C, H* and *I* took a BIM Diploma course in the country and, besides that, *Interviewee A* got Master's degree in BIM abroad.

4.2.1 Software courses

Software courses are the most common type of training delivered nationwide related to BIM. However, the majority do not tend to focus on BIM implementation. In their description, most of them do not even mention the word BIM and when they do is basically to point out that the software is capable of working in a BIM environment. This issue was even reported by several interviewees (*A, B, G, H and I*) who criticised training centres in the country not only for their lack of BIM focus in their software courses but also for their deficiency in teaching software.

Table 3 Academic background of the participants and BIM training/knowledge they provide.

Interviewee	Academic background on BIM	Modes of delivering BIM knowledge and training
A	- BIM Diploma course in *University A* - MSc in BIM in the UK	- Coordination of the BIM Diploma course in *University A*; - Talks.
B	- No education. Autodidact with books and the internet.	- Talks; - Revit courses oriented to BIM; - Revit in-house training and BIM champion of the company he works for.
C	- BIM Diploma course in *University A.* Does not teach about BIM; he is just a supporter.	- Coordination of the BIM Diploma course and talks in *University A*; - Coordination of the insertion of two BIM modules in the Civil Engineering curriculum of *University A*.
D	- No education. Just software courses in Revit. Does not teach about BIM; he is just a supporter.	- Development of conferences where BIM talks and panels have been included; - Coordination of Revit courses oriented to BIM.
E	- No education. Does not teach about BIM; he is just a supporter.	- Host talks; - Interest in delivering courses on BIM.
F	- No education. Autodidact with books and the internet.	- Talks; - Vectorworks courses oriented to BIM; - Software consultancy to companies.
G	- No education. Autodidact with the internet.	- Revit courses oriented to BIM; - BIM Diploma courses; - Revit in-house training and BIM implementation strategies consultancy to companies; - Talks.
H and I	- BIM Diploma course in *University A.*	- Coordination of the BIM Diploma course in *University A;* - BIM Diploma courses; - Participation and organisation of talks, conferences and forums in University A and Training Centre D; - Training and consultancy to companies; - Revit training courses oriented to BIM.

Contrary to this trend, several of the interviewees (*B, F, G, H and I*) that provide BIM software courses reported that they teach their students about BIM through in their classes:

- *Interviewee G: I explained to them BIM with Revit as follows: Revit has different wall types […] These walls have a definition that is called LOD in BIM […] "For you to do a LOD 100, you need a simple basic wall", "For a LOD 400, you need a basic compound wall and is done this way. And because this wall has a LOD 400, it allows you to do construction programming and cost estimation". So, in this way I do both, I teach Revit and BIM […]*

4.2.2 Diploma courses

BIM Diploma courses were the most formal type of training identified. These courses are not regularly provided and tend to be focused on software. When the investigation was conducted, were only found two Diploma courses that were delivered in 2013. The first BIM Diploma course registered was given in *University A*, a recognised University that offers the career of Civil Engineering. The second one was given in *University B*, another prestigious university that provides the careers of Civil Engineering, Architecture and Interior Design.

BIM Diploma course in University A. The course was organised by the staff of this university (including interviewees *A, C, H* and *I*) along with Professors from an American University, who were the facilitators. The Diploma course was conceived from an agreement between both universities. As per *Interviewee C*, the course mainly covered an introduction to BIM, modelling in Revit and the use of Navisworks for programming and clash detection.

BIM Diploma course in University B. Even though the facilitator of this Diploma course could not be contacted for the study, some details of the course could be extracted from the internet. Among the objectives of the Diploma course was to identify and define IPD and BIM processes, explain the use the software Revit and Navisworks and their implementation in BIM and IPD, and the development of a BIM project.

During and after the interviews were conducted, were identified other interviewees that got involved in the delivery of this type of training. When interviewed, *Interviewee G* stated to have designed a BIM Diploma course where was planned to teach BIM along with the software Revit. The course was projected to be delivered at the beginning of January in two universities and had a high reception. Furthermore, after the interviews, it was published a BIM Diploma course to be provided by interviewees *H* and *I* in the *Training Centre D*. The course consisted of three modules: Introduction to BIM, Project's coordination with BIM and Implementation of BIM; and it required students to be Revit skilled to enrol.

4.2.3 In-house training and BIM consultancy to companies

Several of the interviewees have been demanded the provision of these services, which infers that construction companies are getting interested in BIM. *Interviewee B* is driving the implementation of BIM as the BIM champion of the in the company where he works. *Interviewee E* has delivered software consultancy to companies through the *Training Centre A*. *Interviewee G* has driven the implementation of BIM in some companies, and he states this is the activity he is demanded the most. He also provides in-house training in the software Revit, service that he has even delivered abroad. Interviewees *H* and *I* have given consultancies in BIM implementation strategies to companies and in-house training in the software Revit and Navisworks.

4.3 Dissemination of BIM knowledge in the country

As per Mordue *et al*. (2015), events and gatherings are excellent places where people can network with colleagues, unite forces and share ideas. Networking in these type of activities is very significant and allow people interested in BIM to meet frequently to talk about topics and the improvement of BIM in the industry. In the DR, were identified educational events such as talks, conferences, and forums about BIM. All the interviewees have been involved in this type of activities either as facilitators or organisers (Refer to Table 3). These activities have been mainly hosted in universities throughout the country, followed by conferences, professional bodies, and training centres. They are becoming very popular lately. After the conduction of the interviews, the ongoing investigation identified the planning and delivery of four BIM talks between March and August 2017.

Mordue *et al*. (2015) also point out that associations and forums are places where people unite their forces (either in person or virtually) to share ideas, thoughts, and point of views on

specific issues usually through sub-committees or specialist group interest fields. This mode of sharing knowledge also exists in the country. In December 2016 was created the first informative BIM forum of the country, led by five professionals of the AEC industry, including the researcher. The forum has an interactive web page where its members write BIM articles of "quick read" and share information about BIM, local and international BIM events, and places where people can seek for BIM education/training.

The interest in the delivery of BIM knowledge in the country has also come from institutions such as professional bodies. The *Professional Body A* has hosted activities where BIM knowledge have been disseminated: an introductory BIM talk conducted by Interviewee *G*; and seminars held by Interviewee *H* and *I* where the topic of BIM has been covered. Moreover, *Interviewee E* confirmed that the institution is interested in offering BIM courses. There was already one attempt of delivering a BIM Diploma course from the institution, and they currently want capable facilitators for this purpose. After the interview, they have worked along with the forum mentioned above and organised a BIM talk that had a high reception in the AEC industry.

4.4 Future strategies on BIM education

A significant finding was to identify the plan of a university to integrate BIM within a career's curriculum. As per interviewees *A* and *C*, there was a curriculum reform in the career of Civil Engineering in *University A* which will take effect from the students enrolled since August 2016. The modifications encompass the improvement of one module and the insertion of a new module, both to be delivered in the last year of the career. The modified module is called *"Technical drawing for Civil Engineering"* and students will be taught the software Revit instead of the traditional AutoCAD. *Interviewee C* explained that the name of the new module is *"Computer Aided Design"* and *Interviewee A* has been hired already by the university to be its facilitator. The content is still under development; however, *Interviewee A* gave some details including the intentions of teaching students the software Navisworks.

It can be observed that, like the BIM training found in the country, the strategy of integrating BIM in this university is also focused on teaching specific software. Rooney (2017) identified this problem in the BIM education delivered in several countries across the world (Australia, Singapore, Sweden, the UK and the USA). Education about openBIM concepts, BIM management, and BIM collaborative environments is increasing but has a long way to go in the majority of the countries.

It is important to note that, even though the insertion of these modules directed to BIM is part of a curriculum reform that will take effect in 2019 approximately, the university is already introducing BIM to their students. *Interviewee C* explained that since 2012, in the module *"Construction Administration"* of Civil Engineering, students are given a class called *"Introduction to BIM."*

Moreover, the current modes of BIM training and dissemination of BIM knowledge in the country are likely to increase. In response to the question about their plans concerning BIM education, the interviewees stated that they will continue with their work and want to expand it and explore further areas. Among these projects can be mentioned: creation of BIM diploma courses (Interviewees *A*, *B* and *D*); propose the delivery of BIM Diploma courses in *Professional Body A*, mainly in the countryside (Interviewees *H* and *I*); delivery of multidisciplinary software trainings (*Interviewee D*); delivery of Navisworks software courses Interviewees *A* and *D*); and host more BIM events and deliver BIM courses in the *Professional Body A* (*Interviewee E*).

Some interviewees shared other ambitious plans. *Interviewee A* wants to create BIM groups, do research about BIM and elaborate documents such as BIM standards for the country. In the same manner, *Interviewee G* intends to create a BIM standard with the group of students and colleagues he has gathered on his labour as an educator. Also, Interviewee *H* and *I* plan to propose the implementation of BIM in governmental institutions.

5. Conclusions and future work

This study explored the status of BIM education in the Dominican AEC industry. For a BIM infant country, the manifestations of the BIM education are moving in the right direction in the DR. Thus far, there is only provided BIM training which focus on teaching software, and there are different modes of dissemination of BIM knowledge. The current BIM training delivered in the country is prone to expand as BIM training providers are keen to continue with their labour

and teach in other areas. Moreover, the involvement of professional bodies and the creation of BIM communities are good indicators that the implementation of BIM and demand of BIM education are likely to increase in the country.

Furthermore, the interest in BIM is rising in academia. Many universities throughout the country are already hosting workshops/events to disseminate BIM knowledge. The most remarkable progress identified was the plan of integrating BIM into the University curriculum. The integration is designed to be in complementary modules and focused on BIM software, a problematic pattern that has been even identified in several BIM leader countries, but that is being surpassed with time. These findings suggest the need for guidance for a succesful integration of BIM in academia, which is the main BIM education provider. Support from the government, the industry and academia and the creation and implementation of BIM education frameworks would be needed for these purposes. A theoretical BIM education framework has been already elaborated in the research to be part of the toolkit. Future work includes the revision of the framework with the collected data for potential improvements and the dissemination of other relevant findings.

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Scan to Parametric Modelling: A Novel Approach

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Abstract

Comprehensive parametric models, like Building Information Models (BIMs), are fast becoming the main source of information during the entire lifecycle of an asset. While the use of BIM in new build projects has lately gained a lot of momentum, its use in existing assets has been hampered by the challenges surrounding the limitations of existing technologies for developing retrofit models. The most popular approach involves scanning (typically 3D laser scanning) the existing asset before generating the parametric models from the point cloud data (PCD) thus captured. The problem is that although some progress has been made recently in the generation of the non-parametric models from the PCDs, a proper full-blown parametric model is still some way away. Different approaches have been proposed to make the process as effective and efficient as possible but with only varying degrees of success. This paper will review the state-of-the-art in addressing this challenge before presenting a novel approach based on Semantic Web technologies. In the proposed approach, building elements are first identified within the PCDs, which are then marked up using Resource Description Framework (RDF) data model graphs. The Semantic Web approach provides a framework for sharing and reusing the information through this process. Subsequently, the RDF data model graph is converted into Industry Foundation Classes (IFC) or ifcOWL (ifc Web Ontology Language) schemas. Finally, the IFC schemas are used as an open standard building data model to generate the parametric model of the asset. The primary results of this ongoing research are quite promising and should be of interest to the modelling of all kinds of assets, in particular, Historical Building Information Modelling (HBIM).

Keywords: Building Information Modelling, Parametric Model, Semantic Web, RDF, IFC, HBIM.

1. Introduction

Building Information Modelling (BIM) is used in different sectors including Architecture Engineering and Construction (AEC), Facility Management (FM), and other domains to provide information concerning the asset (Quattrini, et al., 2015). Comprehensive parametric models, like Building Information Models (BIMs), are fast becoming the main source of information during the entire lifecycle of an asset (Volk, et al., 2014; Dore & Murphy, 2015). Furthermore, BIMs have a direct impact on different aspects of an asset consisting of increasing the precision of the planning phase, facilitating the decision-making process, improving the data management, enhancing the productivity, flexibility, energy efficiency, sustainability, safety in construction, and facility management (Zhang, et al., 2013; Gao, et al., 2015; Brilakis, et al., 2010). The performance and complementary maintenance of a project can be efficiently improved and supported exploiting accurate BIMs (Turkan, et al., 2012). As a matter of fact, BIMs mapped from an as-designed condition do not necessarily match to the originally constructed facility owing to the changes introduced to the asset during different stages of the construction process (Tang, et al., 2010). Hence, in the past , a variety of automated and semi-automated approaches have been proposed to capture BIMs. The process of generating BIMs utilising the data extracted from the asset can be categorised into two general approaches consisting of 'Scan and BIMs' and 'Scan to BIMs' (Figure 1) (Zhang, et al., 2015). If the as-designed CAD model is available, the process of capturing BIMs can be performed through 'Scan and BIMs' approach (Gao, et al., 2014). However, in unique circumstances such as historical monuments, the asset might not have a model, and the only available data may be 2D drawings and paper-based documents. In this case, BIM's generation can be obtained through 'Scan to BIMs' approach (Zhang, et al., 2015).

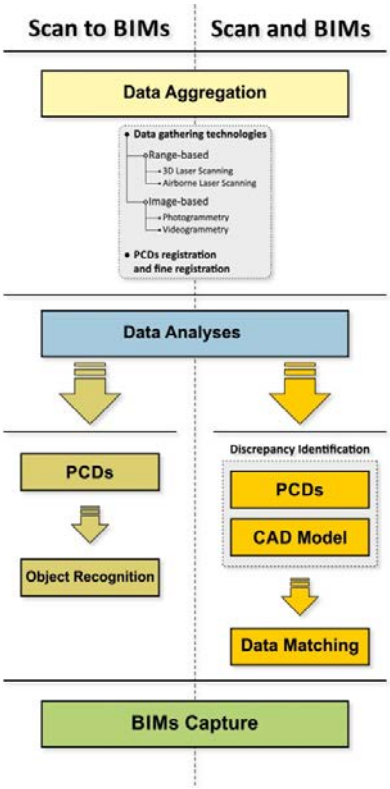

Figure 1 The general workflow of 'Scan and BIMs' & 'Scan to BIMs'.

HBIM (Historic Building Information Modelling) has lately achieved significant attention to develop a suitable BIM framework concerning the modelling of historical monuments. The quality of the represented model, its geometric reliability (Quattrini, et al., 2015), and more significantly, the required asset information embedded in the generated models play a key role in elaborating a suitable HBIM framework. A detailed and semantic representation of HBIM can be useful to address an appropriate LoD in advancing the HBIM framework. However, whilst the use of BIMs in new build projects has lately gained a lot of momentum, its use in existing assets particularly historic buildings has been hampered by the challenges surrounding the limitations of existing technologies for developing retrofit models (Chevrier, et al., 2010; Volk, et al., 2014). The data about significant aspects of an asset in the form of 3D data can be useful in managing the asset information in historic buildings. The digital tools present the feasibility of gathering the 3D-based information of an asset (Quattrini & Baleani, 2015) in the form of images or range data (Oreni, et al., 2013). Varieties of data aggregation technologies are involved in capturing data of an existing asset, including range-based and image-based techniques. The image-based technology consists of Photogrammetry and Videogrammetry (Bosche, et al., 2015). On the other hand, the 3D Laser Scanning (3DLS) is a range-based technology, and is the most popular and accurate approach for gathering the data of an existing asset before generating the parametric models from the point cloud datasets (PCDs) thus captured (Volk, et al., 2014; Bosche, et al., 2015). The challenging part of the process for capturing BIMs is to record and analyse the information embedded in PCDs. The fact is that although some progress has been recently made in generating non-parametric models from the PCDs, a proper full-blown parametric model is still some way away. Several approaches have been proposed to make the process as effective and efficient as possible but with only varying degrees of success. The purpose of this paper is to review the proposed approaches in literature and tackle the challenges. This paper proposes a novel approach that uses the Semantic Web technologies to improve the process of developing parametric retrofit models. The general process of the proposed approach is first to use Resource Description Framework (RDF) data graphs that are popular for its data interoperability to mark up recognised elements extracted

from PCDs. Some Semantic Web characteristics are then used to share and reuse the information embedded in RDFs. Subsequently, the IFC (Industry Foundation Classes) schemas are drawn from RDF by converting RDF into IFCXML. The IFCXML can be finally used as an open source data format to generate the parametric model with the required asset information in BIM software that supports IFC format. The primary results of this ongoing research are quite promising and should be of interest to the modelling of all kinds of assets, in particular, Historical Building Information Modelling (HBIM).

2. Research Methodology

Academic journals, books, and applied publications (e.g. reports, buildingSMART, openBIM, RDF APIs, etc.) that contribute to BIM and HBIM implementation for new buildings and retrofit assets are reviewed to identify the research gap and the challenges involved in capturing parametric models. The reviewed resources focus on 1) BIM process and its related applications for new and existing buildings 2) construction-related technology, such as remote sensing technologies (e.g. 3D laser scanning), 3) the Semantic Web technologies and applications. A keyword search approach is applied in order to limit the scope of resources. Main keywords are 'Building Information Modelling (BIM)', 'HBIM', 'Parametric Model', 'Semantic Web', Resource Description Framework (RDF)', and 'Industry Foundation Classes (IFC)'. The Semantic Web technologies are investigated to pinpoint an appropriate approach for managing the metadata. The result of identifying research gaps and challenges involved in generating parametric models is the proposed approach (workflow) described in section 5.

3. Related work

In the past few years, various studies have been carried out on capturing parametric building elements automatically or semi-automatically using PCDs as the main data source. The approaches proposed in the literature can be classified into two general classes consisting of 'Scan and BIMs' and 'Scan to BIMs' (Gao, et al., 2014; Zhang, et al., 2015; Xiong, et al., 2013). The process of generating parametric models, in either case, consists of several common steps, including data aggregation, data analysis, and parametric model capture. With regards to the data aggregation step, there are various data aggregation technologies, such as Photogrammetry and Videogrammetry (image-based) and Laser Scanning (range-based), available in the construction industry. The 3D laser scanning technology is the most commonly employed data collection approach among other methods due to its data accuracy and sufficient geometric information (Bosche, et al., 2015; Volk, et al., 2014). The difference between the two approaches is in data analysis step in which 'Scan and BIMS' process is achieved through matching the PCDs to the available CAD model to identify the discrepancies and to capture the accurate BIMs. On the other hand, the 'Scan to BIMs' process is attained through the object recognition method which is the process of identifying building elements inside the PCDs and generating the parametric building elements based on the identified element parts, such as lines, boundaries, 2D and 3D shapes, and so forth. Moreover, approaches proposed in the literature are supported by various declared algorithms to assist the process to move from manually generating BIMs, which is a time-consuming , tedious and error-prone due to the human intervention based procedure (Zhang, et al., 2013; Son & Kim, 2016; Xiong, et al., 2013), to an automated or semi-automated practice. In current practice, there are many approaches available among which the most common ones are based on the 2D and 3D geometric features embedded in PCDs. In Gao et al. (2014), a set of various methods are employed to identify the geometric relationships between PCDs and the corresponding CAD model in a real-world mechanical environment. After the identification of geometry-related attributes, the datasets are matched together to find the discrepancies between them and to map the BIMs. In the developed approach and similar methods proposed in other studies different specifications, such as region-based, primitive-based, and distribution-based features, are employed to generate the accurate BIMs (Gao, et al., 2014; Huber, et al., 2011).

However, an existing asset, particularly historic buildings, might not have a CAD model. In this case, the retrofit models need to be generated from PCDs or any other type of collected data directly. The process is known as the 'Scan to BIMs' approach. The method proposed in Zhang et al. (2015) uses PCDs as the main source of data to detect and extract the planar patches of an existing asset. In this method different geometric features embedded in PCDs, such as the

relationship between points and linear characteristics, are used to identify and detect the boundaries and surfaces of a 3D shape. A similar approach is proposed in Xiong et al. (2013) exploiting PCD as source data to capture semantic retrofit models of various interior building elements such as walls, floors, ceilings, windows and openings. The method uses the spatial-related attributes, such as the connectivity, relative distance, and the contextual relationship between elements in PCD to extract planar patches. The detected surfaces are interconnected to form the 3D shape by declaring different algorithms. Recently, the importance of using BIM in historical buildings has been increased among heritage communities to model, document, and represent comprehensive and intelligent 3D models containing the required information embedded in the model for different purposes, such as restoration, conservation, retrofitting, building analysis, and particularly, the facility maintenance (Dore & Murphy, 2015; Oreni, et al., 2014; Barazzetti, 2016).

While many approaches have been proposed to capture BIMs in new and retrofit projects (non-historical buildings), the development of approaches for mapping semantic rich parametric models in historical environments using PCD as input data has gained a lot of momentum recently. The challenge with using BIM in historical environments is that historic buildings contain more complex shapes and components (Barazzetti, 2016) that are not supported by commercial BIM software that are designed to model new buildings and are limited to the complex and irregular geometries that occur in HBIM (Dore & Murphy, 2015; Murphy, et al., 2009). An approach is proposed in Oreni, et al. (2014) which is based on the restoration requirements of a historical building. In this method, different concepts of NURBS (Non-Uniform Rational Base-Spline) have been used to reconstruct geometric elements based on the mutual relationship between them using PCD as the source data, and to convert identified shapes into parametric building elements. Another similar approach has been proposed in Barrazetti (2016) and Barrazetti et al. (2016) to capture parametric objects of an existing building and a bridge using the NURBS features. The workflow of the proposed approach starts with extracting the discontinuity lines and corresponding surfaces from PCDs using the NURBS attributes, and the geometric shapes are generated by interconnecting the extracted planar patches. Along with the mathematical approaches, other methods are also proposed in the literature which are based on parametric building elements library that is developed for HBIM purposes (Murphy, et al., 2013). A semi-automated approach is developed in Dore & Murphy (2015) that is based on a library of different parametric elements and a rule-based algorithm. In the proposed approach, the captured building elements extracted from PCDs and image data are matched with the parametric elements that are generated and stored in a pre-defined library to capture the required BIMs. More information regarding the process of creating new libraries of parametric building elements can be found in Murphy et al. (2013). There are other studies using PCDs to generate BIMs through manual or semi-automated processes that are based on object libraries and architectural ontologies proposed for the use in retrofit buildings and HBIM considering different aspects of an asset (Quattrini, et al., 2015; Attar, et al., 2010; Chevrier & Perrin, 2009).

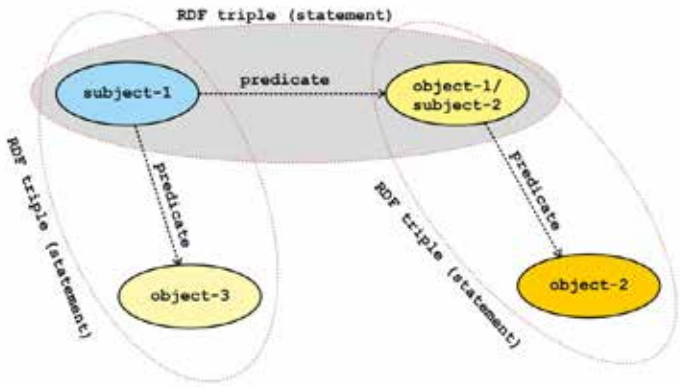

Figure 2 RDF triples (Subject, Predicate, and Object).

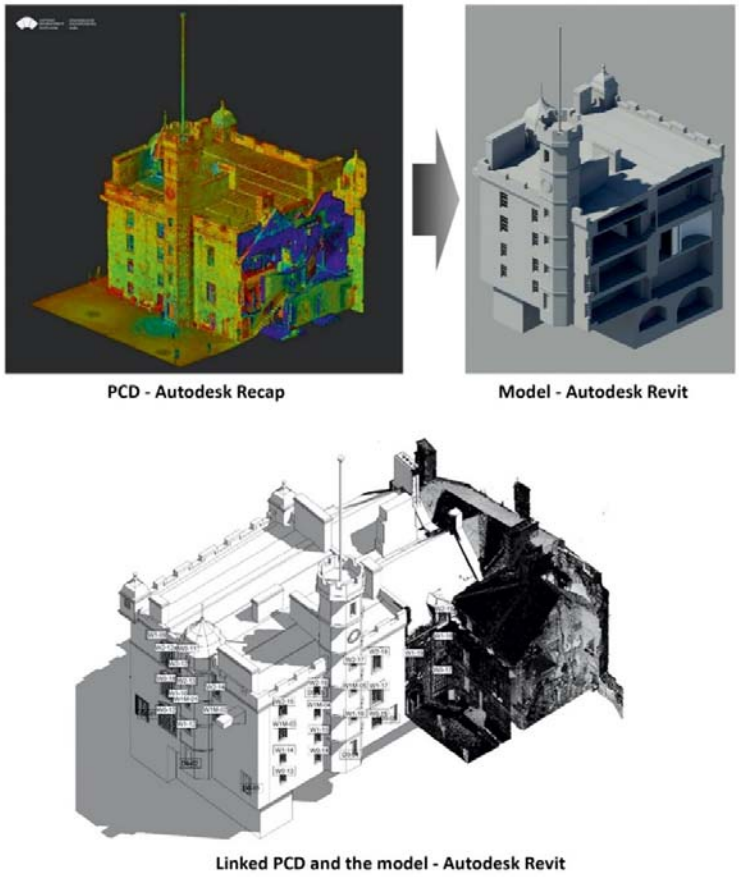

Figure 1 The Edinburgh Castle model generated from PCDs (source: Historic Environment Scotland, 2016).

Although some progress has been made recently in generating non-parametric or parametric elements from the PCDs, a proper full-blown parametric model is still some way away. The process of capturing appropriate details of an asset including the geometry accuracy and the level of automation varies from one method to another. Hence, a single developed approach could not be sufficient for all environments and objects (Fassi, et al., 2011), and the architecture of the method needs to support the project requirements, such as the geometry accuracy, the real representation of the model, and the information appended into extracted geometries. Several challenges are involved in extracting building elements from PCDs and generating corresponding parametric objects. The integration of data aggregation technologies and the BIM platforms is the most common challenge addressed in the literature (Apollonio, et al., 2012), particularly in historic environments due to the complexity and unique form of each component. The modern construction contains regular shapes and objects while the historic building components have irregular shapes that are not supported by BIM software and remain as simple primitive geometries during the process of capturing BIMs. The other challenge that can be addressed is the level of information embedded in the generated models which is a significant part of the Building Information Modelling process. Moreover, the process of appending the required asset information to the extracted elements is the challenging part of generating parametric building objects in HBIM, and it is currently carried out manually and is not covered by any commercial software. The Edinburgh Castle BIM project (Figure 3) carried out by Historic Environment Scotland (HES) is a good example for generating the BIM model from PCD manually. The manipulation, and management of the information appended to extracted geometries or non-parametric elements from PCDs during the life-cycle of an asset is another challenge that needs to be addressed to achieve a suitable BIM framework for retrofit historical buildings.

4. Resource Description Framework (RDF) & Semantic Web

The Semantic Web is a set of standards and technologies that provide a suitable framework for storing, sharing, and reusing the semantics of information (Yu, 2011) on the web. The Resource Description Framework or Format (RDF) as a Semantic Web technology, also as the commonly used standards format, is used as a structure on the Web to describe and interchange the information in the form of metadata (Domingue, et al., 2011). The foundation of the RDF is based on a simple architecture, and basic logic makes RDF capable of managing and processing large-scale data in a variety of different contexts (Powers, 2003). RDFs are expressed as simple statements, and each statement is structured in the form of triples consisting of a subject (instance), predicate (attribute), and an object (value) (Figure 2) (Cyganiak, et al., 2014; Klyne & Carroll, 2004). Data in the form of RDF can be represented in a variety of different formats, such as RDF graph data in which simple statements are connected together through matching the subjects and objects (also known as nodes) to form the graph. The instance is connected to the value through the attribute which is a unique identifier. The RDF graph data compared to other graph databases (DBs), such as Relational DBs and Hierarchical DBs (Powers, 2003), does not have a concept of root or hierarchy which enables RDF to relate resources to another without any hierarchical relationships between them.

5. Scan to Parametric Modelling

An appropriate approach to generate parametric retrofit models is to develop a method that offers a suitable framework to address challenges involved in HBIM and existing assets as much as possible. The work in this paper presents an approach that should be of interest to the modelling of all kinds of existing assets including historical buildings. As demonstrated in Figure 2, the general description of the workflow proposed in this paper can be classified into several steps consisting of data aggregation, data processing, data standardisation, and BIMs capture. Like other approaches proposed in the literature, our approach starts with the data aggregation process. The Point Cloud Datasets (PCDs) gathered by the laser scanning technology are used as the primary data source in parallel with other data sources, such as 2D drawings and asset-related documentations used to append as much information as required to the final output. With regards to the historical buildings, the additional information that can be extracted from the available drawings and documents is useful for managing the required asset information during the life-cycle of the asset. The next step is the data recognition process where the data is analysed to identify the geometric elements within the PCDs. There are a variety of different approaches proposed and developed in the literature concerning the recognition of geometric elements. However, the detected elements can be identified as non-parametric components owing to the lack of embedded information in the PCD. Moreover, in current approaches, the information is added to the components manually using BIM platforms. The other problem with currently proposed approaches is the challenge associated with the manipulation and management of the large-scale information that will be added to the model during the asset life-cycle.

The detected geometries are then marked up using Resource Description Framework or Format (RDF) graph data or other formats of RDF, such as RDFXML and RDF schema. In our approach we use the concepts of RDF, which is a Semantic Web technology, to deal with the large-scale data that is embedded in parametric models. The Semantic Web provides a framework in which the information can be shared and reused. The reason for using RDFs for labelling detected elements within the PCDs is that they present useful advantages over the other approaches. One of the problems in current approaches is to manage the large-scale information. RDF provides the fundamentals for analysing and representing large-scale data (Metadata) throughout the process (Antoniou & Van Harmelen, 2004). The interoperability of the information and the involved sectors is a key player in BIM process, and it is one of the advantages that RDF produces (Antoniou & Van Harmelen, 2004; Domingue, et al., 2011). The use of RDF for labelling elements within the PCDs adds the interoperable features to the information, so they can be used for sharing the information throughout the process efficiently. With regards to historical buildings, similar unique elements can be identified that might share the same information. In currently proposed approaches, the information related to the corresponding element needs to be appended to elements separately and cannot be used by

other elements. However, RDF offers the opportunity to combine and provide semantic information (Powers, 2003) that is shared among different elements and reuse it for similar elements in different projects if needed. This feature of RDF is also used to reduce the scale of the information by sharing them between similar elements.

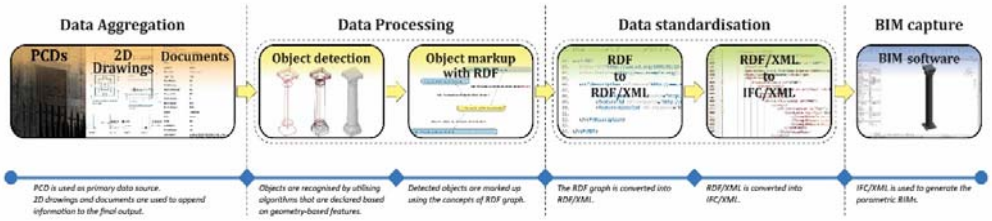

Figure 2 The workflow of proposed approach.

The challenging part of the approach proposed in this paper, however, is the data standardisation step where the primary RDF data needs to be converted into Industry Foundation Classes (IFC). IFC is the common and globally used standard format for the exchange and integration of the data within construction projects (Zhang, et al., 2013; Lee, et al., 2016; Volk, et al., 2014). The IFC formats, such as .ifc, .ifcxml, and ifc schema, are currently supported by a variety of different BIM software (Wang, et al., 2015). Figure 3a demonstrates a simple column (C-1) in the form of IFC format viewed in open source BIM Vision and an IFCXML (text format) for the same column (C-1) is shown in Figure 3b. A simple RDF graph for a part of the column is represented in Figure 4. The subject (IfcColumn) and the object (name: Columns_Metal_Clas:600mm_Diameter:290698) can be represented either as a literal or as a Uniform Resource Identifier (URI) (subject: http://www.example.org/.../IfcColumn/columns#C-1 and object: http://www.example.org/IfcColumn/names#object's-name). The nodes are connected to each other by the predicate (attribute) that directs from subject towards the object and the object of one RDF triple can be the subject of another triple (Powers, 2003). In this example the object is the name of the column; hence the predicate (attribute) as a literal would be 'has a' and as a URI would be http://www.example.org/.../IfcColumn/columns-feature#Name. RDFXML format for the same graph is described in Figure 4 as well. However, before the RDF to IFC conversion, the RDF graph data is first transformed into RDFXML which makes it more feasible to interact with the .ifcxml format. The advantage of using RDFXML instead of XML is that the XML format of RDF has the capability of being processed automatically; the data from other vocabularies can be combined with the source data; and offers optimised querying potential (Powers, 2003). The fact is that RDF and IFC are different artefacts where IFC and IFCXML is a data model and RDFXML is a serialisation of encoding RDF. The architecture of the IFC data model is based on hierarchical DB whereas the relationship between RDF objects is arbitrary, and resources do not have intrinsic importance over one another. Finally, the last step is to generate the parametric BIMs by importing IFC extracted from the previous step into the any BIM software that supports the IFC format.

Figure 3: a) The IFC format of a column viewed in open source BIM Vision; b) IFCXML format of the same column.

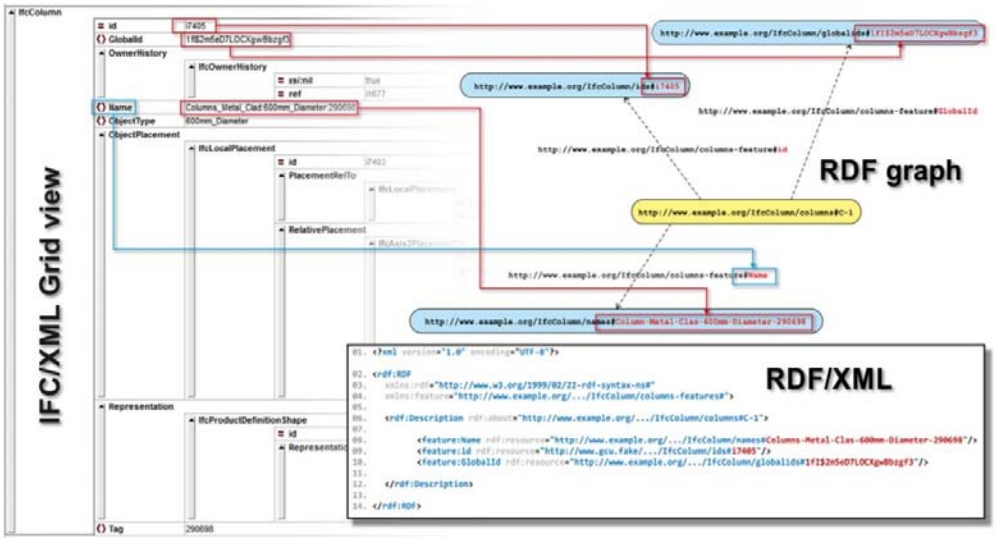

Figure 4 IFCXML grid view, RDF graph, and RDFXML architecture.

6. Conclusion

The approach proposed in this paper aims to tackle the challenges and limitations involved in generating parametric building components for existing assets, particularly, historic buildings, and to provide a suitable BIM framework for mapping retrofit models. A variety of different approaches have been recently proposed to capture geometric elements from PCDs. However, a proper parametric model is still some way away. The approach presented here shows that the use of the concepts of Semantic Web and its related technologies can be an effective solution to the challenges identified in current approaches. The usage of RDF and the Semantic Web in the proposed approach makes it capable of dealing with large-scale information. The Semantic Web gives the opportunity to produce a large-scale database of identified objects that are labelled through the process and share this information stored in the database with the same elements in one project and similar objects in other projects. This advantage can be used to overcome the problem in proposed approaches which are structured based on the object libraries. With regards to the existing assets, building objects change due to the refurbishment and other related reasons, and consequently, the information changes. In our approach, the information can be simply manipulated during the life cycle of an asset by exploiting the concepts of RDF and Semantic Web. The challenging section of proposed approach is the data standardisation where RDFXML as a serialisation of encoding RDF needs to be converted into IFC as a data model. At the moment, some steps of the proposed approach are carried out manually, and the next step of this work is to alter the approach into the semi-automated or automated process. However, the preliminary results of this ongoing research are quite promising.

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Pervasive Augmented Reality in the Construction Industry: Barriers, Drivers and Possible Applications

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Abstract

Augmented Reality (AR) represents a viable and efficient approach for combining Virtual Reality with the real world. It also augments user's perception of a real-world entity by inserting relevant digital information into the real environment and creating an environment where computer generated information is superimposed onto the user's view of a real-world scene. The idea of Pervasive AR (PAR) adds context-awareness and continuity to the typical AR technology, thus providing continued assistance to the users. This paper is aimed at main drivers and barriers for the implementation of PAR within the field of Architecture, Engineering and Construction (AEC). A review of the literature was performed highlighting the main barriers and drivers for the implementation of PAR in the AEC sector, as well as possible applications of this technology. The literature review showed cost of technology, hardware issues and development of applications as the main barriers for implementing PAR. Whereas, error and cost reduction; and continued assistance were the main drivers of implementation. Although there are some barriers to overcome, the future implementation of PAR in the construction sector looks promising with possible applications of this technology in the AEC sector such as visualisation of spatial, drawing or technical information for designers, the jobsite workforce or marketing purposes.

Keywords: Augmented reality, pervasive augmented reality, construction industry, AEC sector.

1. Introduction

AR represents a viable and efficient approach for combining virtual reality with the real world (Kamat*, et al* , 2010). AR augments user's perception of a real-world entity by inserting relevant digital information into the real environment. Similarly, Chi *et al* (2013) explain AR creates an environment where computer generated information is superimposed onto the user's view of a real world scene. Simple AR solutions are marker based; this means that rely on markers to locate the overlay information on the screen. More robust solutions are context-aware, this means that they provide relevant information to the user based on the user's task and context.

According to Abowd et al. , (1999) context can be defined as:

> *"Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves."*

This definition makes it easier for an application developer to enumerate the context for a given application scenario. If a piece of information can be used to characterise the situation of a participant in an interaction, then that information is context. According to Hong, et al., (2007) context can be classified into preliminary, integrated and final context. Preliminary context refers to raw sensor measurements, whereas integrated context encompasses inferred information from distinct sensors; Final context addresses information processed by the application, which tries to generate a higher level of understanding about the user's behaviour.

Although this categorization divides context into a three-level scheme, ultimately context derives from the device's sensors. Hence, context-aware applications try to understand what the user is doing by using information obtained from sensors.

To be more specific, Abowd et al. , (1999) established a context-aware system as follows:

> *"A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task."*

The application of visualisation techniques such as AR for planning, analysis, and design of Architecture, Engineering, and Construction (AEC) projects is relatively new compared to the sizeable amount of AR-related research conducted for diverse applications in fields such as manufacturing, medical operations, military, and gaming (Agarwal , 2016).

Recent investigations suggest that the implementation of AR applications in the AEC require the development of Pervasive AR solutions (Grubert*, et al* , 2017). Pervasive AR is a continuous and pervasive user interface that augments the physical world with digital information registered in 3D, while being aware of and responsive to the users' context (Grubert*, et al* , 2017). Moreover, Pervasive AR is the integration of context-awareness, responsiveness and continuity into traditional AR. This study presents the main barriers in the implementation of pervasive AR in the AEC sector, as well as possible applications of this paradigm. The findings are based on a critical review of the literature which is explained in section 0.

2. Background

2.1 Development of context-aware augmented reality in the AEC sector

One of the first attempts to develop an AR system solution was Sketchan+. It is an experimental tool which made a first attempt to use AR in the early architectural design stages. This AR prototype utilised a scribbling interface through the metaphor of a digitizer tablet and provides a 3D sketch as a virtual response. The next generation of sketchand+ is BenchWorks, developed as an AR prototype for analysing representational design in an urban design scale, which focused on techniques and devices necessary to create 3D models for urban design. The system was designed as a workbench, which combined optical tracking (the use of ARToolkit) with magnetic tracking. Another AR system derived from ARToolKit was developed by Dias, *et al.,* (2002), which provides a Mixed Reality system (MIXDesign) specifically for implementing tasks in architectural design, which developed tangible interfaces using ARToolkit patterns on a paddle and gestures.

Table 1 Timeline of context-aware AR research projects for the AEC sector.

Year	Contribution	Author
2006	Presented various case studies to illustrate the concept of context-aware service delivery within the AEC sector	(Anumba and Aziz , 2006)
2007	Used AR to assist in the training of operators of heavy equipment	(Wang and Dunston , 2007)
2007	Used AR to develop a cooperative reinforcing bar arrangement support system	(Yabuki and Li , 2007)
2008	Discussed the importance of location in context-awareness. Location aware apps can utilise the knowledge of the user location to provide relevant information.	(Behzadan*, et al* , 2008)
2008	Investigates constraints related to construction sites for the implementation of accurate calibration methods for multi-range AR systems.	(Shin, Jung and Dunston , 2008)
2009	Used AR to display 4D models used for managing construction activities	(Golparvar-Fard*, et al* , 2009)
2009	Used AR to display the positioning and layout of underground infrastructure and to mitigate undesired damages.	(Schall*, et al* , 2009)
2009	Presented research that investigated the effectiveness of three wireless technologies for dynamic indoor user position tracking	(Khoury and Kamat , 2009a)
2009	Investigated algorithms for identification of contextual data in location-aware applications, based on a dynamic user-viewpoint tracking scheme in which mobile users' spatial context is defined by position and three-dimensional head orientation.	(Khoury and Kamat , 2009b)

2013	Developed a low-cost mobile AR-based tool for facility managers which reduces data overload inefficiencies and enhance situation awareness	(Irizarry, *et al* , 2013)
2013	Presented a mobile AR system which enables a project's workforce to query and access 3D information on-site by utilising photographs taken from standard mobile devices. The user's location is derived from a 3D point cloud model generated from a set of pre-collected site photographs which is compared agains the users's images.	(Bae, Golparvar-Fard and White , 2013)
2015	Measured the potential used of AR in civil engineering and compared to other technologies	(Meža, Turk and Dolenc , 2015)
2016	Examined the concept of AR and its various implementations in Civil Engineering.	(Agarwal , 2016)
2017	Presented the concept of Pervasive Augmented reality.	(Grubert, *et al* , 2017)

There are several noted efforts towards collaborative AR systems in design and planning. For instance, Wang *et al.* (2003) developed an intuitive mixed environment called Mixed Reality-based collaborative virtual environment (MRCVE) to support the collaboration, design and spatial comprehension in collaborative design review sessions. The environment could be for mechanical contracting, face-to-face manner or distributed over a network.

Some investigations are focused on to the utilisation of AR technologies to address problems in the fields of AEC. Table 1 shows various research projects oriented to provide cyber-information to field personnel through mobile devices and AR systems. Some of these investigations have primarily focused on using Global Positioning Systems (GPS), Wireless Local Area Networks (WLAN), or Indoor GPS for accurately positioning the user within congested construction environments. Meanwhile, others have attempted to implement AR to help with heavy equipment operations. A common conclusion of these investigations is the positive effect obtained by the integration of AR in one or several processes of the AEC sector.

2.2 Conceptualisation of pervasive augmented reality

The first step in traditional AR is tracking and registration, which according to Chi, *et al.,* (2013) determines where to display digital contents. Initially, tracking and registration were performed using marker-based tracking toolkits. For designing various marker based applications, different toolkits such as ARTag, ARToolKit and ARToolKit Plus are utilised. ARToolKit is open sourced, easy to configure, well-documented and widely used in AR applications. Also, it has less execution time than ARTag and ARToolKit Plus Khan, *et al.,* (2015). Nevertheless, although ARToolKit is a simple toolkit, its users still have several problems in their attempt to achieve high quality and robust tracking of the markers.

With the rise of mobile and wearable devices, the increasing availability of geo-reference and user generated data and the accessibility of high speed; the construction industry counts with the right scenario for implementing AR technologies based on real-time data (Grubert, *et al* , 2017). This enables the users of AR systems to interact with their surroundings instantaneously.

Current AR applications usually serve a single purpose and are used only for short times. Standards used in AR hardware and sofware prevent a continuous, multi-purpose usage of the interface. However recent developments on head-mounted AR products have enabled a continuous AR experience. Grubert, *et al.,* (2017) refers to the concept of continuity in AR experience as "pervasive augmented reality" addressing it as a continuous, omnipresent and universal augmented interface to provide information in the physical world. Furthermore, it is defined as follow:

"Pervasive Augmented Reality is a continuous and pervasive user interface that augments the physical world with digital information registered in 3D while being aware of and responsive to the user's context."

Consequently, Pervasive AR derives from the addition of context awareness and continuity to typical AR.

2. Research methodology

This study is aimed at exploring the key features of pervasive augmented reality within the scope of the AEC sector across the literature. This section presents the methodology used to select the most appropriate research publications covering the topic of pervasive AR in the AEC sector.

This paper follows a systematic approach for reviewing compendium of literature to explore the current research in this field. The search for peer-reviewed journal articles has been done via databases. The literature was searched using the online service Google Scholar. The main advantages of these services are ease of use and a relatively broad universe of cited and citing items (Franceschet, 2010). To establish a search timeframe the trends of web search popularity for the term "Augmented reality" was obtained from Google trends. As can be appreciated in Figure 1.

The term "Augmented reality gained popularity in the transition of the year 2008 and 2009. Based on this data only publications between 2007 and 2017 were considered. Two searchers were made with the keywords "Augmented reality AEC" and "context-aware augmented reality". The selection criteria were indication of AR and construction in the title or abstract. The publications considered were open access journals within the category of original research or review.

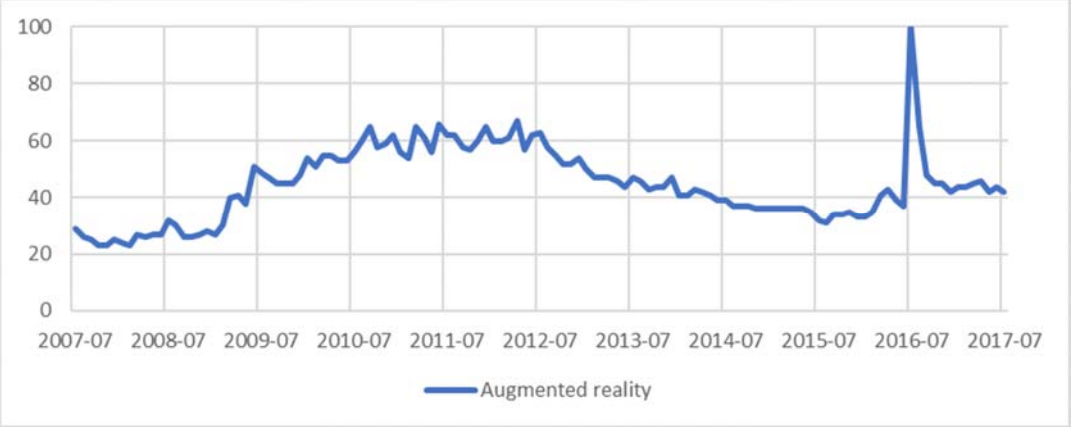

Figure 1 Interest over time according to Google trends since 2007 for the term "Augmented reality".

Following the guidelines of (White and Marsh , 2006) a systematic content analysis was performed to create themes for main barriers, drivers and applications of AR in the construction industry. Once these themes were identified, they were analysed and presented in section 4.

3. Findings and discussion

This section presents the barriers, drivers obtained from the literature for implementing pervasive AR in the construction industry. Also, possible applications are categorised and presented.

3.1 Barriers to the implementation of pervasive AR

3.1.1 Cost of AR technology

Being a relatively new concept, the initial costs of setting up an AR system in place can increase the costs of the projects (Agarwal, 2016). An increased cost would cause a negative acceptance among the decision makers of the project.

3.1.2 Hardware issues

The main goal of AR applications is to overlay virtual information on top of real world objects. AR applications need to create the perception that simulates that virtual and real entities coexist in the same space with an adequate spatial alignment of real and virtual entities, without proper registration, this perception is compromised (Agarwal , 2016).

Size and weight represented another important issue to consider (Azuma*, et al* , 2001). Nowadays Smart devices allow user to implement AR-based applications with mobility. Others head mounted displays like the Daqri Smart helmet and HoloLens are aiming to provide a mobile solution for the manufacturing and construction industry (Greenhalgh*, et al* , 2016).

3.1.3 Development of applications

The development of user-friendly applications that abide to the right paradigm of context-awareness and pervasiveness is an important barrier for implementing pervasive AR solutions. With the field of AR being very vast and diverse companies need to consider developing applications specifically for the AEC sector.

3.2 Drivers

3.2.1 Error and Cost reduction

The most significant advantage that this technology provides to the user is the reduction of errors that may take place during the construction proves. By providing a virtual design on the field, it becomes easier to control the different processes and achieve a better output (Agarwal, 2016). Since error rectification reduces, the cost of material and workforce utilised for that rectification is reduced, that helps in reducing the overall overheads of a project (Agarwal, 2016).

3.2.2 Continued assistance

Pervasive AR is all about continuity instead of isolated tasks, this means that all the possible applications of this technologies should be integrated into a personalised single device or system which provides continued assistance to the user (Grubert*, et al* , 2017).

3.3 Possible applications of pervasive AR

Based on the literature possible applications of AR include: Design, visualisation of drawings and technical information onto the jobsite, and marketing.

3.3.1 Design

Spatial models can help the designer identify the flaws and rectify them at the design stage itself. Also, it can contribute to create innovative designs as the architect can see the structure in real time, which can help in various advantageous changes (Agarwal , 2016).

3.3.2 Visualisation of drawings and technical information onto the job site

The translation of drawings into a structure is not an easy task. It involves various steps of identification of different structural elements and subsequently constructing them. Since the project is envisaged in phases, it may so happen that errors might creep in during various stages (Agarwal , 2016). The visualisation of drawings into 3D structures requires the integration of AR with other technologies such as BIM, to enable context aware solutions based on 3D information. One example is the utilisation of AR to display the positioning and layout of underground infrastructure and to mitigate undesired damages (Schall*, et al* , 2009).

3.3.3 Marketing

Explaining a project to a person without a technical background is a problem that all projects have to face. Architectural drawings may be extraordinary, but they are still on a smaller scale and generally 2-D. Using the concept of AR, the client can be given a virtual tour of the project, with all the colours and the different views that can be observed for the project. This can lead to better marketing strategies for organizations (Agarwal , 2016).

4. Conclusions and Recommendations

In this paper, we addressed the concept of pervasive AR, which is a recently added theory in the field of visualisation in construction. This concept consists of continued context-aware assistance integrated into an AR solution. This paper aimed at finding literature-based barriers and drivers for implementing PAR in the construction industry as well as possible solutions derived from PAR. The main drivers for the implementation of PAR are error and cost reduction, and continued assistance; whereas the main barriers are cost, hardware issues and development of applications.

The implementation of PAR is promising since it could bring error reduction and consequently cost reduction into construction projects by providing continued assistance and context-aware suggestion to the work-force. Nevertheless, the cost of the technology is a crucial limitation for its implementation, as well as existing hardware issues that might need to be overcome before an actual implementation.

The implementation of this technology looks like the definite future for the construction industry, and although some present limitations might slow down its implementation, the possible applications are promising, such as visualisation of technical information on the jobsite, visualisation of spatial model for design and marketing.

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BIM Based Design Protocol for the Optimized Building Orientation and Material Selection in Turkey

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Abstract

Energy consumed in the residential buildings in Turkey is significantly high, making the 40% of the total energy consumption. This is also partially due to ineffective and non-environmental decisions made by designers at the early design stage in relation to the building orientation and materials selected for building envelopes with no accurate calculation of how much both the building orientation and envelope would work for the energy efficiency of a residential building. A better building design may lead to better energy performance and reduced consumption and CO2 emission.

BIM as a new way of working methodology promises energy efficient design solutions considering the building orientation and materials aspects for improved high building performance in Turkey. Thus, this research aims to develop a BIM enabled framework for the best possible building orientation and the most appropriate building materials selection for the residential building construction in Turkey.

Research adopts case study methodology that helps to acquire qualitative and quantitative insights and understanding current practice and literature. Experimental modelling, testing and simulation are carried out in the research: Revit based BIM modelling is followed with gbXML (Green building XML) and Design Builder for energy performance simulation in relation to the building orientation and envelops. The outcome will be a design protocol and guide for the optimised building orientation and material selection in residential building construction in Turkey. This design protocol and guide will help designers in Turkey for how to best optimize building orientation and material selection using BIM successfully for sustainable design.

Keywords: energy consumption, energy efficiency, building orientation, building envelope, building information modelling (BIM), residential building, Revit architecture, design builder.

1. Introduction

Energy efficiency is a keyword that can be found nowadays in all domains in which energy demand exists. People and companies need to modify their activities in an efficient way because of the continuous increasing in energy use, energy shortage and soaring prices of energy resources. According to a study for European countries, buildings are the most energy user sector, making 40% of the total energy consumption. Furthermore, 3% can be ascribed to the residential buildings (Chwieduk, 2016). As mentioned by (Cao et al., 2016), the energy use has greatly increased due to population expansion, more time spent indoors, rising demand of building functions and global climate change. To achieve significant energy saving, buildings should be designed and operated properly. In this instance, efficient energy can be as a solution to energy shortage and CO2 carbon emissions.

As mentioned by (Yıldız, 2008), the amount of energy used may differ from place to place due to the local factor in each country, it highly depends on developing living standard, comfort conditions. Since 1980, the energy use has duplicated and is expected to keep rising. According to a study done in turkey in 2008, the energy consumed by building including residential and commercial buildings was up to 1,185 PJ. Furthermore, the ministry of energy expected that this amount of energy will grow to 2,000 PJ by 2020.

It is also cited by (Eskin & Türkmen, 2008), in Turkey, there is a need for efficient energy usage because building are responsible for a great amount energy use making around half at present of total energy consumption, which will result in the increased CO2 emission to the atmosphere.

According to study done in 2000-2008, the residential building account around 80% of total existing building in Turkey and 80% of the energy is used for heating purposes. Therefore, there

is a need to apply insulation practice to achieve better energy performance and avoid heat loss. It is also mentioned that almost 80% of energy used derived from conventional fuel use. Figure 1 presents the breakdown of energy sources in Turkey (Kazanasmaz, 2014).

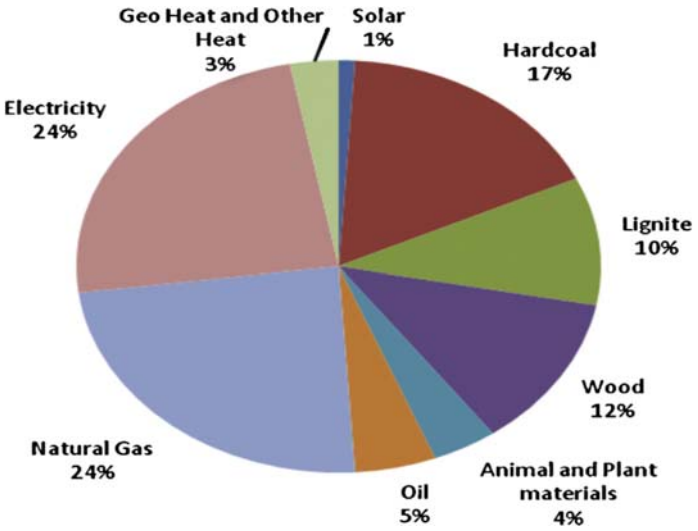

Figure 1 The breakdown of energy sources in buildings in Turkey (Kazanasmaz, 2014).

Energy used in residential buildings is significantly high in Turkey, making around 40% of the total energy consumption. Considering the energy used by other types of buildings, and the increased fuel used, the contribution of this sector to the whole air pollution becomes significantly high. According to energy statistics in Turkey, the actual energy used by buildings ranged between 100 and 200 kWh/m2 and the average is 175 KWh/m2. While in European countries, the total energy consumed including heating cooling and ventilation is around 100 KWh/m2, as a result the energy used in Turkey is two times higher than the energy used in European countries (Kazanasmaz, 2014). These considerations directed us to focus on studying the energy consumption in Turkey.

2. Background

Energy saving as the second most important signal of energy efficiency is to maximize the energy production and reduce energy consumption with highest efficiency and to decrease energy losses at lowest level without impacting economic growth and living standards. As cited in the definition, the most critical concept is to reduce energy use by stopping energy losses. (Yıldız, 2008).

According to Abanda and Byers, (2016), there are many factors that can impact the energy use in buildings. Many of them can be fixed and managed to obtain better energy efficiency. The energy performance of the building envelope materials including (external walls, roofs, windows etc.) can help in calculating how much energy is needed inside the building. They also suggested that by enhancing building envelope and insulation, more energy can be saved.

As cited by Mirrahimi (et al., 2016), building envelope can be divided into two types, namely opaque including (walls, floors and roofs) and transparent including (windows, shy light and glass door), they can work to physically separate the inside of the building from outside environment so they are exposed to humidity, rain, wind and solar radiation. As a result, it protects the inside environment as well as climate control at the same time.

As cited by (Han & Taylor, 2016), energy use can be decreased by enhancing the thermal performance of the building envelope. The ability of the envelope materials to store and release heat with a certain temperature can significantly decrease overheated hours and reduce energy used. Therefore, envelope materials can work as a suitable and promising solution for not only enhancing indoor comfort but also decreasing the energy used by buildings.

Cao (et al., 2016) cited that building enclosure play a significant role in providing indoor comfort as they separate the indoor from outdoor environment. Furthermore, they developed

efficient strategies regarding building envelope materials including (walls, fenestration and roofs). Regarding their review, enhancing building envelope generally depends on two approaches: decreasing (U-value) thermal transmittances combined with passive heating or cooling. The U-values of envelope material remarkably impact building energy use by decreasing heat gain or loss partially under harsh environment situations. The ability that a building must naturally heat or light its internal may significantly influence energy efficiency and reduces energy use. This is often measured by building orientation (Abanda and Byers, 2016). Morrissey (et al. 2011) mentioned that among the parameters that effect passive solar gain, building orientation is one of the most important one. Radwan (et al., 2016) defined building orientation as a way the building positioned on site, the position of windows and other structures. They also mentioned that the relative position of the Sun would help in more heat gain in buildings. In other words, making the right orientation of building is an important concern in passive solar gain. Furthermore, Wong and Fan (2013) suggested that to increase solar gain, which is important during colder seasons. It is necessary to orient the building correctly so that it can gain a large amount of solar radiation. Pacheco (et al, 2012) declared that building orientation is one of the most crucial factors, which have a real impact on the energy use of building.

As cited by (Cho et al. 2012), the increasing awareness of energy use and the impact of climate on building operations, designer and architects must put more consideration on energy performance and building's sustainability. To ensure that, crucial decisions during the early design stage is highly needed. The use of emerging BIM in building energy simulations has deeply enhanced the process of building energy analysis allowing for better decision making and appropriate prediction of building performance.

Bahar (et al., 2013) claimed that nowadays there is an emphasis on high-performance buildings. Therefore, BIM- based thermal analysis during early design is highly needed, because BIM include the construction and use of unified and reliable information about a building. Moreover, it leads to better decision-making and appropriate forecast about the building performance. Pacheco (et al., 2012) defined BIM as a set of policies, processes and technologies combined to manage building design and project information digitally during building's life cycle.

As mentioned in a study done by Abanda and Byers (2016), BIM can help in optimizing building envelope by assessing the heat transferred through envelope materials to reduce energy loads. Furthermore, it can be used to decrease the energy needs and analyse renewable energy options of buildings before being constructed. They also mentioned that BIM model can be used to study the effect of the building orientation on energy use during the early design stages of a project. Froese (2010) mentioned that BIM will be employed soon to completely and virtually create the whole project through simulations even before it is constructed on site. This fact is considered as one of the most important strengths of BIM.

3. Rational of Research

The aim of energy efficient building design is to achieve minimum amount of energy used by buildings. To do that, design parameters should be studied and considered during the design stage about environment, which is a crucial factor that suggests enough information to develop well-suited building design.

There are numerous studies proved that selecting materials by taking account of climatic conditions results in less energy use and comfortable indoor environment. But nowadays buildings are designed without taking account of environment situation. For example, new buildings in Turkey consume a great amount of energy to supply comfort conditions. This is due to inefficient design (Kocagil and Oral, 2015).

This is also supported by Mangan and Oral (2016), who mentioned that the new building design in Turkey does not take into consideration the environmental impact and energy assessment. Moreover, they also declared that the residential buildings in Turkey just like all over the world are highly responsible for CO2 emission, which is due to high energy consumption. Therefore, improving the building energy performance is needed, which in turn will result in a fewer CO2 emission and energy use.

For this reason, current practice is leading in optimizing building orientation and envelope for energy efficiency. That is why strategic BIM use is needed in concept design in Turkey since there are evidence of successful BIM use for energy efficient building design in other places.

Therefore, this paper aims to define a strategic BIM guide considering the local values and factors influencing the concept design for energy efficient buildings in Turkey.

4. Research Method

A representation of the research process is illustrated in figure 2 for better understanding of the methodology formulated. A comprehensive study about the current energy use in Turkey has been undertaken and reviewed as the first stage. Particularly reviewing the factors that influence the use of building energy, the energy analysis and Building Information Modelling are presented. The relationship between building energy consumption and building energy orientation and building envelope is discussed. Next, a comprehensive review is carried out to address the suitability of BIM use and the energy analysis in this research.

As shown in figure 2, using design builder, the simulation process starts with analysing the virtual building model in term of orientation and building envelope. After developing the new building design model to generate a new energy saving model. The results from the new building energy consumption model is presented and compared with the existing energy consumption level to define strategies for the energy efficient building design in Turkey by addressing building orientation and building envelop.

5.Rationale for using Design Builder software for building orientation and building envelopes simulation.

The software used in this study was selected by considering four main criteria. Firstly, according to a study done by kurul (et al., 2013) they stated that currently Revit architecture is considered as one of the most famous BIM tools being used in construction sector. Secondly, as soon as the building is modelled, it's necessary to choose appropriate energy simulation software. Design builder was chosen to perform the simulation process. This was generally due to the ability of the software in experiencing too many orientations and building envelope in a short time without the call to return to the original geometric building model. Furthermore, as mentioned by bahar (et al., 2013) design builder can be used for thermal design and analysis, calculating heating and cooling loads, natural and artificial lighting, heat transmission and scheduling. To this end, design builder is chosen due to its ability to carry out the detailed energy simulation using energy plus. Thirdly, it's important to find a way that makes the communication easy between BIM software and energy simulation software, this kind of connectivity can be defined under the term of interoperability. The term interoperability is defined in many ways by many authors, commonly they all have the same meanings.

Rezaei (et al., 2014) and Bahar (et al., 2013) defined interoperability as a way of communication and exchanging data between two or more various software. Kensek (2014) refers to interoperability as a tool of transferring data in an effective way to different domains and platforms. Moreover, Eastman and Crosby (2011) said that interoperability makes it sure for data to be transferred without the need of replication and it let many applications to be used in the same time at different phases of the project.

Sokolov (et al., 2011) reported that the development of XML (extensible mark-up language) marks a significant success in transferring building data between BIM applications and building energy analysis tools, confirming that gbXML (Green building XML) format is one of the best data format for exchanging data or interoperability. This was also agreed by

Laguela (et al., 2014) enforced the use of gbXML for writing BIM model because of its ability to include thermal descriptive information. They also stated that the gbXML schema can be considered as a data base where descriptive information is linked with geometry.

Another advantage of using gbXML was mentioned by Ham and Golparvar-Fard (2015), who said that using gbXML in the importing process from the BIM software to energy simulation tool, there is no need to recreate the building geometry within the simulation interface, considerable time would be saved too.

Finally, the last reason for using Revit and design builder was due to their ability to easily communicate through gbXML through which a building model can be seamlessly transferred from Revit to design builder for energy analysis.

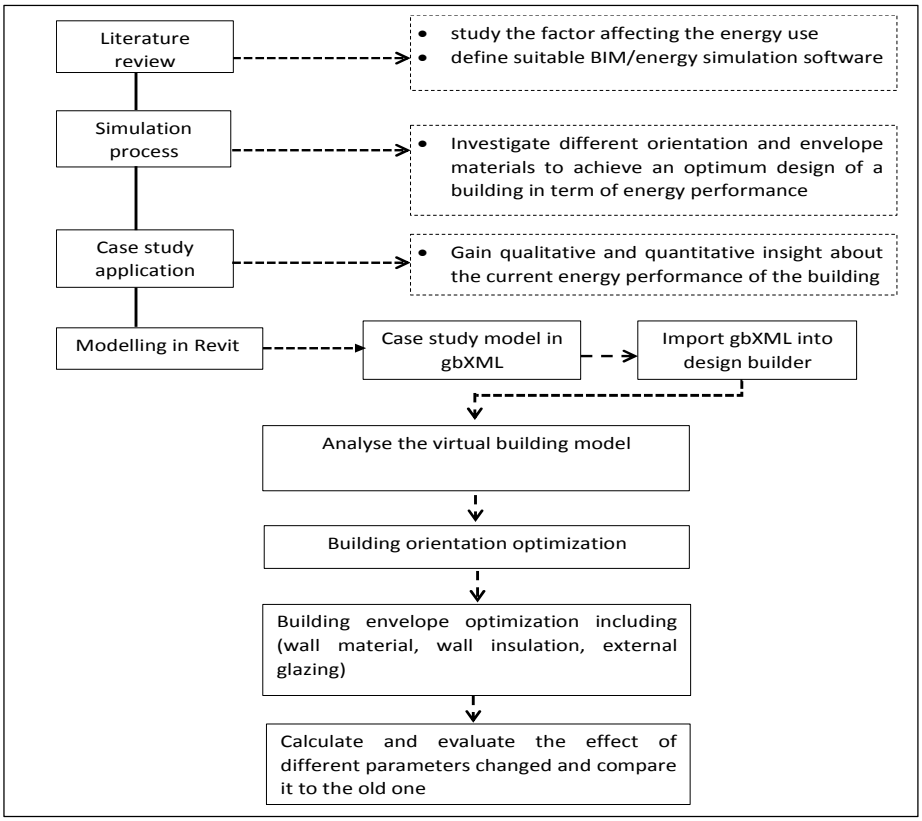

Figure 2 Research Process.

6. A Case Study Application

The building is small-scale domestic construction currently being inhabited by a family. It is a 2-storey house. The first floor consists of two bedrooms, a kitchen, a dining room, a living room, a bathroom and two WC. The second floor comprises of three bedrooms, two bathrooms a WC and a roof. Figure 3 shows the first and second floor plan of the building.

Figure 3 On the left, 1st floor and on the right, 2nd floor plan of a residential building.

6.1 Model development

To show how the building model would look like, Revit architecture 2016 was used or the development of a 3D house plan, building materials like walls, brick, and wood were edited to the building model as well as topography and site elements such as trees and shrubs. Figure 4 shows a rendered image of the building's completed geometry.

Figure 4 Building geometry.

To run the energy simulation, the building model was exported from Revit using gbXML as shown in figure 5. When the model is fully converted, it can be saved as a gbXML file, then imported into design builder with the process shown in figure 6.

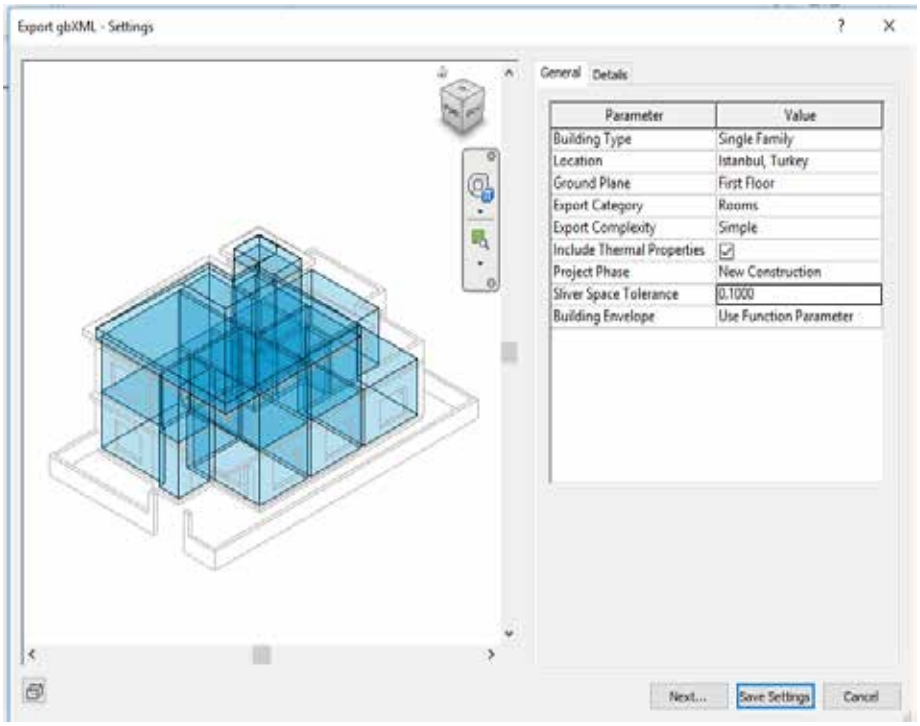

Figure 5 the exporting process from Revit to gbXML.

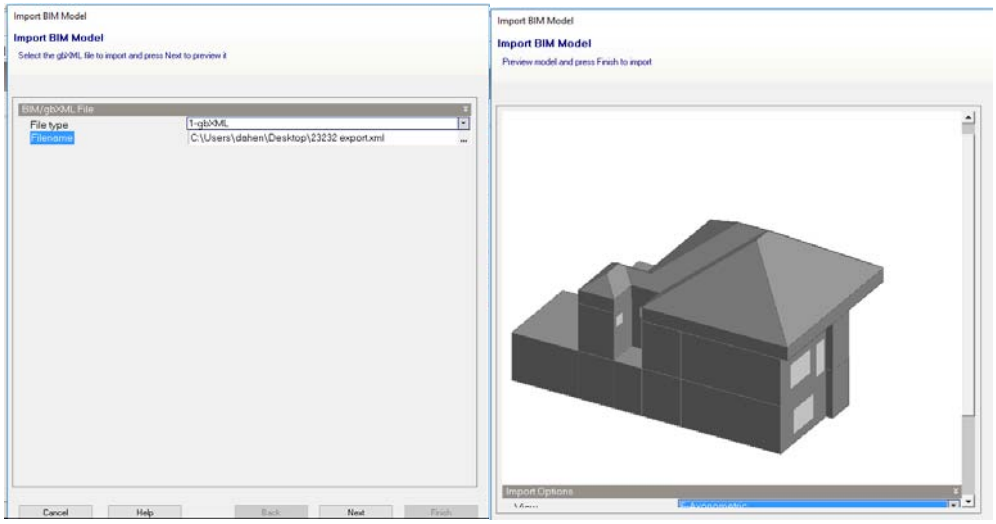

Figure 6 The process of selecting gbXML file and preview of baseline house building geometry.

The final results of the importing process into Design Builder are shown in figure 7. All the building data seems to be correct. The Design Builder provides templates that can be used to quickly load data into the model. Templates data can be loaded at site, building, block and zone levels, the templates data options are: Location, Activity, Construction, Glazing HVAC and Lighting.

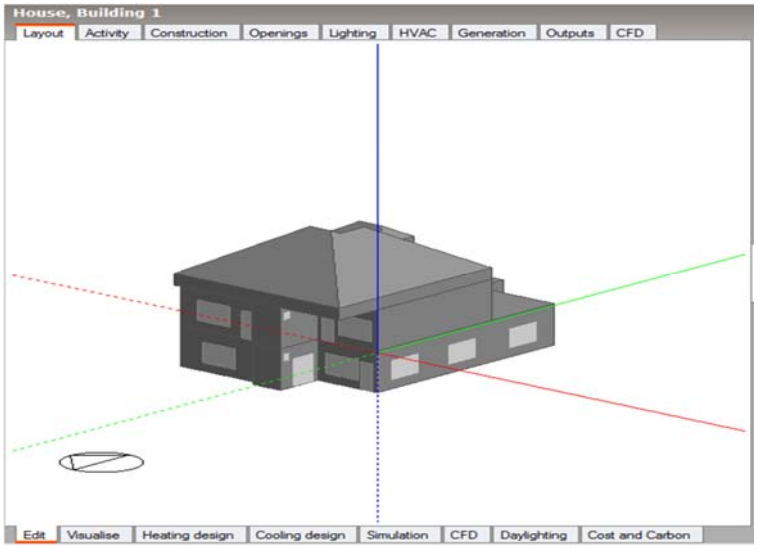

Figure 7 House building model in design builder.

6.2 Energy Modelling

Once the model geometry is imported, analysis model parameters can be defined and baseline energy models can be created in Design Builder.

6.2.1 Assigning Location and Weather Data

The weather data in Design Builder are obtained from ASHRAE weather Database©, 2005. The weather data file of Turkey- Istanbul was chosen. From the weather file: The longitude and latitude of the chosen location are 40.97° E and 28.82° N respectively, the altitude is 37 meters

above sea level, the site orientation is (0) direction, ASHRAE climate zone is 3C. Figure 8 shows the location assigned to the model.

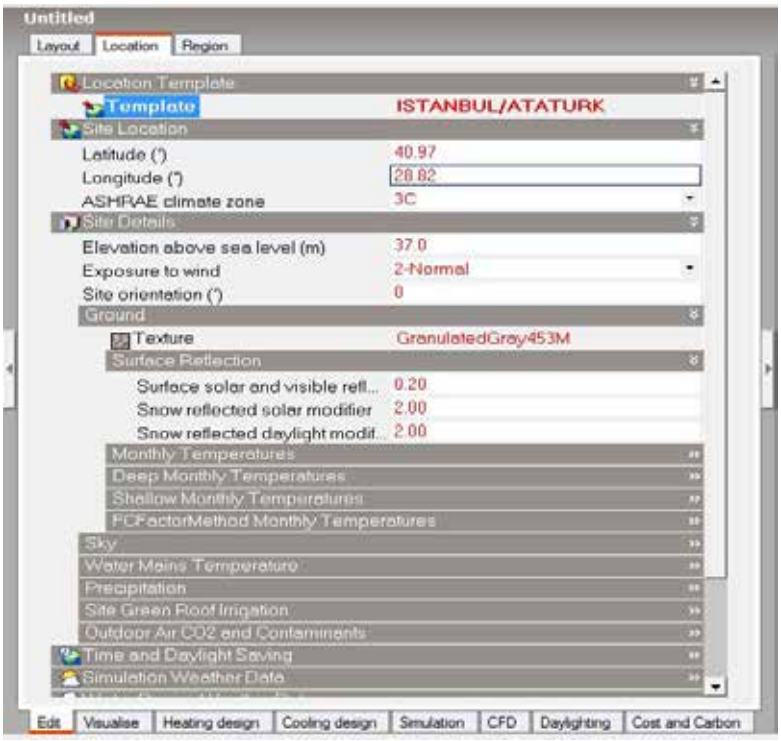

Figure 8 Location template of the baseline model.

6.2.2 Construction Materials Used in the Actual Building Design

Table 1 illustrates the physical characteristic of the opaque envelope materials used for the actual design model including external walls, internal walls, floors and slab.

Table 1 The Physical characteristic of building envelope materials.

Elements	Material	Thickness (m)	R-value (M2-k/W)	U- value (W/m2. k)
External wall	Cement plastering	0.015	0.486	2.493
	Block hollow wall	0.2		
	Gypsum plastering	0.015		
Internal wall	gypsum plastering	0.015	0.621	1.610
	Block hollow wall	0.2		
	Gypsum plastering	0.015		
Ground floor	Concrete medium density	0.1	0.366	2.732
	Concrete medium density	0.05		
	Ceramic clay tile	0.1		
Flat roof	Ceramic tile	0.04	0.334	2.994
	Cement mortar	0.025		
	R.C.C concrete slab	0.15		
	Gypsum plastering	0.015		
Pitched roof	Clay tile roofing	0.025	0.341	2.930
	Air gap	0.02		
	Roofing felt	0.05		

Regarding the glazing used for the building, a single glazed façade with no shade is used and consists of one layer of transparent glass. The frame used is wooden window. The properties of the material in this construction are shown in table 2.

Table 2 The Physical properties of glazing.

Material	Thickness	Frame	Total solar transmission (SHGC)	Light transmission	U- value
Single glazing	3 mm	Painted wooden window	0.858	0.898	6.257

7. Parameters Studied

To save energy cost, a precise energy design is the most effective technique (Mirnoori, 2013). Firstly, a passive design strategy was applied by manipulating the building orientation until the most appropriate direction of the building is identified for the minimum use of energy. Secondly, different envelope materials including walls, insulation and glazing were simulated and compared to the actual materials used to achieve maximum energy saving in regard of heating and cooling loads.

7.1 Building orientation

Building orientation has an impact on buildings to naturally heat and cool internal spaces. Therefore, using BIM will help in understanding the effect of building orientation on energy use during the design stage (Abandaand Byers, 2016). For this reason, a couple of tests was done to measure the impact that building orientation has on the energy use in regard of cooling and heating loads. In this case, the word (test) refers to the use of design builder to manipulate a building model and collect information regarding its energy use. The orientation of virtual building was at (0) direction, which means that the front phase of the building is facing the south direction. Then the direction was rotated 45 degrees counter clock wise from 0 to 360 at each test (figure.8). This simulates the effect of changing the building's orientation toward the sun. Once the solar radiation is captured at all direction, the best orientation can be achieved.

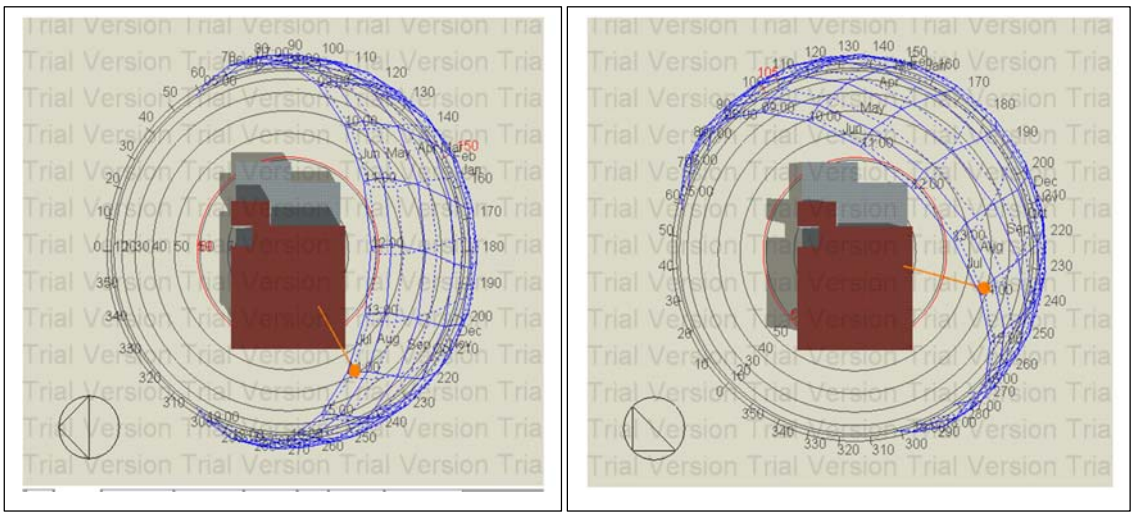

Figure 9 Building solar radiation rotated every 45 degrees.

7.2 Building Envelope Materials

7.2.1. External Walls

In the virtual building model, concrete block-hollow (heavy weight) was used and U-value is 2.493. Three other materials were used, simulated and compared to each other, those materials are: concrete block-hollow (light weight), burned brick and aerated brick. Table 3 illustrates the physical properties of those materials.

Table 3 properties of materials used for external wall.

Material	Thickness (m)	Density (kg/m3)	Thermal conductivity (w/m k)	u- value (w/m2. k)
Hollow block heavy weight (base line wall)	0.2	1220	1.35	2.493
hollow block light weight	0.2	1400	0.51	1.934
Burned brick	0.2	1920	0.72	2.048
Aerated brick	0.2	1000	0.3	1.087

7.2.2. Wall Insulation

Insulation materials were added to the wall construction and were simulated. As mentioned by Uygunoğlu (et al., 2016) the most insulation materials used in Turkey are as follow: expanded polystyrene foam (EPS), extruded polystyrene (XPS) and rock-wool (RW). Those materials were tested simulated and the best one was chosen for the optimized building design in term of heating and cooling loads. The characteristic properties of those materials were presented in table 4.

Table 4 The properties of insulation material used.

Properties	Expanded polystyrene (EPS)	Extruded polystyrene (XPS)	Rock-wool (RW)
Thermal conductivity, W/m K	0.04	0.034	0.47
Density, kg/m3	15	35	92

7.2.3. Glazing

In the virtual model, single glazing-clear 3mm was used. Double glazing- grey 6 mm was also tested and compared to the actual one. Table 5 illustrates the physical properties of the glazing used.

Table 5 The Physical properties of glazing used.

Material	Thickness	Frame	Total solar transmission (SHGC)	Light transmission	U-value
Single glazing	3 mm	wooden window	0.858	0.898	6.257
Double glazing	6 mm	wooden window	0.468	0.381	3.157

8. Analysis and results

The results of the case study can now be analyzed and discussed.

8.1 The impact of building orientation on building energy consumption

To study the impact of building orientation, the building has been rotated counter clock wise each at 45 degrees and the results are illustrated in table 6.

Test 1: 0 degree: This represents the actual building direction. The front of the building is facing the south direction. The rooms at the front are the kitchen and reception rooms. In this case, the total cooling and heating load are 4077.94 KWh, 16985.08 KWh respectively and the total annual energy consumption is 21063.02 KWh.

Test 2: 45-degree: the building is rotated 45-degree counter clock wise from the base run. This rotation will change the percentage of windows area that will be open to sun radiation. In this case, the total cooling and heating load are 4037.87 KWh, 16892.65 KWh respectively and the total annual energy consumption is 20930.52 KWh.

Test 3: 90-degree: the building is rotated 90-degree counter clock wise from the base building direction. In this instance, the right side of the building is facing the south direction, where considerable number of windows will be open to the sun radiation. The total cooling and heating load are 4162.64 KWh, 16676.59 KWh and the total annual energy consumption is 20839.23 KWh.

Test 4: 135-degree: The building is rotated 135-degree counter clock wise from the initial case and both the right and back side of the building is facing the south direction. In this case, the cooling and heating load are 4459.20 KWh, 16682.38 KWh respectively and the total annual energy consumption is 21141.58 KWh.

Test 5: 180-degree: The building is rotated by 180-degree counter clock wise. In this case, the front of the building is facing the north direction. The cooling and heating load are 4445.71 KWh, 16673.74 KWh respectively and the total annual energy consumption is 21118.71 KWh.

Test 6: 225-degree: The building is rotated by 225-degree counter clock wise. The cooling and heating load are 4403.59 KWh, 16716.44 KWh and the annual energy consumption is 21120.03 KWh.

Test 7: 270-degree: The building is rotated by 270-degree counter clock wise. In this case, the west side of the building is facing the south direction where a small number of windows will be opened to the sun direction. In this case the cooling and heating load are 4248.61 KWh, 16726.16 KWh respectively and the annual energy consumption is equal to 20974.77.

Test 8: 315-degree: The building is rotated by 315-degree from the base case, the cooling and heating load are 4282.64 KWh, 16929.63 KWh respectively and the annual energy consumption is 21212.27 KWh.

As it shown in table 8, it is obvious that the lowest annual energy consumption is 20839.23 at 90-degree and the upper annual energy consumption is 21212.27 KWh at 315-degree direction, knowing that the actual building position is at 0-degree. When comparing the best direction 90-degree to the actual building position (0 degree), 223.79 KWh energy saving can be achieved.

Table 6 The Effect of heating and cooling energy consumption.

Test	Building orientation	Annual Heating load (KWh)	Annual cooling load (KWh)	Annual energy consumption (KWh)
1	(0)	16985.08	4077.94	21063.02
2	(45)	16892.65	4037.87	20930.52
3	(90)	16676.59	4162.64	20839.23
4	(135)	16682.38	4459.20	21141.58
5	(180)	16673.74	4445.71	21118.71
6	(225)	16716.44	4403.59	21120.03
7	(270)	16726.16	4248.61	20974.77
8	(315)	16929.63	4282.64	21212.27
9	(360)	16985.08	4077.94	21063.02

8.2 The Impact of Wall Materials on Building Energy Consumption

Once the optimum building orientation is achieved, three types of wall materials were tested and simulated. This is to calculate the impact of wall materials on heating, cooling and annual energy consumption. As mentioned in previous section, heavy weight hollow block is used for the actual building. The other three types of wall material are: hollow block light weight, aerated brick and burned brick respectively.

As shown in Table 7, the lowest energy consumption is recorded when using aerated brick, which is equal to 20680.39 KWh. This is because the aerated brick has the lowest U-value 1.087 (w/m2-k). When comparing annual energy consumption of the best wall material brick wall, 20680.39 KWh to the actual building wall material (hollow block heavy weight, 20839.23 KWh), 158.84 KWh energy saving can be achieved. It means that the designers should consider aerated brick as an appropriate wall material according to Istanbul- turkey environment.

Table 7 The Effect of wall materials on heating and cooling energy consumption.

Wall type	U- value (W/m2-k)	Heating load (KWh)	Cooling load (KWh)	Annual energy consumption (KWh)
Hollow block (Heavy weight)	2.493	16676.59	4162.64	20839.23
Hollow block (light weight)	1.938	16621.90	4159.53	20727.12
Aerated brick	1.087	16542.57	4137.82	20680.39
Burned brick	2.048	16636.19	4149.35	20785.54

8.3 The Impact on Insulation on Building Energy Consumption

The effect of insulation materials with the aerated brick on the heating and cooling energy consumption for Turkey- Istanbul is illustrated in Table 8. When using extruded polystyrene (EPS), the total energy consumption is reduced to 20625.93 KWh, while the expanded polystyrene (XPS) and rock-wool recorded 20630.68 KWh, 20635.15 KWh respectively for the annual energy consumption, knowing that the annual energy consumed with aerated brick without insulation materials is equal to 20680.39 KWh. It is obvious that the extruded polystyrene is the best material to use in Turkey, around 54.46 KWh energy saving is achieved.

Table 8 The Effect of insulation material on heating and cooling energy consumption.

Insulation materials	Thickness (m)	Heating load (KWh)	Cooling load (KWh)	Annual energy consumption (KWh)
Expanded polystyrene (EPS)	0.020	16500.78	4129.90	20630.68
Extruded polystyrene (XPS)	0.020	16496.49	4129.44	20625.93
Rock-wool (RW)	0.020	16504.85	4130.3	20635.15

8.4 The Impact of Glazing Type on Building Energy Consumption

The effect of glazing type on the heating and cooling energy consumption is shown in Table 9. For single glazing-clear 3mm the annual energy consumption is equal to 20625.93 KWh. A double glazing- grey 6mm was also tested and simulated, the results shows that when using this type, the annual energy consumed will decrease to 20594.72 KWh. This means around 31.21 KWh energy saving can be achieved.

Table 9 The Eeffect of glazing type on heating and cooling energy consumption.

Window type	U-value	Cooling load (KWh)	Heating load (KWh)	Annual energy consumption (KWh)
Single glazing-clear-3mm	6.257	4129.44	16496.49	20625.93
Double glazing-absovtive-6mm	3.157	4099.27	16495.45	20594.72

9. Conclusion

The emerging BIM have rarely been implemented in energy simulation studies. Consequently, the advantage of evaluating energy need of a building before being constructed is not reaped. In this study, Revit architecture and Design Builder were both employed to carry out energy analysis by altering building orientation and envelope materials. Moreover, this study has been successful in proving that orientation and building envelope have effects on energy consumption. It has also showed how Revit architecture and Design Builder can work through gbXML to carry out building energy analysis. The main findings of this study are presented as follows:

- A concurrent procedure is highly needed to make active decisions during the design stage especially when there are many alternatives to choose. The integration between BIM and energy analysis can help to resolve this issue.
- Building orientation must be chosen carefully before deciding its position and the orientation. Things must be chosen according to weather or climatic implications of the area because such can affect the building badly. According to the achieved results, building orientation can impact the energy load making (223.79 KWh) energy saving.
- According to the study on wall materials, it was concluded that aerated brick has the maximum impact on energy consumption, which makes (158.84 KWh) energy saving for one year. Therefore, it could be considered as the most appropriate material to be used in Istanbul-Turkey.
- In regard to the insulation materials, it was proved that insulation material has an effect on energy consumption. Among the three materials identified previously, extruded polystyrene with (0.02m) thickness was the most appropriate material to be used in Istanbul-turkey, making (54.46 KWh) energy saving.
- Regarding the study on glazing type, it was concluded when using double glazing 6mm 31.21 KWh energy saving will be achieved.

Finally, it is recommended to conduct the similar simulation process in other cities with different environment conditions.

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The Utilisation of Smartphones' Apps as a Service Tool at Kuwaiti Academic Libraries

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Abstract

This paper aims to investigate how Kuwaiti Academic Libraries (KALs) have responded to the rapidly evolving Smartphone-Apps (SP-Apps) environment, as well as exploring the level of electronic services provided in these libraries. This study can illustrate whether the governmental, academic libraries in the State of Kuwait have already benefited from the mobile services provided by smart phones or not.

In this study, the researchers use both qualitative and quantitative methods. Therefore, questionnaires and interviews used in order to collect in-depth data in this field. The questionnaire sample was 400 respondents. They divided in two KALs; Kuwait University Library (KUL) and Public Authority of Applied Education Training Library (PAAETL). While, eight individual interviews conducted one-to-one in this research. This paper may be important for academic libraries to identify shortcomings in the smartphones` content and services they provide, and in highlighting efforts by libraries to address their users' needs in this area.

The findings show that, most participants expressed the need to introduce an SP-App to their library. They also confirmed that there are many difficulties in creating an SP-App including lack of budget, lack of awareness of library management, lack of clarity about library management strategic objectives and vision for an SP-App. Designing SP-Apps that have reliable content and user interface that is easy to use is a considerable challenge. For this reason, the study highly recommend introducing SP-Apps for KALs as soon as possible. The recommendations proposed are relevant to Kuwait. Further research may be useful in this field in other developing countries, in order to test or develop the suggested strategy.

Keywords: Academic Library, Smartphone, Information Communication Technology, Kuwait.

1. Introduction

Mobile access is in greater demand than ever before by library users. Smartphone Applications (SP-Apps) are becoming the preferred way to access almost any type of information. In fact, today SP-Apps are used widely in higher education institutions. Academic libraries, in the age of the web 2.0, have an exciting opportunity to engage their users in new and dynamic ways. Providing mobile services allows academic libraries to remain relevant and ahead of the curve in an ever growing mobile society. Kuwait has also benefited from SP-Apps. Today, the Kuwaiti government has an SP-App called "Kuwait Government Online (KGO) Portal". This application provides a mobile means to use the portal and benefit from many government services. Such services include query and information services, and electronic payment via Government E-Payment System, which is supervised by the Ministry of Finance. Furthermore, to receive portal tweets and information on the application, users are sent updated e-Government visual news and awareness material on their smart-handheld devices (Kuwait Government Online, 2015). In line with the Kuwaiti government's plan to include all sectors of the State under this portal, decision-makers in state-supported higher education institutions also seek to address such needs. Hence, this study investigates how governmental Kuwaiti Academic Libraries (KALs) have responded to the rapidly evolving SP-Apps environment, as well as explores the level of electronic services (e-services) they provide.

1.1 Smartphones Adoption in Higher Education Institutions

Many studies have shown that Smartphones are increasingly the preferred choice for web access among students. Bomhold (2013) noted that students are using smartphones in their

daily lives; therefore, implementing mobile learning strategies in the classroom would satisfy students' desire to extend their use of smartphones into their learning environment. In 2013, EDUCAUSE Center for Analysis and Research (ECAR) collaborated with more than 250 higher education institutions in the USA, Canada and other countries, to collate responses from more than 112,000 undergraduate students about their technology experiences and expectations. The findings showed that 76% of participants had used smartphones for academic purposes. Moreover, the survey indicated that students were ready to use their smartphones more for academic purposes, and they looked to institutions and instructors for opportunities and encouragement to do so (Dahlstrom, Walker, & Dziuban, 2013). Chen and Denoyelles (2013) collected data from 1,082 students in 12 different colleges at the University of Central Florida (UCF), in order to explore students' mobile learning practices in higher education. The study findings indicated that among all the students, who had access to mobile devices, more than half reported that they used smartphones for academic purposes. This result is expected, while several practical barriers keep students from using smartphones as an academic tool. According to Dahlstrom, Walker and Dziuban (2013, p. 29), "inadequate battery life, slow network connections and device usability concerns were the top-three limitations of smartphone as academic tools" (see Figure 1).

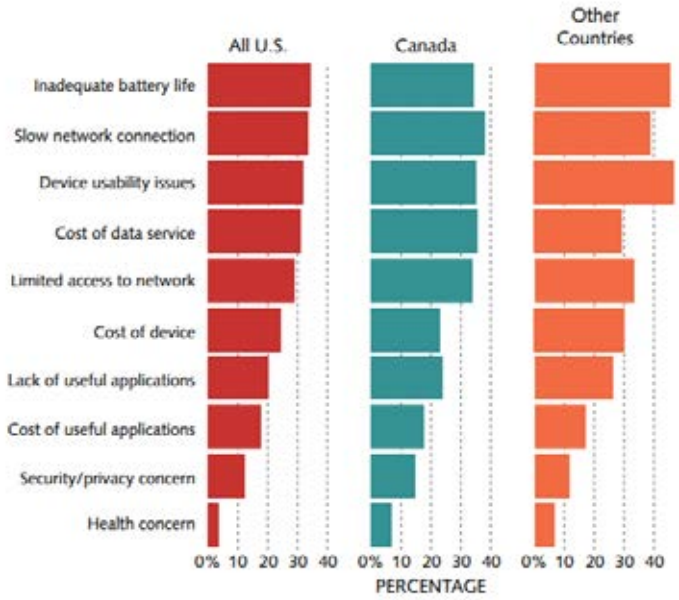

Figure 1 Barriers to using smartphones as learning tools. Source: Dahlstrom, Walker & Dziuban, 2013, p.30.

1.2 Smartphones Apps (SP-Apps) for Academic Libraries

Before discussing SP-Apps for academic libraries, it is necessary to define Application (App). An "App" is software that performs particular functions for users. The term is particularly popular in the context of mobile devices such as iPhone, iPad, Android and other smart devices (Douglas and Melody, 2012). An App is usually accessed by tapping on an icon on the home screen of smart devices. There is no need to search for a program or key in the address of a website, which means it is very easy to use. Thus, many academic libraries make their software and websites available in an App form, making it easier for users to find and use their e-services. For example, University of Leeds has launched two Apps:

- "UniLeeds" offers a range of services to students, staff and visitors.
- "Blackboard Mobile Learn" provides mobile access to the University's Virtual Learning Environment (VLE).

"UniLeeds" offers a set of tasks and options, which was selected based on student feedback (see Figure 2).

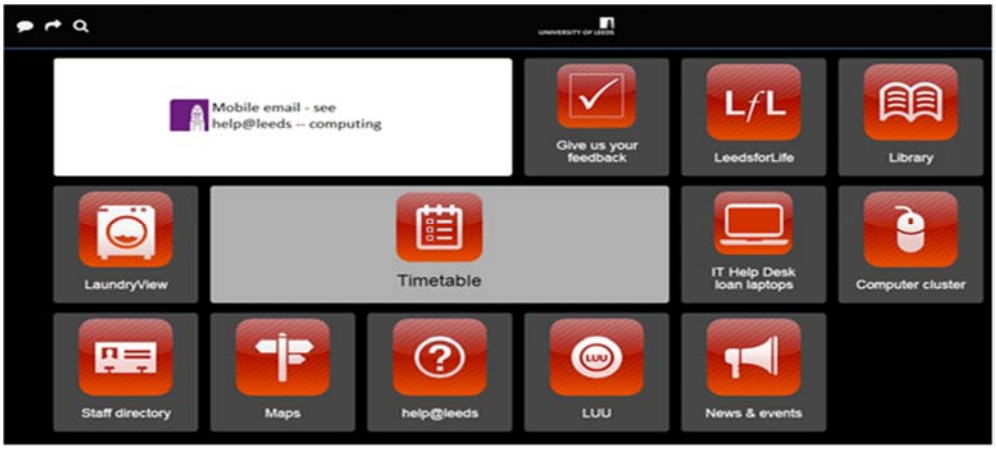

Figure 2 Options available on the UniLeeds mobile App. Source: Caperon, 2015, p.6.

The "UniLeeds" is designed to work on most popular smartphones such as iPhone, Android and BlackBerry devices, and provides mobile web pages for other operating systems (Caperon, 2015). Users can access "UniLeeds" to view their library records, online catalogue and e-services, as well as information on fines, book renewal and the opening hours of university library facilities. Another good example is the Harvard University application. The "Mobile Harvard", or "M-Harvard", is a university-wide initiative to improve the mobile experience of students, faculty, staff, visitors and those who interact with Harvard's campus and community. Established in January 2013, "M-Harvard 2.0" is the latest version of the application with a number of functional, design and content enhancements. "M-Harvard 2.0" now includes native applications for Android and iOS operating systems, as well as mobile web application access to any web-enabled smartphone (Harvard University, 2015). In the "M-Harvard App", users can access all e-services including databases, e-journals and e-books. Furthermore, they can ask a librarian directly, find the latest news and events about the library and search the catalogue.

In relation to user satisfaction with library m-services, California Digital Library (CDL) conducted two surveys and collected responses from 295 participants and 14 interviews. The finding was that smartphone users access known materials on mobile library services quick pieces of information, and that is due to their regular use of the electronic databases and catalogues. In other words, there appeared to be a need among users to transfer data between devices such as search results to primary computers. In addition, 55% of respondents preferred to search the library catalogue on their mobile frequently or occasionally (Meier, 2010). In the same vein, Cambridge University conducted a survey and found that 55% of respondents favoured accessing the library catalogue from a smartphone (Mills, 2009).

App use is not confined to Western universities. Some Arab countries have already created special Apps for their academic libraries. For instance, United Arab Emirates University (UAEU) has devoted much time and effort introducing mobile technologies for teaching and learning services. Operators of the project released their first mobile App a few years ago and last year they enhanced and released the first truly native mobile application.

The current enhanced mobile App introduces new real-time information and services that support students in their academic programmes and student life. This will play a strategic role and is in line with the university's goal of placing students at the centre of university experience. It is also aligned with the UAE Smart Government vision. UAEU mobile App provides many services, including library services such as browsing library catalogues, renewing books, requesting documents, checking availability and asking a librarian, as well as information on library opening hours, current awareness and online search services (UAE University, 2015).

Alosaimi, Alyahya, Alshahwan, Al Mahyijari and Shaik (2016) investigated the prevalence and correlates of smartphone addiction among university students in Saudi Arabia. In the study, the librarians at King Fahad University confirmed that "the use of electronic services have increased after they applied smart phone application". Some librarians in Saudi Arabian

universities stated that they faced some difficulties applying SP-Apps including budget, ICT literacy, infrastructure, qualified staff and maintenance (Alosaimi et al., 2016).

The literature review results demonstrate the importance of activating mobile services in academic libraries among students. In addition, there are some difficulties when academic libraries seek to apply SP-Apps. Consequently, this study identifies the mobile services needed in governmental KALs. Furthermore, it explores users` satisfaction with these services.

2. Methodology

Several studies confirm that the definition of the research questions is one of the most important steps to be taken when designing a study (Kuzel et al., 1994; Walsham, 1995; Yin, 2009). Therefore, the research questions are linked directly to the aim of the study:

- What is the users' satisfaction with e-services provided by governmental KALs?
- What are the desired features of e-services in governmental KALs?
- Why is it important to establish an SP-App in governmental KALs?
- What are the main barriers, if any, that may hinder building an SP-App for KALs?

Researchers in this study used both qualitative and quantitative methods. The qualitative research method was used because of the basic philosophical assumption of people's behaviour and experience, which are of importance in this paper. The quantitative research method provided a significant amount of data and feedback, in addition to easy access to the participants at a low cost. Hence, interviews and questionnaires were used to collect in-depth data.

Participants in the current research project were drawn from two governmental academic libraries in Kuwait: Kuwait University Library (KUL) and Public Authority for Applied Education and Training Library (PAAETL). Eight hundred users (undergraduate students) participated in the questionnaire, and eight interviews were conducted with the staff responsible for electronic services in both libraries (KUL and PAAETL)

2.1 Questionnaire

The questionnaire is divided into four main sections. The first section aims to collect data related to the demographic profile and the libraries` usage. The second section obtains data related to the satisfaction of the respondents regarding the e-services offered to them. The third section collects data on the importance of using SP-Apps in libraries, and the last section seeks reasons from those registered users who had never taken advantage of the e-libraries' services at all. The questionnaire sample consisted of 800 respondents (undergraduate students) from two university libraries (KUL and PAAETL). From February to June 2016, the questionnaires were sent out to both libraries. All questionnaires were returned. The questionnaire sample was undergraduate students, in order to achieve a balance between participants` responses. A non-probability sample was used because it is difficult to find an accurate representation of the total population. The researchers explained fully and clearly what the research was about and how it would be disseminated. Moreover, they gained the participants' permission before distributing the questionnaire.

Because the two libraries seem to have different problems with both users and libraries, researchers will be dealing with these issues separately in the discussion section. They will focus on the common issues in one section and the unique issues in another section.

2.2 Demographic profile

This part of the questionnaire seeks to identify the participants` profiles, in order to present clearly the percentages.

2.2.1 Participants

The findings show that of the 800 participants divided into two libraries, 435 (54.4%) were *female*, while 365 (45.6%) were *male*.

Table 1 Participants` profiles.

University		Undergraduate Students		
		Male	Female	Total
KUL	Count % of Total	179 44.8%	221 55.2%	400 100%
PAAETL	Count % of Total	186 46.5%	214 53.5%	400 100%
TOTAL	Count % of Total	365 45.6%	435 54.4%	800 100%

2.2.2 Library usage

The findings show that, with regard to KUL, of the 400 participants, 83 (20.75%) never used e-services in their libraries. The remaining 317 (79.25%) respondents had used them. However, the proportions of library users were distributed as follows: 39 (12.30%) used the library every day, 113 (35.64%) 2-3 times per week, 87 (27.44%) once a week, 51(16.08%) once a month and 27 (8.51%) less than once a month. Regarding PAAETL, the results show that of the 400 undergraduate students, 172 (43%) never used e-services in their libraries, while 228 (57%) had used them. The proportions of library users were distributed as follows: 21 (9.21%) used the library every day, 57 (25%) 2-3 times per week, 89 (39.03%) once a week, 32(14.03%) once a month and 29 (12.71%) less than once a month.

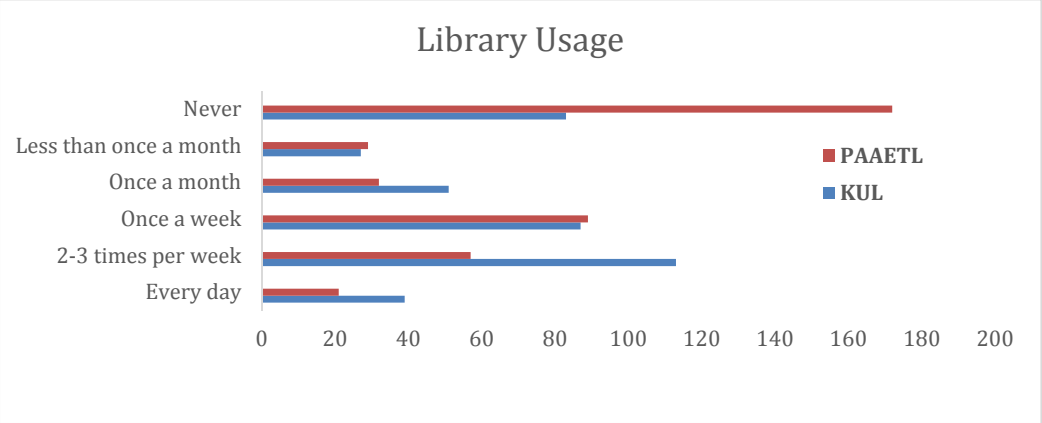

Figure 3 Library usage.

The result confirms that a number of participants did not use their e-services in both libraries. Consequently, a question is asked at the end of questionnaire to identify the reasons for this.

2.3 User satisfaction with electronic services

This part of the questionnaire seeks to obtain results on the satisfaction of the respondents regarding the e-services offered. Only the opinions of 545 (68.12%) respondents who used e-services in their libraries were analysed.

2.3.1 E-services use in the library

This question seeks to identify the percentage of students who regularly use e-services in their libraries. Participants can choose more than one answer. In KUL, the finding shows that most participants [312:99%] used *"Internet services*", 293 (92.43%) *"library e-catalogue*", 157 (49.53%) *"Reference services*", 271 (85.49%) *"online database"*, 188 (59.31%) *"E-journals*" and

127 (40.06%) "*E-books".* In PAAETL, the results are different: 218 (95.61%) preferred to use *"Internet services*", 112 (49.12%) *library e-catalogue*, 54 (23.68%) *"Reference services"*, 53 (23.25%) *"online database*", 74 (32.46%) "*E-journals"* and 42 (18.42%) "*E-books".*

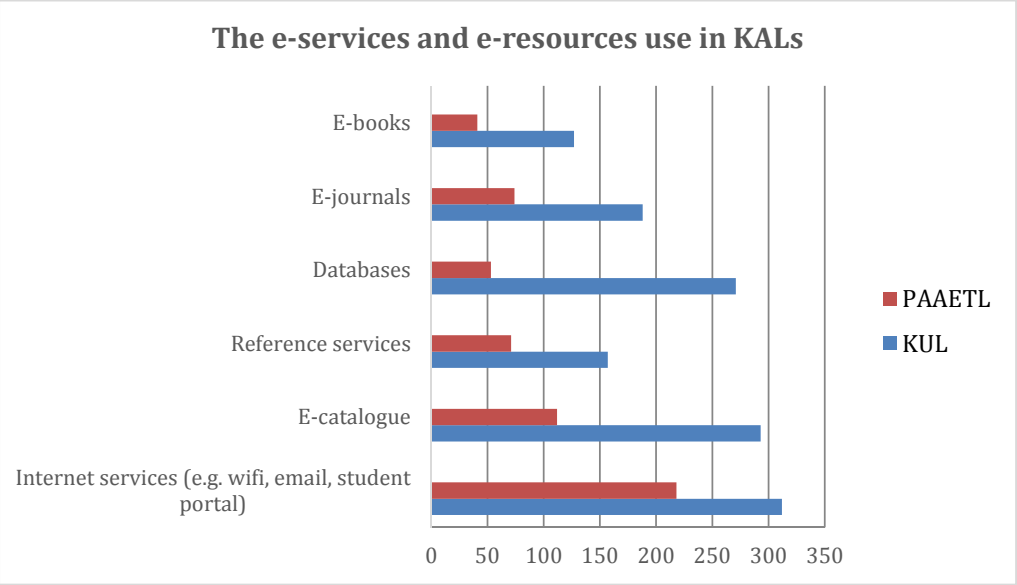

Figure 4 The e-services and e-resources use in KAL.

2.3.2 The level of electronic services in the Kuwaiti Academic Libraries (KPLs)

The question sought to identify, in general, the viewpoint of the respondents towards the e-services offered by both libraries. Starting with KUL, the findings show that 51 (16.08%) thought it was *"Poor*", whereas 97 (30.60%), 113 (35.64%) and 56 (17.66%) respondents said it was *"Satisfactory*", *"Good"* and "*Excellent"*, respectively. On the other hand, the findings for PAAETL show that the majority of respondents thought it was "*Poor"* (109; 47.80%), otherwise it was *"Satisfactory"* (70; 30.70%) or *"Good*" (31; 13.59%). An insignificant number indicated that the level of services was "*Excellent*" (18; 7.89%).

Table 2 The level of e-services in KALs.

How Do you rate the e-services in your library?		KUL	PAAETL	Total
Poor	Count	51	109	160
	% of Total	16.1%	47.8%	63.9%
Satisfactory	Count	97	70	167
	% of Total	30.6%	30.7%	60.3%
Good	Count	113	31	144
	% of Total	35.6%	13.6%	49.2%
Excellent	Count	57	18	75
	% of Total	17.6%	7.9%	25.5%
TOTAL	Count	317	228	545
	% of Total	58.1%	41.9%	100.0%

2.4 The importance of SP-Apps in the KALs

This part of the questionnaire seeks to identify the importance of the use SP-Apps in KALs.

2.4.1 The usage of smartphone Apps

In this question we endeavoured to identify how many participants, in both universities, used smartphone Apps in general. Regarding KUL, 393 (98.3%) respondents said *"Yes"*, while 7 (1.7%) said *"No*". In comparison, 395 (98.7%) participants at PAAETL said *"Yes"*, whereas only 5 (1.3%) said *"No*".

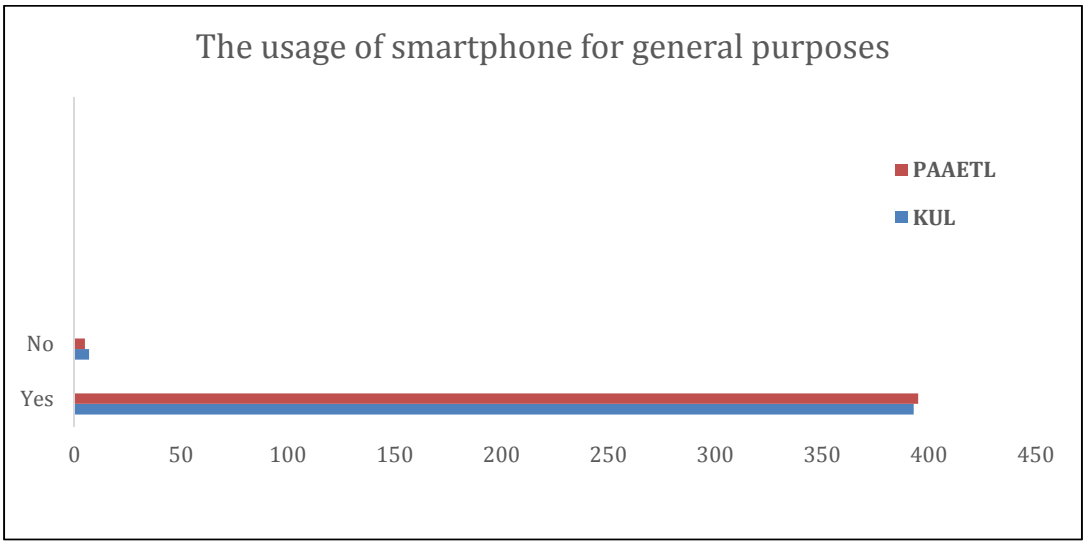

Figure 5 The usage of smartphones for general purposes.

This finding indicated that the majority of study participants used smartphones for general purposes.

- If yes, how often do the participants actually utilise a smartphone?

This question seeks to identify how often the participants actually utilise the smartphone Apps. KUL respondents said very often (219; 54.8%), often (107; 26.7%), sometimes (62; 15.5%), or rarely (12; 3%). Regarding PAAETL, respondents said very often (209; 52.3%), often (122; 30.5%), sometimes (59; 14.7%) or rarely (10; 2.5%).

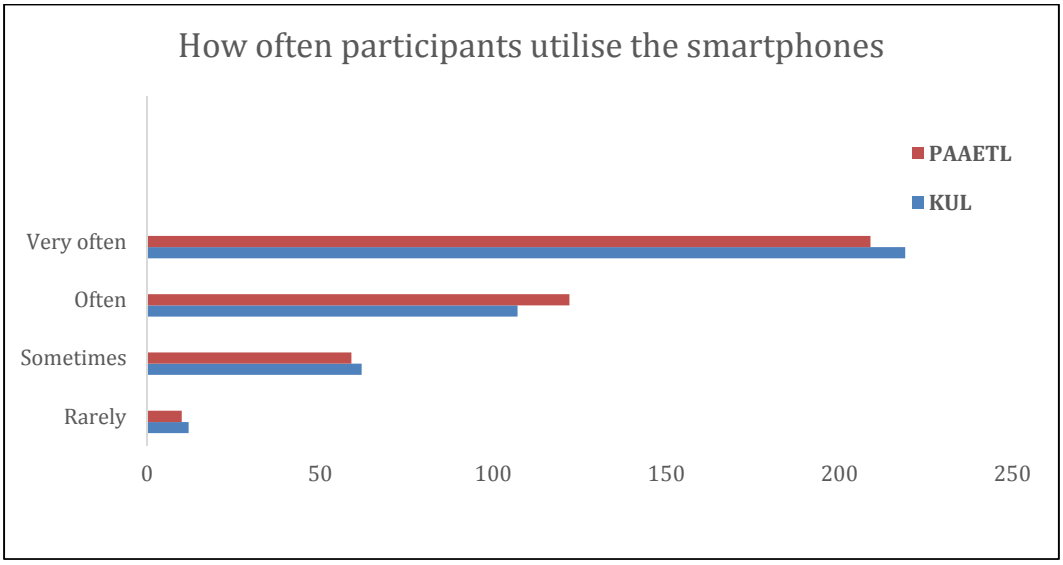

Figure 6 How often participants actually utilise a smartphone.

2.4.2 Do you prefer to use a smartphone when visiting your university or/and library website?

Regarding KUL, 229 (57.25%) participants said *"Yes"* and 171 (42.75%) said *"No"*. On the other hand, in PAAETL, 143 (35.75%) respondents said *"Yes"* and 257 (64.25%) said *"No"*.

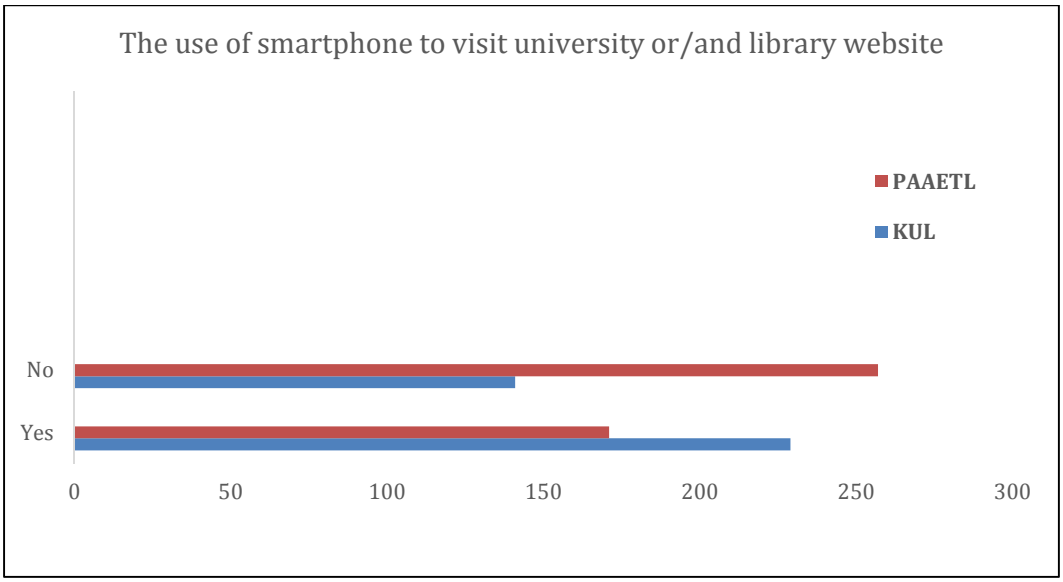

Figure 7 The use of a smartphone to visit university or/and library website.

2.4.3 Do you think that it is essential to introduce an SP-App for your library?

Most participants thought it was important to introduce an SP-App for their libraries. In KUL, 324 (81%) said *"Yes"* and 76 (19%) said *"No"*. Regarding PAAETL, 297 (74.25%) said *"Yes"* and 103 (25.75%) said *"No"*.

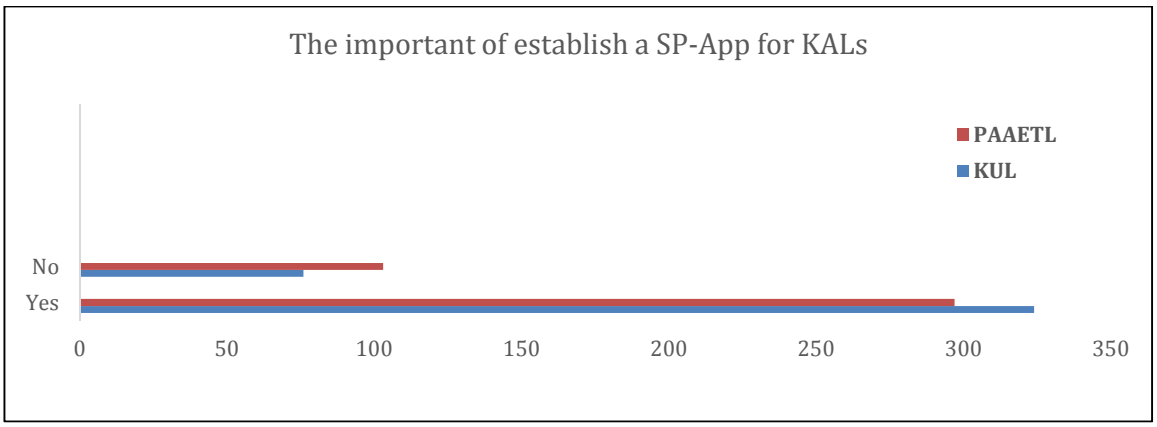

Figure 8 The importance of establishing an SP-App for KALs.

If yes, why is it important?

There were several answers, and these are some of them:

- It is very easy to use.
- We can use it 24/7.
- It saves time and effort to get the information.
- It is familiar for the students.

2.5 The reasons why some registered users had never taken advantage of the e-libraries' services at all

This section sought to identify the reasons why some respondents never used electronic services in their libraries. The responses of 255 (31.88%) participants who had not used e-services in their libraries were analysed. Most comments were similar:

- I do not know how to use the e-services offered in our library.
- I prefer to use Internet at home or/and another library website.
- It is not easy to use.
- I do not have experience of using electronic services in our library.

2.6 Main Findings

Common Issues:

- Both users in KUL and PAAETL prefer to use *Internet services* more than other services.
- The majority of participants used SP-Apps for general purposes.
- Most users in both libraries used smartphones very often.
- Most participants believe that, it is very important to interduce an SP-App to their libraries.

Unique Issues:

- The findings showed that KUL has useful e-services and resources such as e-books, e-journals, databases, reference services and e-catalogue, while PAAETL does not.
- In general, the level of e-services in KUL is better than in PAAETL.

2.7 Interview

A total of eight one-to-one interviews were conducted with librarians in both KUL and PAAETL. The purpose of the interview was to explore sensitive issues and to gather detailed information about the current and future initiatives regarding mobile and electronic services provision. However, researchers clarified for all interviewees the purpose of the study. Moreover, they explained to the participants that their names and responses were confidential, and that they had the freedom to decline answering any question.

In order to analyse the data from the interviews, the researchers used "Miles and Hubermann's iterative pattern coding" technique. Essential results from the interviews could be obtained through three processes: Creating interview transcripts, Generating pattern codes and Drawing a checklist matrix.

2.7.1 Data Analysis of Interview

The data gathered from the eight librarians were analysed and presented below according to each data pattern:

Table 3 Thematic groups and data pattern.

Thematic Group 1: Technological Context	
Data Pattern 1	Electronic services (quality & quantity)
Data Pattern 2	Smartphone App
Thematic Group 2: Financial Context	
Data Pattern 3	The budget
Thematic Group 3: Management Context	
Data Pattern 4	Vision and Perception
Data Pattern 5	Difficulties and Barriers

2.7.2 Technological Context

Electronic Services (Quality and Quantity)
All interviewees in both libraries believed that the e-services in the academic libraries assisted the learning process. However, regarding PAAET Library (PAAETL), participants acknowledged that the e-services in their libraries were limited. Therefore, all of them were unsatisfied with the e-services offered, and wished to see extensive change in the current situation. One of them said:

"*In fact, the e-services offered in our library are very few when compared with the number of library users. The library has only Online Public Access Catalogue (OPAC), Horizon System and LibraNet operating*".

On the other hand, the participants from Kuwait University library (KUL) confirmed that the e-services in their library were good and they were satisfied with them. One participant from KUL said:

"We are registered with 82 databases in different languages (English/Arabic) that cover all subjects in the university. Moreover, we have an operating system that can allow the users to search more than 10000 e-books and e-journals called Unified Search".

Although there were different points of views between the interviewees, participants in both libraries confirmed that KALs needs to benefit from the e-services` advantages including user familiarity, ease of use and 24/7 accessibility.

Smartphone Apps (SP-Apps)
When asked participants if they have SP-Apps in their libraries, all interviewees in both libraries confirmed that they did not have SP-Apps. However, one participant in KUL said:

"In 2013, we had planned to introduce an SP-App for the library, but unfortunately it was cancelled because there was not enough budget at that time".

Also the participants from PAAETL said that there was attempts to design an SP-App, but the lack of budget was the main reason to unaccomplish it. All participants believed that SP-App would be very important for their libraries allowing users access to the e-services from any time and any place. Moreover, all own a smartphone and are familiar with its functions and applications.

2.7.3 Financial Context

The Budget
Budget plays a major role to improve and develop library services. In fact, all the participants emphasised that budget is one of the most important factors that contribute to establish and design an SP-App for their lbraries. However, most participants in both libraries confirmed that the main reason preventing the introduction of an SP-App in their libraries was lack of budget. Just one interviewee in KAL had another opinion:
"I think the budget is perfect and it could cover the SP-App project, but managing this budget unfortunately is not good".

2.7.4 Management Context

Table 4 Interview Checklist Matrix.

Pattern Code	Weak	Adequate	Strong
Electronic Services (quality & quantity)	X		
Smartphone App	X		
Budget	X		
Vision and Perception		X	

Vision and Perception

The majority of interviewees already have plans to improve their libraries` services in order to meet users' needs. Regarding the SP-App, most of them confirmed the importance of introducing applications for their libraries. Therefore, one participant in KUL said:

"KUL has already begun work on this project, but the lack of awareness of library management and the lack of budget are the main reasons for the failure of the project".

According to the interviewees from PAAETL, currently there is no plan for an SP-App for their library and may be this or/and similar study could give them a good visualisation to create an SP-App for their library.

Difficulties and Barriers

Although varied problems were illustrated above, the interviewees indicated other crucial difficulties currently facing their libraries with regard to the introduction of an SP-App. These are summarised below:

- A shortage of qualified individuals to manage this application.
- The refusal of some librarians to change and adapt to the new environment.
- Lack of budget.
- Lack of clarity about library management strategic objectives and vision for SP-Apps.
- Lack of library management awareness of the importance of SP-Apps in their libraries, which they do not view as a priority.

2.8 The Main Findings

The table below summarises the findings of the interview instrument by pattern code. Table 4 displays the iterative pattern codes derived from the interview instrument and assigns them to a scale (weak, adequate and strong), according to the opinion of all interviewees.

The analysis of interview data showed both common and different issues. For instance, the majority of interviewees expressed the need to introduce an SP-App to their library. They also confirmed that there are many difficulties in creating an SP-App including lack of budget, lack of awareness of library management, lack of clarity about library management strategic objectives and vision for an SP-App. Table 4 shows that electronic services (quality and quantity), smartphone application and budget are weak. Moreover, vision and perception are inadequate.

3. Research Discussion

The purpose of this study was to investigate how Kuwaiti Academic Libraries (KALs) have responded to the rapidly evolving Smartphone-Apps (SP-Apps) environment, as well as exploring the level of electronic services provided in these libraries. According to the study's results, there were commen points and unique points. Though, the findings in the literature review, questionnaires and interviews confirmed the importance of SP-Apps in academic libraries. In literature review section, studies and figures indicate the importance of applying SP-Apps in libraries in order to help end users find their needs as well as saving their time and effort. In the same vein, study participants, whether students or librarians, stressed that the SP-Apps in KALs has become an urgent need to develop and improve the services in their libraries. In order to discuss the results of the study, it is necessary to answer the following research questions:

What is the users' satisfaction with e-services provided by governmental KALs?

In general, the results indicate that most users in governmental KALs are not satisfied with e-services provided by their libraries. However, when viewpoints are compared, KUL users are more satisfied than PAAETL users with the e-services offered. This finding shows that decision makers in KUL are seeking to provide better e-services to their users.

What are the desired features of e-services in governmental KALs?

The results confirm that governmental KALs need to improve their e-services, especially in the PAAETL as there was a clear lack of e-resources and services. This could be done if they benefit

from other academic libraries' experiences, whether regionally or globally. However, the findings indicate that the most desired features of e-services in governmental KALs are;

- Users can access all e-services and e-resources including databases, e-journals and e-books.
- Users can ask a librarian directly.
- Users can find the latest news and events about the library.
- Users can search the library catalogue easly from any where.
- SP-Apps work on most popular operating systems such as IOS, Android.
- SP-Apps introduce new real-time information and services that support users in their academic programmes.

Why is it important to establish an SP-App in governmental KALs?

The findings confirm that SP-Apps have become essential for academic institutions and academic libraries in particular. For instance, the literature review indicated that many international and regional academic libraries such as Leeds University Library, Harvard University Library, UAE University Library and King Fahad University Library have introduced these Apps to provide best services for their users. In the same vein, the study results show that most governmental KALs` users believe it is important to introduce an SP-App in their library for several reasons:

- It is very easy to use.
- Users can use it 24/7.
- It saves time and effort obtaining information.
- It is familiar for most users.

What are the main barriers, if any, that may hinder building an SP-App for KALs?

Dahlstrom, Walker and Dziuban (2013) found that inadequate battery life, slow network connections and device usability concerns were the top three limitations of using a smartphone as an academic tool. The present study results indicate that there are crucial difficulties facing governmental KALs' efforts to establish SP-Apps:

- A shortage of qualified individuals to manage this application.
- Some librarians' refusal to change and adapt to the new environment.
- Lack of budget.
- Lack of clarity about library management strategic objectives and vision for SP-Apps.
- Lack of library management awareness of the importance of SP-Apps, which they do not regard as a priority.

4. Conclusion & Recommendation

The majority of studies confirm that it is very important to use SP-Apps in academic libraries. Furthermore, according to several studies, the new generation depends on the use of smartphones. For this reason, it was necessary in this study to investigate how governmental Kuwaiti Academic Libraries (KALs) have responded to the rapidly evolving SP-Apps environment, as well as explore the level of e-services they provide. Unfortunately, the study results confirmed that the e-services of government KALs are limited and not satisfactory. In addition, the KALs still do not benefit from the features of SP-Apps like other academic libraries around the world such as the University of Leeds Library, Harvard University Library, Library of UAE and Saudi Arabia etc. In this regard, the researchers present recommendations that may contribute to the introduction of SP-Apps for KALs:

- The Ministry of Higher Education in cooperation with the KAL management should enact new policies, plans and strategies to improve the e-services in their libraries. Especially in the PAAETL, where the study results confirmed that the e-services and resources were very limited and need to improve.
- The successful theories and practices of SP-Apps in the higher education institutions and libraries of developed countries should be taken into account. Such practices have been fully tested for several years in different academic libraries. Adopting schemes already in existence would undoubtedly raise the credibility of the intended enterprises.
- It is important to modify the current situation via raising the level of government support and increasing the annual budget for academic libraries of the authorities responsible for

this issue as represented by the Ministry of Higher Education. This should be carried out in order to cope with tremendous global developments in information technology and communication as well as meet the needs of library users.

- Designing SP-Apps that have reliable content and user interface that is easy to use is a considerable challenge. For this reason, the study results highly recommend introducing SP-Apps for KALs as soon as possible.

While the study has provided new data about the SP-Apps in KALs, further aspects need to be considered in future research. The recommendations proposed are relevant to Kuwait. Further research may be useful in this field in other developing countries, in order to test or develop the suggested strategy. Moreover, the data and recommendations could be adopted for different scenarios; for example, different countries or other libraries.

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Smart Shoes for Visually Impaired/Blind People

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Abstract

Sight is considered the most important sense and the blind people are observed upon with pity by others. Technology helps the blind people to communicate with the environment, the communication process and the dissemination of information has become very fast and on a wider scale to include all parts of the world which greatly affected to the human life, thus increasing the ways of entertainment and comfort and reduced suffering and hardship in many things. Blind people are part of this world, so the technology must leave a significant impact on their lives to make what was impossible for them as possible and available to them today. The assistance provided earlier for blind people were as a particular hardware devices such as talking OCR Products, identifying color, barcode readers; that hardware were expensive and limited capabilities due to rapid change in hardware. The challenges faced by impaired/blind people in their daily lives are not well understood. In this paper, we try to present an application called SMART SHOES where is it's a way to give hand to blind people with the aid of technology in order to solve some of their faced problems. The Application results enhance the understanding of the problems facing blind people daily, and may help encourage more projects targeted to help blind people to live independent in their daily lives.

Keywords: VISUALLY IMPAIRED, BLIND PEOPLE, real time system, Arduino, Android, and voice recognition.

1. Introduction

285 million people are estimated to be visually impaired worldwide: 39 million are blind and 246 have low vision, about 90% of the world's visually impaired live in low-income settings where 82% of people living with blindness are aged 50 and above. Globally, uncorrected refractive errors are the main cause of moderate and severe visual impairment; cataracts remain the leading cause of blindness in middle- and low-income countries. The number of people visually impaired from infectious diseases has reduced in the last 20 years according to global estimates work and 80% of all visual impairment can be prevented or cured. (World Health Organization, 2017) (Parentcenterhub.org, 2017)

2. Related work

In the past, the visually impaired used to face difficulties in moving and transporting from a place to another. Some of them used to have a guide dog to help them walk around and to avoid collisions. Some of them used to ask for someone else's help. This inspired a lot of developers to develop products to assist the visually impaired and to make them feel more independent. Two of these popular products are: White Cane, and SonicGuide.

White cane also known as a "Hoover" cane, named after Dr. Richard Hoover who designed it. White cane is designed primarily as a mobility tool used to detect objects in the path of a user. But using a cane has some disadvantages. And some of these disadvantages are that using a cane is difficult while travelling. For example using a cane is difficult in a crowded restaurant, or in placing it into a car or a plane or even a bus. The White Cane is made from metal, which makes it heavy and inflexible and susceptible for snapping or cracking. Currently got some researches and experiments to develop an e-white cane. (Vera, P., Zenteno, D. and Salas, 2014)(Gassert, R., Kim et al, 2014)(Rizzo, J.R. et al, 2017).

SonicGuide is a smart head mounted device that uses a camera that takes pictures and analysis them based on an algorithm to find the abnormal objects in the way and warns the user by sending alarms to a connected earphone. But also this device has some problems on its own. It is heavy and wearing a device on the head all the time may cause pain and some neck injuries. It is also power consuming due to the camera that takes pictures all the time. Some research focus more on new Sonice Guide. ((Dunai, L. et al 2013, 2014) (Bujacz, M. and Strumiłło, P., 2016).

The Smart Shoes is not the only assistive walking device for the visually impaired people, there was some devices such as: Mini Guide (Sendero Group.com, 2017), and UltraCane (ultracane.com, 2017). We have studied the existing products well enough to develop a better and more efficient one. There is no perfect product, but there is always room for improvement. In Smart Shoes, we tried to give a hand to help those people. We have designed a small, wearable and a hands-free device that allows the user to use both of their hands while walking. Nevertheless we took care of battery issue, so we used the right hardware that does not as power consuming as the other devices.

Portability, low cost, and above all simplicity of controls are most important factors which govern the practicality and user acceptance of such devices. The Smart Shoes device is a kind of portable device. Hence it should be a small-sized and lightweight device to be proper for portability, the device should be easy to control: no complex control buttons, switches and display panel should be present. Moreover, the device should be low-price to be used by more blind persons. Our system is developed for portable (small size and lightweight), connected with Android application, easy to use, and low power consumption (supplied by battery).

2.1 Smart Shoes Project

Many blind people require travel aids to navigate in unknown environments. We present Smart Shoes project that enable the visually impaired users with mobility impairment to avoid obstacles. By leveraging existing robotics technologies, our system detects obstacles such as curbs, and staircases in the ground or even moving objects, and transmits obstacle information through haptic feedback (vibrations and beeps). Initial experiments show that our device enables human users to navigate safely in indoor and outdoor environments.

Being blind generally refers to a complete lack of functional vision. However, blindness involves varying levels of vision ability, sometimes under varying conditions. Vision is the result of light rays hitting the back of the eye, or retina, and then the optic nerve transmitting electrical signals to the brain. Blindness occurs when an inadequate amount of light hits the retina, or the information has not been delivered to the brain correctly. An examples of the targeted visually impaired users shown in table 1.

Table 1 Targeted Users.

	User	**Notes**
User 1	Legally blind person	Complete blindness
User 2	Color blind person	Also called “dyschromatopsia”
User 3	Night blind person	

The DFD for the SMART SHOES Android application part for SMART SHOES system shown in figure 1 where it will illustrate how the data flows in the system. The actions can be done by the Smart Shoes uses are shown in figure 2. The Smart shoes system composed of two main components: Mobile Phone and Shoes with sensors.

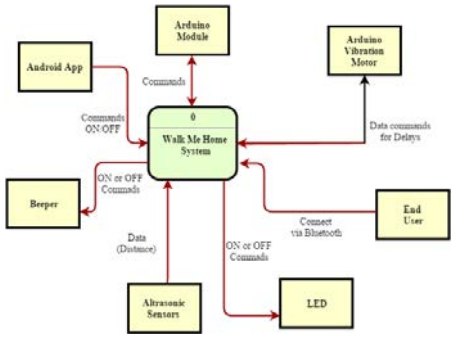

Figure 1 Smart Shoes DFD

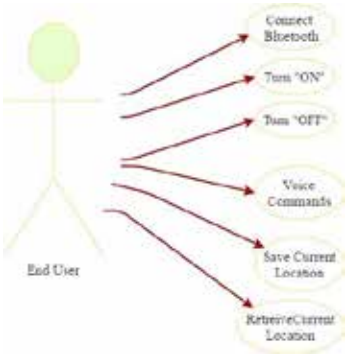

Figure 2 Smart Shoes Use Case

2.2 Smart Shoes Implementation

2.2.1 Database Implementation

For this project we used a database called TinyDB. TinyDB is a non-visible component that stores data for an app .Apps created with App Inventor are initialized each time they run: If an app sets the value of a variable and the user then quits the app, the value of that variable will not be remembered the next time the app is run. In contrast, TinyDB is a persistent data store for the app, that is, the data stored there will be available each time the app is run. An example might be a game that saves the high score and retrieves it each time the game is played. (Ai2.appinventor.mit.edu, 2017)

2.2.2 Graphical User Interface (GUI) Implementation

Graphical User Interface (GUI) plays a vital role in any system. It makes it easier for the user to accept, interact and understand the Project. The following figures show the basic Graphical User Interfaces implemented in "Smart Shoes" application.

For developing the interfaces of Smart Shoes project we used **AppInventor 2** in order to design and implement the android application. **App Inventor for Android** is an open-source web application originally provided by **Google**, and now maintained by the **Massachusetts Institute of Technology** (MIT) (Ai2.appinventor.mit.edu, 2017). The implemented interfaces shown in figure 3 and figure 4.

Figure 3 Splash Screen

Figure 4 Main Screen

The user of Smart Shoes system can use his mobile to save current location, where he can retrieve it later on to return back. This feature currently limited to one place only. To facilitate this feature, the Smart Shoes system allows the user to save and call back the location by voice command.

2.3 Arduino Components (Modules) used in the project

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing. (Arduino.cc, 2017). Figure 5 shows the Arduino Nano front view used in the Smart Shoes system, and figure 6 shows the Arduino Nano back view.

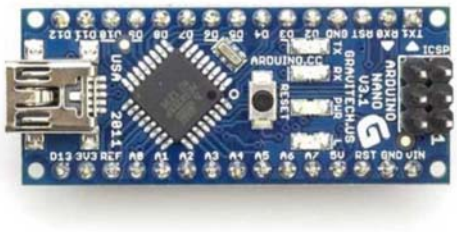

Figure 5 Arduino Nano front

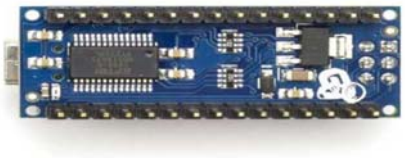

Figure 6 Arduino Nano back

Figure 7 shows the HC-SR04 Ultrasonic sensor interface Arduino used in the Smart Shoes system where figure 8 shows 433MHz Wireless Serial Transceiver Module - 1 Kilometer used in the Smart Shoes system.

Figure 7 HC-SR04 Ultrasonic sensor interface Arduino

Figure 8 433MHz Wireless Serial Transceiver

Figure 9 Bluetooth Module, **-** Figure 10 shows the rest of Smart Shoes components (Cables, Vibration motor, LED, Beeper).

Figure 9 Bluetooth Module HC-06

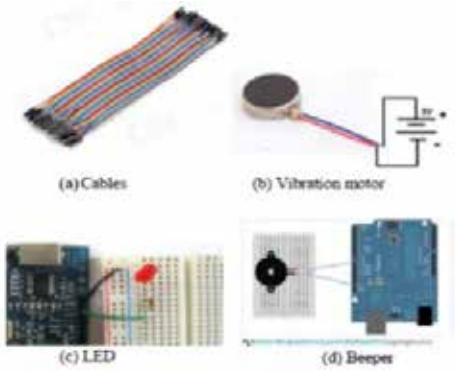

Figure 10 Arduino components

2.4 Smart Shoes Prototype

The prototype of Smart shoes is shown in Figure 11 where it shows the Smart Shoes with the attached device from front and side as well.

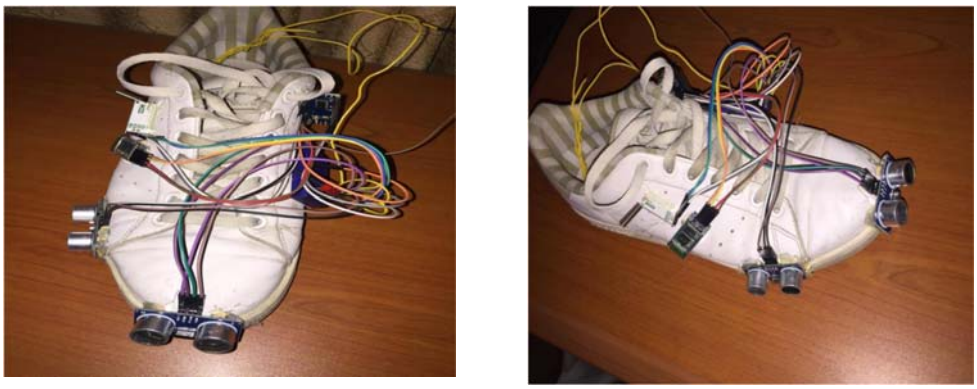

Figure 11 Smart Shoes Prototype

The shoes were supplied by different sensors as shown in figures (5-10) to sense the obstacles in front of the user or beside him, the shoes will beep if there is any obstacle in range of 5 meters, the beep will be louder if the obstacle is closer, when it will be less than 2 meters the beeping will be too loud and the vibrating sensor will be activated so the user will feel that.

2.5 Testing Results

System Testing is the process of evaluating a system or its component(s) with the intent to find whether it satisfies the specified requirements or not, also the process of analyzing a software component to determine the differences between existing and required conditions system and to evaluate the features of the system component and make sure that is satisfies the functional and non-functional requirements (Sharma, R.K. and Gandhi, P., 2016). There are many types of tests and should be considered in System Testing such as Graphical User Interface Testing , Usability Testing , Speech recognition testing , hardware testing , Installation Testing and Maintenance Testing (Hooda, I. and Chhillar, R.S., 2015) .

2.6 Heuristic Evaluation

Heuristic evaluation is usability expert's review your user interface, voice commands, and compare it against accepted usability principles. Heuristics for Usability Evaluation and their Descriptions: Visibility of system Status, Match between system and the real world, User control and Freedom, Consistency and Standards, Error prevention, Recognition rather than recall, Flexibility and efficiency of use, Aesthetic and minimalist design, Help users recognize, diagnose and recover from errors, Help and documentation (Rosa Yáñez Gómez *et al* 2014).

Heuristic evaluation was performed on our project including hardware and software by three IT experts who basically examined the interface and the hardware and gave us a beneficial feedback which it can be seen in table 2 where it shows the summary of evaluations by heuristics. Column 1 shows the number of heuristic, column 2 shows the frequency given by the experts out of 10, and column three is the heuristic frequency over total of frequencies. The ratio presented to show the percentage of the heuristics frequency for the whole system.

Table 2 Summary of evaluations by heuristics.

Numbering Scheme	Heuristics	Frequency	Ratio (%)
H1	Visibility of system Status	5	7.57
H2	Match between system and the real world	5	7.57
H3	User control and Freedom	5	7.57
H4	Consistency and Standards	10	15.15
H5	Error prevention	7	10.60
H6	Recognition rather than recall	6	9.09
H7	Flexibility and efficiency of use	8	12.12
H8	Aesthetic and minimalist design	5	7.57
H9	Help users recognize, diagnose and recover from errors	5	7.57
H10	Help and documentation	10	15.15
Total		66	100%

2.7 Cooperative Evaluation

Cooperative evaluations are a technique to improve a user interface specification by detecting the possible usability problems. It sets down procedures by which a designer can work with the sort of people who will ultimately use the software in their daily work. So that together they can identify potential problems and their solution. Twenty participants cooperate with us to test the project and gave us their feedback. During the evaluation session, participants were accompanied in order to help them when they face problems in performing a specific tasks. The result of a sample cooperative evaluation is shown in table 3.

Table 3 Cooperative Evaluation Tasks for participant.

Task no.	Task	Time Taken to complete the Task (seconds)
1	Explore application as visitor	40
2	Connect to the Bluetooth module	43
3	ON/OFF Buttons	10
4	ON voice commands	23
5	OFF voice commands	35
6	Remember voice commands	25
7	Walk me voice command	24
8	Save current location	10
9	Navigate the previously saved location	20

The summary of completing the tasks by the twenty participants is shown in table 4. The average of each task is shown in last column. The average of all participants is 278 seconds. The difference between the default and the average of twenty participants is 30 seconds.

Table 4 Task Completion Times in (Seconds).

Task No.	Default	Average
1	40	41
2	50	48
3	90	62
4	20	24
5	30	27
6	20	21
7	25	24
8	15	14
9	18	17
Total Time	308	278

3. Conclusion

There is no doubt that every project has its own weaknesses. In this section, we are going to mention the weaknesses of the Walk Me Home project. One of the weaknesses in our project, is that it is only compatible only on Android platforms. Another weakness is that the hardware is not waterproof yet. A third weakness in the mobile application is when the user asks the application to walk him home, they need to tap the navigate button on the right bottom corner, since they are visually impaired users, it is going to be a problem, and since we aim to provide the best product.

One of the strengths in our product that it's depending on voice commands. Since we are dealing with visually impaired users, this gives our product a strong advantage. The hardware we worked on helps not only the user, it also helps the other people nearby. For example, if someone is moving towards the user, and the user couldn't notice them, a connected beeper is going to make beeping noises to warn them.

The room for improvement still wide and open in this area. In particular this project can be improved by adding some other pieces of hardware into a device such as a Controller that fully controls the functionality of the hardware, by turning it on and off, connecting the device to the mobile application by Bluetooth technology, and also saving the current location and translating the voice commands. Another improvement is enhancing the mobile application by growing the database which allows the user to save more than one location to visit in the near future, also creating a community for visually impaired users, which allows them to interact with volunteers, and arranging possible meetings.

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Mining Association Rules from XML Data Techniques

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Abstract

The problem of mining association rules from XML has been attempted by many techniques, some techniques used indirect mining; the XML data will be converted into relational data in a preprocessing step and the mining algorithm will be executing on a preprocessed data and results will be post processed and viewed in XML format again. The direct technique does not require any preprocessing or post processing of the input data. In this paper we analyze those two methods for mining association rules from XML (direct and indirect methods).

Keywords: Mining Association, XML, Data, Data Techniques.

1. Introduction

Knowledge discovery in database (KDD) is defined as the "extraction of implicit, unknown, and potentially useful information from data''. The word implicit means that we are looking for information that is contained in the database, and unknown stands for a result or information we did not expect to have before. KDD consist of many steps and one of them is data mining. The knowledge discovery process takes the raw results from data mining and transforms them into useful and understandable information which can be used in different implementations and decisions making processes. This information is not typically retrievable by standard techniques such as query languages but is uncovered through the use of artificial intelligence techniques.

2. Web mining and association rules

A rapid growth of data on the web has led to web mining. Web mining is the process of applying data mining techniques to the content, structure and usage of web resources, mainly XML data and other semi-structure data in order to find a structure or patterns from the web pages. Like other data mining applications web mining can use the structures on the web and it can be applied on semi-structure or unstructured data like tree form text.

Association rule techniques were introduced by (Agrawal, Imieliński and Swami, 1993). It is one of the main techniques of data mining and it is widely used these days. Initially it was designed for market basket analysis. This analysis represents the set of items purchased by a customer from a supermarket. The purpose of this analysis is to mine and extract the customer behaviors and patterns of buying items. So that it can help promoting and advertisement purposes. The output of this analysis is a knowledge that can't be extracted using simple queries from a database. And hence it shows the value of association rules.

It is noted that the overall performance of mining association rules is determined by the first step which is the most time and input output consuming. After the large items are identified the generation of the association rules is just a straightforward and can be derived from the large items. The amount of frequent items play the major role in the number of rules generated. A high support threshold will lead to the reduction of the number of frequent items and also the number of association rules, since association rules is the result of intersection the frequent items. In order to check the support and confidence of the rules we might need to refer to the original data to count (depending on the support counting mechanism of each algorithm) (Agrawal, Imieliński and Swami, 1993).

3. XML

Extensible Markup Language (XML) (Anon, 2017) is a text file format for representing tree structures in a standard form. The whole structure of an XML document, if we abstract over less

important details, is a tree of variable nodes, in which nodes are labeled, leaves of the tree are text nodes, and the ordering between children of a node is significant. XML can be seen as a concrete syntax for describing such tree structures using mark-up texts.

XML is adopted among several applicative settings, such as, data integration, online documentations, electronic commerce, legacy as well as scientific data repositories, applications of data exchange, digital libraries, and information systems, on the Web. XML structure represent an important source of supplementary information with respect to textual content (Costa, Ortale and Ritacco, 2013).

XML data is different from relational data in several respects. The most obvious one is that relational data tend to be flat and have a regular structure, whereas the structure of XML data can be varied. On the other hand, XML data may be heterogeneous (for example, an XML element may consist of various types of value. And user-defined tags are store throughout the document. In order to mine XML data, additional efforts may be required.

4. Mining Association Rules from XML Data

Mining association rules from XML has been attempted by many techniques, ((Guleria, Sharma and Sood, 2015) gave an overview of some of the association rules algorithm) some techniques used in indirect mining approach. In this approach, XML data will be transformed into relational data (or flat file) in a preprocessing step and the existing mining algorithm will be applied on a relational data and results will be transformed into XML format again. Figure 1 below describe the process of transformation of data from XML to relational and then to XML again. An example of this approach can be found in (Braga 2002), which used XMINE operator to extract association rules from XML documents.

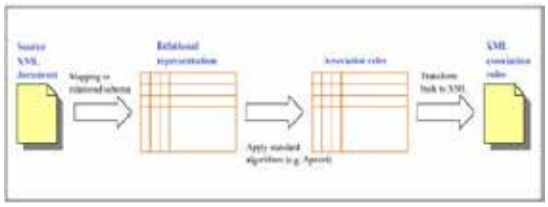

Figure 1 Indirect Mining Processes.

Another approach is to extract association rules from XML documents directly without any pre-processing or post-processing of the data. Such approach have many directions as well we highlight two of them; 1) mining XML using a Query language for XML where the mining algorithm (Apriori) will be embedded within the query language. There is many query languages such as XQuery and Xpath. A good example of mining association rules using a query language as described in the figure 2 below.

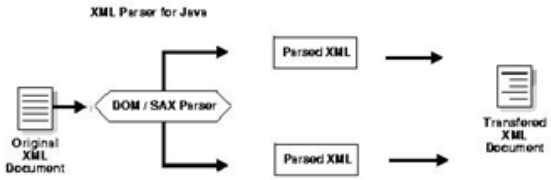

Figure 2 Direct Mining Techniques.

Another direct mining technique is to use a high level programming language that support direct access to XML like Java which support accessing XML files using DOM or SAX, a comparison can be found in (A Comparison of Association Rule Mining Methods for XML Data, 2012).

5. Indirect Mining Methods

5.1 XMINE Operator

XMINE operator was first introduced by (Braga 2002), and used to mine association rules from XML documents. The purpose of designing XMINE operator is to satisfy the need to extract interesting information from XML documents by taking full advantage of the intrinsic properties of XML.

The XMINE operator is based on XPath and uses XQuery-like syntax to retrieve data from XML documents. The actual mining process will be performed by MINE RULE. MINE RULE is a SQL-like operator for mining association rules from relational data. In general, the process of using XMINE operator to extract association rules from XML documents can be divided into three phases. In the first phase, it uses XPath expressions to locate data in the source XML document, then using XQuery-like syntax to retrieve data and to specify the constraints (minimum support and minimum confidence). The retrieved XML data are transformed into relational format for the second phase.

In the second phase, the XMINE operator uses MINE RULE to do the actual mining task. MINE RULE uses the constraints specified in the previous phase to mine association rules, such that the rules with support and confidence greater than the user-defined thresholds are generated. In the third phase the output of MINE RULE which is in relational format where mapping the XML data to a relational structure is transformed back to XML.

5.2 XAR-Miner Framework

A new proposed a framework, called XAR-Miner, for mining ARs from XML documents efficiently have been proposed in [12]. In XAR-Miner, raw data in the XML document is first preprocessed to transform it into either an Indexed Content Tree (IX-tree) or Multi-relational databases (Multi-DB), depending on the size of XML document and memory constraint of the system, for efficient data selection and AR mining. Task-relevant concepts are generalized to produce generalized meta-patterns (high level patterns), based on which the large ARs that meet the support and confidence levels are generated.

The framework of AR mining of XML data consists of the following major parts: (1) Pre-processing (i.e., construction of the Indexed XML Tree (IX-tree) or Multiple Relational Databases (Multi-DB)); (2) Generation of generalized meta-patterns; and (3) Generation of large ARs of generalized meta-patterns.

The preprocessing work of XAR-Miner is to extract information from the original XML document and transform them into a form that is suitable for efficient AR mining; an Indexed XML Tree (IX-tree) when all the XML data can be loaded into main memory, or Multi-relational Databases (Multi-DB) otherwise. So decision is done according to the XML data size and the main memory available to select the proper strategy for XML data transformation and storage before AR mining tasks are performed.

If the size is bigger than memory available, XML data will be transformed into Multi-relational Databases to accommodate the extracted XML data. In this architecture, an XML document will be transformed to a few relational databases, each of which will store the indexed structural values of a leaf node in the XML document.

6. Direct Mining Methods

6.1 Extracting Association Rules with XQuery

XQuery is designed to be a general purpose XML query language, it is often very difficult to implement complicated algorithms such as FP-growth algorithm discussed earlier.

Extraction of association rules from XML documents directly without any pre-processing and post-processing of the data can be done by using Xquery. This technique uses a structure of XML document and a mining algorithm such as APRIORI implemented in XQuery and the results are produced in XML format as well. No pre-processing or post-processing is required for this technique (WU, 2008).

The above technique is based on implementing a mining algorithm that can mine relational data, onto an XML data using XQuery hence the XML mining process depends mainly on the mining algorithm itself. In another words, it depends on the implementation and the choice of the language to access and process XML (Harbarth, 2003).

XQuery has some limitations; hence it affects the performance of data traversal. The choice of breadth first search or depth first search is considered when traversing XML file. In their approach (Cho, 2014)

6.2 Extracting Association Rules using Java Based Applications

A novel approach for mining association rules from XML document by using programs written in a high level programming language. Most of implementations of such approach require the input to be in a custom text format and do not work with XML documents directly. In order to adopt this approach to XML data, it requires an additional step for converting the XML data into the custom text files. This step often affects the overall performance of this approach. If the programs are coded in Java platform then it can work directly with XML documents. This offers more flexibility and performs well compared to other techniques.

Java platform provides flexible techniques to handle XML documents. Programs written in Java can access XML documents in one of the following two ways.

1. Document Object Model (DOM): This allows programs to randomly access any node in the XML document, and requires that the entire document is loaded into memory.
2. Simple API for XML (SAX): This approach follows event-driven model and allows programs to perform only sequential access on the XML document. And it does not load the entire document into memory.

The input format made of an XML document contains one root level element called the transactions with the corresponding opening and closing tags. Within that tag a list of transactions with id that contains elements. The implementation outputs the association rules and its corresponding support and confidence in XML format which is an optional feature since the normal form of " X →Y "is more user friendly support and confidence. Comparing this implementation with XQuery implementations of Apriori shows that Java based application perform much better when dealing with mining XML data.

New direct mining approaches can be found in (Dr. V.D. Kulkarni et al., 2012) where association rules are mined directly from XML documents, without transforming the data into any intermediate format. It looks for general association rules, without the need to impose what should be contained in the antecedent and consequent of the rule, and it stores association rules in XML format again using a tree based association rules miner.

7. Conclusion

Traditionally, data mining techniques are used to mine information from structured data. Recently, with the widespread use of the Web, semi-structured data is becoming more widespread. The semi-structured data can be effectively represented using XML. Using traditional methods to mine information from XML data directly does not work, because they assume that the data or documents being mined have complete information and a regular structure, so, there is a need to develop a new method for mining information from XML documents directly.

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Towards Sustainable Knowledge Management in Construction Site

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Abstract

Knowledge management is the discipline of creating learning environment that encourage the continuous creation, use and re-use of both companies and employees knowledge for new business value, and to provide solutions in the critical cases based on pervious experiences.

Developers and management team in the construction industry interested in creating safe, green, and sustainable construction site. Pursuing this goal is often face financial and technical limitations.

The objective of an ongoing study is to design sustainable knowledge management documentation tool to document any safety violation, accident, and unhealthy behaviors inside the construction site. The study also aims to increase the use of knowledge management and sharing the information which will enhance the safety and health during all the stages of construction.

The proposed system will integrate building information model and knowledge management under one platform, which will help user to cut cost and save time, enabling easy and automatic access and retrieval of the right information to the right people at the right time.

This paper review the outlooks of key professionals in the field of construction management in United Arab Emirates, the views were collected via questioner survey and face to face interview. One of the interesting findings during the interview was highlighting that different managers tend to act in different ways based on their previous experience. Sharing previous experience using sustainable knowledge management tool will certainly be valuable addition to the industry.

Keywords: Sustainability, Knowledge management, construction, BIM.

1. Introduction

Knowledge is the result of a combination of expertise, values, personal approach, know-how, technical abilities, skills, successes and failures that individuals and organizations acquire from personal, social and organizational interaction. Since construction has become a knowledge-driven industry, the proper management of all the knowledge involved has become a fundamental element to address activities under the sustainable construction path.

To achieve this goal construction counts on the support of knowledge management as a key process that enables capability and innovation development, cultural changes, the transfer of knowledge and lessons learned from the various stages of each project and from one project to others. This allows better decision making, performance and competitiveness improvements and customer satisfaction thanks to the reduction of mistakes and of work repetition and allows an easy adaptation to changing conditions while promoting construction sustainability and sustainable development.(Tan H. et al, 2010), (Kamara J. et al, 2002), (CEN, 2004), (Egbu C. et al, 2004)

The Building Information Model (BIM) is gaining a wider recognition in the international construction industry and an important field of future research can be to integrate the knowledge management system with the (BIM) under a joint media which serves to eliminate wasting resources and time resulting from duplications. When a project is completed its BIM is handed to the owner. Research work needs to finds solutions whereby the information management system can capture the learnt lessons during the project's life embedded in the BIM and store them in the organizations files for future reference. (Egbu C. et al, 2005)

2. Problem Formulation

Large projects are typically 20% longer to finish than scheduled and 80% more expensive, the industry still making less use of new digital solution due to cost, and technical limitations, it is also reported that research and development spending in the construction industry is one of the lowest among other industries with less than 1% of the revenue, that low percentage also applies to the investment in information technology solutions to be one of the least digitized industries (Agarwal R. et al, 2016).

The above statistics shows lack of sustainable long term approaches to enhance construction industry.

3. Problem Solution

Time is a very important in the construction industry being a decisive factor determining profit loss or profit made. The required quick response to site conditions not foreseen during design and the fact that professional staff might leave the project team before project completion dictates the strong need for a knowledge management system. This system helps to save the gained experience and make it available to the project or other similar projects.

Knowledge management tools locate the required information and forward it to the relevant destination quickly and efficiently. It can also provide access to information in other construction sites and to the design team. The Building Information Model (BIM), which is being recognized by the construction industry as a suitable and efficient project programming control system, can be integrated with existing knowledge management systems avoiding resources duplication wasting, this integration will help to drive the industry towards more sustainable forms of construction. (Egbu C. et al, 2005)

A knowledge management system is required for this association. The integration of knowledge management documentation system and building information model under one platform was discussed as a preferred system in the construction industry however developing a model incorporating all aspects of this system was identified as a future research topic.

VR simulation can be used for the adoption of comprehensive knowledge management system since it includes all of the elements required for active learning. The simulation utilizing this VR feature, is found to be feasible in safety training and for the assessment of construction workers' learning results (Xie H. et al, 2006).

4. Data Collection and Data Analysis

In order to embark on developing the systems required for this researches it was necessary to seek practical site experience through a survey.

The objectives of the survey were to establish whether knowledge management documentation system exist on construction sites, if its output is monitored by the relevant staff, the survey of six specifically related questions was distributed to six construction managers. This was followed by a personal interview with each member to better understand their reasons behind the views expressed in their answers shown in Table 1.

Table 1 Knowledge management questionnaire results.

Question	Yes	No
Do you have Knowledge management documentation system in your construction project?	5	1
Do you agree that knowledge management documentation system will help in spreading the knowledge through the team?	6	0
Do you agree that knowledge management documentation system will help to prevent similar mistake from happening again?	4	2
Do you think that Integrating the knowledge management documentation system with BIM under one software platform will provide efficient control in construction industry?	6	0
Do you think that the above integration will help in accident investigation?	6	0

5. Results

The results indicate the existence of knowledge management documentation system in construction industry.

Figure 1 below shows that 83% of the participants have Knowledge management documentation system in their construction project, however during the interview all of them indicated that the systems which are currently in place are paper based knowledge management, these systems are far from being sustainable waisting time and resources which can be easily addressed using electronic documentation system.

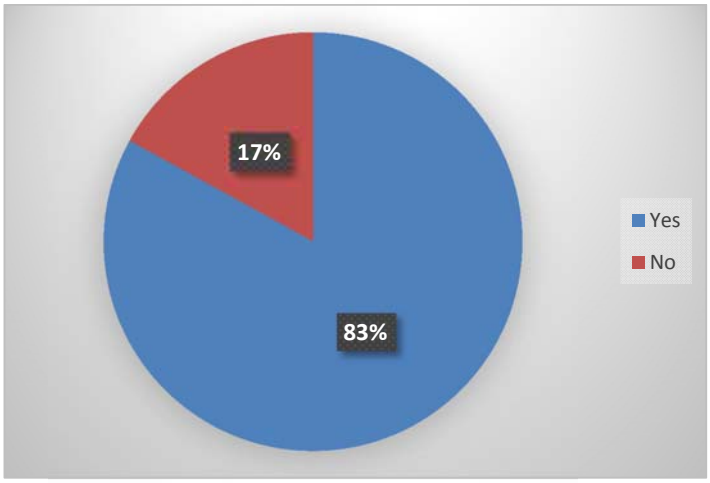

Figure 1 Responses to ''Do you have Knowledge management documentation system in your construction project? ''

A person having specific knowledge and working within the organization is a single data source which the knowledge management process has to share the information regarding his experience. Organizations can leverage experience by making use of their knowledge management efforts. This fact reflected clearly in figure 2 below, the figure shows that 100% of the participants agreed that knowledge management documentation system will help in spreading the knowledge through the team.

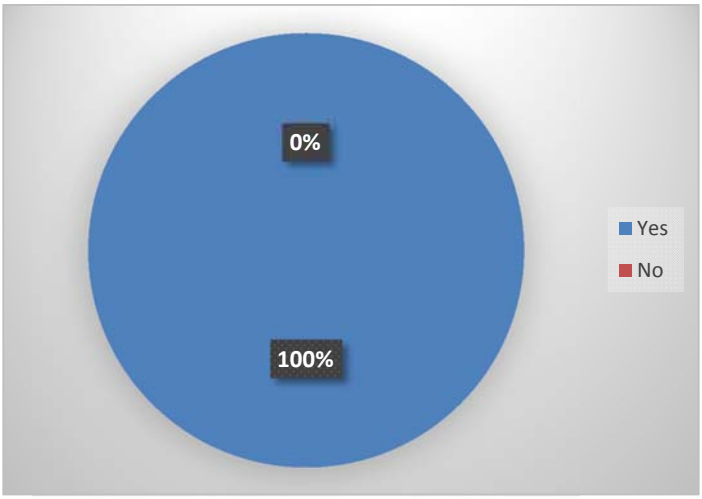

Figure 2 Responses to ''Do you agree that knowledge management documentation system will help in spreading the knowledge through the team? ''

Figure 3 below shows that 67% of the participants agreed that using knowledge management documentation system will help to prevent similar mistake from happening again

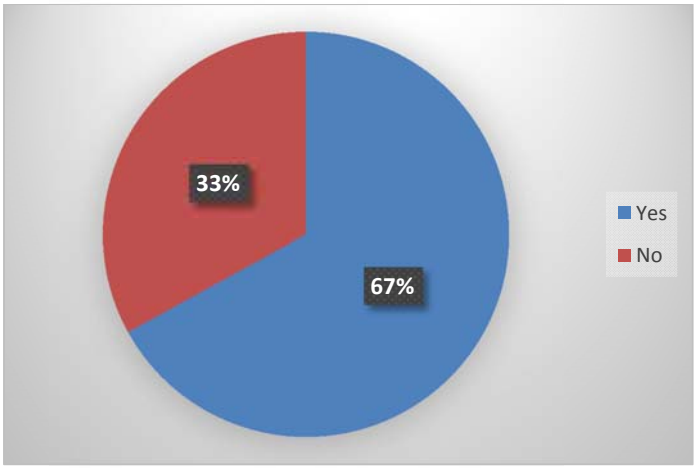

Figure 3 Responses to '' Do you agree that knowledge management documentation system will help to prevent similar mistake from happening again?''

In the modern construction industry, the project team needs to have a quick response in order to achieve the objectives of the organization which makes the effective knowledge management very important. This fact dictates that knowledge management should be an important factor in the business strategy of any company making use of the learnt lessons from previous projects. This fact reflected clearly in figure 4 below, the figure shows that 100% of the participants agreed that integrating the knowledge management documentation system with BIM under one software platform will provide efficient control in construction industry

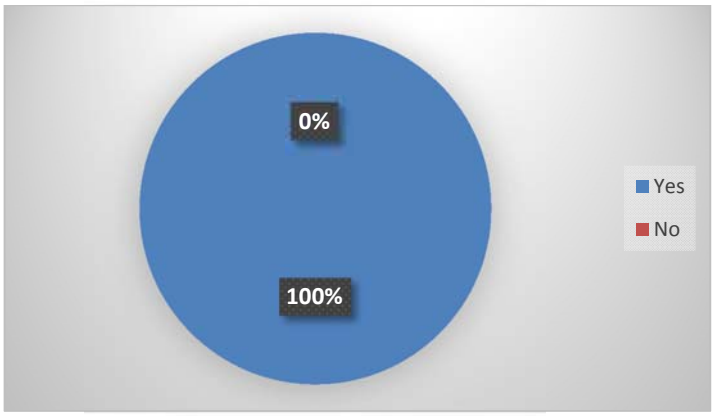

Figure 4 Responses to '' Do you think that Integrating the knowledge management documentation system with BIM under one software platform will provide efficient control in construction industry?

The impact of knowledge management documentation system monitoring on the sites safety was measured by the frequency of interaction between the two. The results in figure 5 shows that 100% of participants use knowledge management documentation system in reviewing the safety conditions on ground. This is a very positive result indicating the importance the site management in accident investigation.

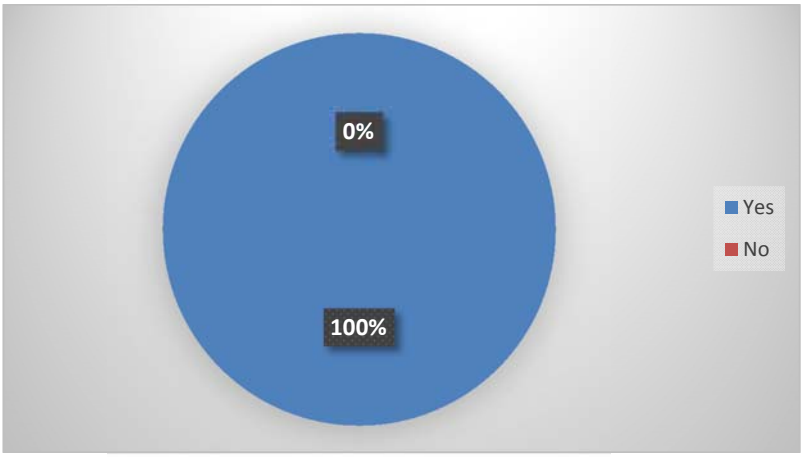

Figure 5 Responses to '' Do you think that the above integration will help in accident investigation?

The interview helped to clarify this results as the managers expressed the view that different managers tend to act in different ways based on their previous experience. A recorded accident and the way it was dealt with which is archived in the knowledge management system can only serve as a guide and hence cannot be translated into a mandatory policy. In this respect, it cannot be said that the previous recommended preventive measures have to be adopted and hence similar accidents will be prevented.

The participants also showed concern to the system's access authorization. As the system has only two modes of operators, some interviewed managers wanted further classification in order to secure the project's information and safeguard against unauthorized access.

6. Conclusion

This paper has shown that although the use of IT tools for sustainability in construction are readily available, there is still a need to enhance the way knowledge circulated and start the implementation of sustainable knowledge management tool The Building Information Model This need was determined from interviews construction managers working within different contracting companies in Dubai, Integrating knowledge management documentation system with BIM in one platform can be translated into a sustainability management tool for construction projects, and that integration will avoid resources wasting, and will help to drive the industry towards more sustainable forms of construction.

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Section 6

Entrepreneurship

Critical Success Elements for Small and Medium Enterprises: Perceptions of Entrepreneurs in Bahrain

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Abstract

The aims of this research are to scrutinize the perceived critical success elements of Bahraini entrepreneurs, to identify how Bahraini entrepreneurs perceive critical success elements for small and medium enterprises' and how they are considered as more important in terms of these elements. SMEs contribute significantly to the economic development and growth, particularly to innovation, job generation and international competitiveness. A total of one hundred entrepreneurs were surveyed through a random convenient sample. The analysis is based on the outcomes of the questionnaire survey that was given out to a sample of Bahraini entrepreneurs. In addition, eighteen elements are categorized in five dimensions (i.e. management, performance, employees and team environment, product and sales promotion, and government's support).

The researchers hypothesized that there is a significant relationship between the critical dimensions of success (management, performance, employees and team environment, product and sales promotion and government's support) and the success of small and medium enterprises in Bahrain. They also hypothesized that critical success elements for small and medium enterprises' perceptions of Bahraini entrepreneurs are consistent and well recognized. Findings revealed that there is a significant relationship between the critical dimensions of success and success of SME's in Bahrain, and these critical success dimensions perceptions of Bahraini entrepreneurs are consistent and well recognized.

Keywords: Small and medium enterprises, enterprises success elements, successful enterprise.

1. Introduction

Small and medium enterprises are one of the main drives for growth and economic diversification and contribute significantly to economic development and contribute significantly to creation of jobs and innovation. They provide local jobs, and can exploit the opportunities from globalization. It is generally agreed that economic diversification and job creation for Gulf nationals will not succeed if SMEs do not play a substantial role in the process (Ashoor & Ashoor, 2013). Small and medium business owners try their best to organize resources and generate new jobs. What assists them in comparison with larger companies is their greater flexibility in being able to respond to shifting markets and their ability to produce new products and services to market much faster than larger companies (Scozzi, 2005).

In Bahrain, SME's are widely viewed as important to the growth and stability of the economy because of their importance, varieties of programs have been assigned by government to support them. The Bahraini Small and Medium Enterprises Society, is an organization dedicated to the economic future of Bahrain. The society is run by a board as one of the premier groups in Bahrain that work with a range of emergent entrepreneurs, existing business partners, industry contacts and established authorities in the kingdom to bring about prosperity. Further, Tamkeen, The Bahrain Development Bank and The Bahrain Chamber of Commerce and Industry, is providing SMEs with development, funding, consulting and training programs. These have been developed by the government to enable the Bahraini entrepreneurs raise capital to start and develop an enterprise. It is broadly believed that entrepreneurship has a positive impact on social development and economic growth (Carree & Thurik , 2002)

2. Literature Review

The definition of SMEs adopted in this research is based on the definition provided by 'The Ministry of Industry, Commerce and Tourism, Kingdom of Bahrain'. Table (1) defines SMEs according to the number of employees, capital investment (BD), manufacturing section and annual turnover (BD).

Table 1 Categories and other details of SMEs'.

Category	Number of Employees	Capital Investment (BD), Manufacturing Section	Annual Turnover (BD)
Small	11 – 50 (up to 100 for construction sector)	20,001 – 500,000	100,001 – 1 Million
Medium	51 – 250 (up to 400 for construction sector)	500,001 – 3 Million	1,000,001 – 5 Million

It is usually deemed that one of the main barriers to the new SME development in the GCC and in Bahrain particularly is that the people and citizens of these countries are more fascinated by joining the public sector, since it provides a good sustainable option for employment. Such tendency supposedly gives more job security, benefits, short working hours, acquaintance with fellow workers and relatively acceptable wages that make the public sector more desirable for those looking for jobs. As a result, this has created an inflated public sector with lower productivity (Darwish, 2014). Identifying this issue encouraged the researchers to scrutinize the elements that lead to SMEs' success. This is to help decision makers to establish sustainability in the economic cycle and to lower the economic burden on the government.

It is shown that clear goals, top management support, client consultation, availability of technology, client acceptance, monitoring and feedback, good communication and troubleshooting to handle unexpected crises are considered as the success elements for SMEs (Pinto and Rouhaianen , 2011) .

Many studies such as (Chawla et al., 2010, Benzing et al., 2009, Hung Manch et al., 2007, Yusuf, 1995) showed that management skills, customer service and environmental conditions are critical for business success. (Coy et al., 2007) pointed out that good customer service and product quality were the most important elements for business success.(Rose et al., (2006) showed that the entrepreneurs high educational level and long experience had a positive relationship to their success.(Wijewarden and Zoysa, 2005) pointed out that "…customer orientation, product quality, efficient management, marketing strategy and supportive environment ." are elements that had positive impact on the success of SMEs.

Referring to literature, we identified the elements of success studied by various scholars and designed them to be the basis for this research. The researchers reviewed the literature for those scholars who identified the elements of success which are used in the research model. The research model was based on what has been revealed by previous research, then it was structured in a theoretical model and tested accordingly. This research is conducted in subjection to the previous work done in this area. Eighteen success elements are categorized in five dimensions leading to business success as follows:

2.1 Management

The role of top management has been considered as a very critical factor that affects the success of any enterprise. Business is seen as not only a dependent on management for authority and direction and support, but as ultimately the medium for implementing business goals (Beck, 2005). Management support may involve aspects such as allocation of sufficient resources (financial, manpower, time etc. (Achanga et al., 2006). In fact, good leadership has a very important role to play in the success of any enterprise. The model of integrated competing values clarifies the leadership style that the manager might adopt.

Within this model, there are five operational roles. Mainly, innovators that create, encourage and facilitate change and a broker that develops scans and maintains networks to acquire needed resources. In addition, a deliverer that works to motivate behavior, sets goals and

clarifies roles and a monitor that ensures rules & standards are met and checks on performance. Finally, a developer that is aware of individual needs and facilitates development (Vilkinas and Cartan, 2006).

Given the previous points, clear organizational goals and objectives serve basic functions as providing guidance and direction, facilitating planning, motivating and inspiring employees and helping organizations evaluate and control performance. Evaluation and control allows organizations to compare their actual performance to their goals and then make any necessary adjustments. Clear goals and objectives allow employees to monitor their own progress all year round and correct their efforts as necessary (Jerome et. al., 2014). By the same token, management commitment is an important element in helping employees to successfully do their jobs. This is the level of management commitment that is required for any initiative to be successful. Management commitment includes activities such as communicating enterprise's quality value, reinforcing quality messages, meeting with the work force and the customers giving formal and informal recognition, receiving training and training others. Managers develop and facilitate the achievement of mission and vision and develop values required for long term success (Kermati and Azadeh, 2007).

2.2 Performance Dimension

It is believed that the empowerment is crucial to employees in order to perform their jobs and succeed. They do their best when they feel trusted and empowered to create, solve problems and take actions. Empowerment is an authority in terms of encouraging and allowing individuals to take personal responsibility for improving the way they do their jobs and contribute to the organizational goals to improve productivity and satisfy the customers (Bateman and Sneel, 2002). Entrepreneurs must look into this as a major element to achieve success and raise performance which is the ultimate cause of any business, therefore the monitoring and evaluation of performance play a very important role in the enterprise's success. They provide the required checks and balances for ensuring that the plans and objectives are achieved (Mauricio and Carlos, 2002). On national and international scales, sustainability criteria and indicators for monitoring and evaluation of performance are important tools for enterprise's management towards goals and influencing policy and practices (Margoluis and Sakafsky, 2010).

Further, effective communication is needed for a successful business. The transfer of information from sender to receiver under the condition that the receiver understands the message is known as "communication" (Weihrich, Koontz, 1998). Business communication can be inside the organization known as internal communication and outside the organization known as external communication. Organizational communications proves to build up relationships among the employees in the workplace as it helps in facing changes within the organization and provides a strong basis in case of a management crisis. Good communication raises staff's moral and contributes positively towards achieving the strategic goals of the organization (Fox, 2006) .The final element that needs to be considered is troubleshooting to handle unexpected crisis or mishap and deviation from plan. This is a strategy for developing problem-solving skills that can be applied to any field or problem. It is a complicated skill, as it involves information management, overcoming failure and creativity in finding solutions and problem solving (Rugarciaet.Al., 2000). In addition, managers occasionally face unexpected problems and out-of-control crisis that could threaten their enterprises. Troubleshooting skills provide managers with a comprehensive toolkit that enables them to react effectively to unexpected disruptions (Parlak, 2004).

2.3 Employees and Team Environment Dimension

The work done by Fortune and while (2006) showed that qualified staff is at the heart of any enterprise and provides sustainability and development for the business. A leader should work on building a team that can provide continuous improvement to the business. This improvement includes not only the ability to complete a given task, but to think beforehand, innovate and continuously improve. Qualifications generally fall into two categories; technical Skills which are based on past trainings and education or through the experience, and community Skills which provide the platform to interact in a positive and constructive manner. A qualified staff fulfills the requirements of both technical and community skills. Equally

important, training is a very crucial element towards the success of any enterprise. By selecting the right type of training, the business ensures that the staff possesses the suitable skills for the task they are meant to carry out to help meet the current and future business requirements. Further, it assists in addressing staff weakness, improve staff performance, increase their productivity and decrease cost (Apospori et al., 2008). Coupled with employees' satisfaction, it is critical that entrepreneurs pay attention to the satisfaction of their staff. Employees expect to be appreciated for their performance by their managers as this would result in more productivity that would eventually lead to higher profits for the business. (Branham, 2005) explains if the staff members feel that they are not treated fairly, they are going to look around for better opportunities to proceed further with their career. Since retention rate is a good indicator for success then Employees' satisfaction will result in a good retention rate (Rudman, 2003)

Further, team environment which is defined by Scarnati (2001) as a "cooperative process that allows ordinary people to achieve extraordinary results". Successful team work relies upon the synergy existing between all team members creating an environment where they are all willing to contribute in order to promote a positive, effective team environment where goals are achieved through collaboration and social interdependence rather than individualized, competitive goals (Luca and Tarricone, 2001).

Moreover, the use of technology is regarded as a key provider of openings for businesses. The conclusive advantages can be considered as increased markets, improved goods and services, decreased costs, increased paths for communication, substantial productivity gains, innovative ways of doing business and more effective and efficient business processes (Zhu and Kraemer, 2006). As internet and related technologies open new markets for suppliers, business partners and customers, more and more businesses are employing the network to involve value chain activities (Chong, 2004).

2.4 Product and Sales Promotion Dimension

Without sales, there would be no business in the first place, therefore it is important that the businesses in order to succeed must have a sales promotion plan in place. Sales is important to the business as it will not only assist in increasing revenues but will highly impact the purchasing behavior of customers (Liao et al., 2009). Sales will not nurture without the good quality of the product which is considered as a critical factor of enterprise's success as there is a strong positive relation between product quality and enterprise's profitability. High quality produces a higher return on investment. Product quality has been recognized as a strategic organizational priority as it is a critical component in the design and manufacture of products which are considered superior to those of competitors. Enterprises pursue product quality, the presumption that it will improve their competitive position, business success and differentiate their products. Customers increasingly expect products to be high quality (Dunk, 2007). Active listening to clients is equally important as it is crucial for customers to notice that entrepreneurs have not just heard them but also are listening to them. Listening to clients can increase their trust and confidence in Business (Artika, 2009).Moreover, suppliers' good performances have a critical importance in determining the success of business by assuring the availability of raw materials for goods and services provided. Suppliers are of vital importance to develop operational procedures and business performance throughout the supply chain. Improved supplier's performance assists in accomplishing the overall organizational excellence (Estampe et al., 2013).

2.5 Government Support Dimension

This has a fundamental role to play in generating the conditions necessary for enterprises to emerge and develop. "The government assistance offered to SME's can be divided into two sub-groups, financial assistance which includes various forms of investment incentives and soft policy loans and Technical assistance which includes human resources training, export promotion initiatives and quality and technology programs." (Fajnzylver et. al., 2009).

2.6 Business Success

For the purpose of this research the researchers will adopt (Perez and Caninno, 2009) definition of a successful enterprise as being "an organization that makes current customers happy and gets new customers while earning a profit."

3. Methodology

3.1 Research Problem

Referring to the literature review above, it is noticed that there are various opinions of researchers regarding the concept of success elements. It is necessary for entrepreneurs to consider strategies to achieve success taking into consideration working environment changes and challenges. For these reasons, this paper aims to identify the critical success elements for small and medium enterprise's perceptions of entrepreneurs in Bahrain, and what is considered as more important in terms of these elements.

3.2 Importance of the study

This study is considered important because it is conducted in Bahrain, this adds value to the research because it is in a different economic set up. Although the government of Bahrain is showing great interest strategically in developing entrepreneurship culture. Researchers will have a good knowledge of how these elements are perceived by Bahraini entrepreneurs.

3.3 Research Objectives

The objectives addressed by this research are as follows:
To identify the critical success elements for small and medium enterprises' perceptions of entrepreneurs in Bahrain. Further, to recognize how entrepreneurs distinguish between the different elements of success according to their impact on the success of their businesses.

3.4 Research Hypotheses

Hypothesis 1:
There is a significant relationship between the critical elements of success (management, performance, employees and team environment, product and sales promotion, and government's support) and success of small and medium enterprises in Bahrain.

Hypothesis 2:
Critical success elements for small and medium enterprises' perceptions of Bahraini entrepreneurs are consistent and well recognized.

3.5 Research Framework

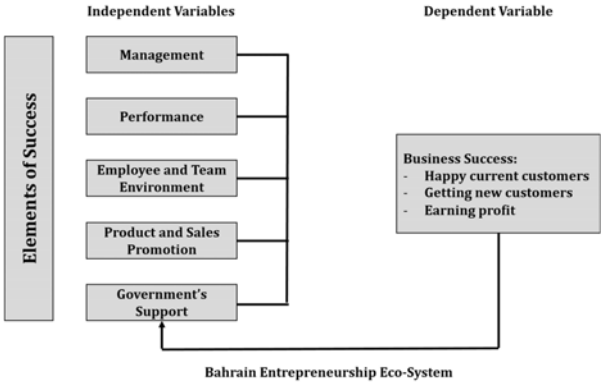

Figure 1 Illustration of the Research Framework.

3.6 Population of the study

The researchers selected a convenient random sample (n=100) of entrepreneurs in the Kingdom of Bahrain. This number is considered suitable to formulate an idea about the perceptions of Bahraini entrepreneurs regarding small and medium enterprises' elements of success, and is reasonable to produce the required analogy. The sample provided information through filling in a survey questionnaires which is considered the core of data for this paper.

3.7 Data Collection

A five-point Likert was used to collect questionnaire survey as follows:

5	4	3	2	1
Very important	Important	Somewhat important	Not important	Not important at all

The number of 130 questionnaires were circulated and a total of 110 were collected. Ten of them were incomplete, so we discarded them. One hundred were considered with a response of 84.5 %.

4. Analysis, Discussion and Results of Statistical Analysis.

4.1 Reliability:

The data were analyzed using SPSS and below you find the statistical results with the discussion of the result of Cronbach Alpha:

Table 1 Cronbach Alpha.

Reliability Statistics	
Cronbach's Alpha	**No. of Items**
0.835	18

The Cronbach's Alpha is 0.835, indicates a high level of internal consistency for the research questionnaire with this specific sample which confirms that the measurements used in this study indicates a high level of internal consistency for the research questionnaire

4.2 Frequency Distributions Results:

Some good results are shown in the overall frequency distributions for every dimension and every variable:

Table 2 Frequencies of output from SPSS (Management).

Item	Very Important	Important	Somewhat important	Not important	Not important at all
Top management support	34 34%	37 37%	18 18%	10 10%	1 1%
Good Leadership	39 39%	43 43%	14 14%	3 3%	1 1%
Clear Goals and Objectives	36 36%	48 48%	16 16%	*	*
Management Commitment	39 39%	41 41%	16 16%	3 3%	1 1%

The results of Table (2) show concerns about the top management support, more than quarter of the sample seems to be skeptical of the role of top management in the success of a business. This has two folds, the first is that entrepreneurs are of challenging characters, independent

and problem solvers, or they have been neglected while starting their enterprises. However, the majority reflected that management dimension is crucial for the success of enterprise.

Table 3 Frequencies of output from SPSS (Performance Dimension).

Item	Very Important	Important	Somewhat important	Not important	Not important at all
Empowered Decision Makers	62 62%	22 22%	7 7%	5 5%	4 4%
Monitoring & Evaluation of Performance	38 38%	45 45%	16 16%	*	1 1%
Good communication to provide the necessary data to all stakeholders	38 38%	44 44%	15 15%	1 1%	2 2%
Troubleshooting to handle unexpected crises and deviate from plan	46 46%	36 36%	15 15%	3 3%	*

The performance dimension is considered to be vital to the success of SMEs in Bahrain. This table demonstrates high awareness of the sample and a consistent mindset to praise performance and consider it as crucial to achieve successfully the required targets. The low importance shown may be due to those who faced difficulties in running their projects or were not able to achieve and accomplish all the dimension items.

Table 4 Frequencies of output from SPSS (Employee and Team environment Dimension).

Item	Very Important	Important	Somewhat important	Not important	Not important at all
Qualified Staff	44 44%	44 44%	10 10%	*	2 2%
Continuous Training	25 25%	36 36%	31 1%	8 8%	*
Employees Satisfaction	22 22%	38 38%	31 31%	9 9%	*
Team Environment	30 30%	23 23%	20 20%	19 19%	8 8%
The Use of Technology	32 32%	18 18%	36 36%	13 13%	1 1%

The results of the above table show that employees and team environment are considered to be important to the success of SMEs in Bahrain. This table demonstrates high recognition of the sample and consistent mindset to consider employees and team environment as decisive to the success objective. However some of the sample gave a hesitant opinion regarding these items. Perhaps the fast changes happening in many technologies are worrying to entrepreneurs in Bahrain and they may not be able to cope with changes due to cost issues or difficulties in adaptation of practice. Also, may be cost factor is hindering the training and this reflects on staff satisfaction and the team spirit. This collectively indicated some concerns which needs to be addressed in further research.

Table 5 Frequencies of output from SPSS (Product and Sales Promotion Dimension).

Item	Very Important	Important	Somewhat important	Not important	Not important at all
Sales Promotion	36 36%	48 48%	16 16%	*	*
Product Quality	40 40%	45 45%	13 13%	1 1%	1 1%
Active listening to Clients	28 28%	47 47%	18 18%	5 5%	2 2%
Suppliers good performance	35 35%	46 46%	18 18%	1 1%	*

Product and sales promotion are considered important for the success of any SMEs. This table demonstrates high acknowledgment of the sample and a consistent mindset to consider product and sales promotion as crucial to the success of any project. The low importance shown may be due to not being able to afford costly promotion and development of product.

Table 6 Frequencies of output from SPSS (Government's Support Dimension).

Item	Very Important	Important	Somewhat important	Not important	Not important at all
Government's Support	39 39%	44 44%	14 14%	2 2%	1 1%

A very small percentage of the sample (17%) denied the importance of the government support. This could be due to some routine procedures they have incurred or their lack of experience in licensing and getting financial support

4.3 Testing linear Correlations

Table (7) below shows Person Correlation coefficients as a high measure of strength and direction of the linear regression between the two variables. There are linear positive correlations between all variables except Government's Support and Product & sales Promotion, where *p- value is* greater than 0.05. This seems a worrying issue for entrepreneurs in Bahrain.

Table 7 Correlations Output from SPSS.

Mean	Std.Deviation	Dimensions	Government's Support	Management	Performance	Employee and Team Management	Product and sales Promotion
4.04	0.800	Government's Support	1	0.722** 0.00	0.599** 0.00	0.304** 0.002	0.124 0.220
4.00	0.697	Management		1	0.651** 0.00	0.363** 0.00	0.241* 0.016
4.15	0.513	Performance			1	0.305** 0.002	0.362** 0.001
3.79	0.601	Employee and Team Management				1	0.293** 0.003
3.87	0.550	Product and sales Promotion					1

4.4 Testing Multiple Regression and Anova

R in multiple regression is an indicator of how well the overall regression equation predicts the observed data. In the current multiple regression analysis for the research, the result of 0.781

indicates that the linear combination of five independent variables (government's support, management, product & sales promotion, employee & team environment, and performance) strongly predicts the actual dependent variable. R square in table (8) is 0.610, which suggests that Business Success level explains 61% of the variance of their Government's support, Management, Product & Sales Promotion, Employee & Team management, and Performance. This indicates that the relationship between Business Success and independent variables is moderately strong. From the results the difference between R Square and Adjusted R Square is very small (Adjusted R Square= 0.593). Therefore, the researchers can report unadjusted R Square.

Table 8 Multiple Regression Model Summery Output from SPSS.

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	0.781	0.610	0.593	0.445
Predictors: (Constant), Government's support, Management, Product & Sales Promotion, Employee & Team environment, Performance				

Table (9) below labeled ANOVA provides the results of a test of significance for R and R square using the F- statistic. The results showed in the table below that the *p- value* is well below 0.05 (P=0.00), therefore we can conclude that R square and adjusted R square for the multiple regression conducted predicting Business Success based on the linear combination of Government's support, Management,Product & Sales Promotion, Employee & Team management, Performance is statistically significant.

Table 9 Multiple Regression ANOVA Output From SPSS.

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	29.339	4	7.335	37.116	0.000[b]
	Residual	18.773	95	.198		
	Total	48.112	99			
a. Dependent Variable: Business Success						
b. Predictors: (Constant), Government's support, Management, Product & Sales Promotion, Employee & Team environment, Performance						

Table 10 Multiple Regression Coefficients Output From SPSS.

Coefficients[a]					
Model	**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
	B	**Std. Error**	**Beta**		
(Constant)	-0.176	0.442		-0.400	0.690
Performance	0.409	0.115	0.301	3.555	0.001
Management	0.384	0.113	0.300	3.530	0.001
Employee& Team environment	0.120	0.081	0.104	1.480	0.142
Product & Sales Promotion	0.063	0.089	0.050	0.710	0.480
Government's support	0.440	0.071	0.504	6.169	0.000
a. Dependent Variable: Business Success					

Under the column, marked *Unstandardized Coefficients* and *B*column is the value for the intercept (*a*) in the regression equation on the first row (*Constant*). The result in table (10) indicates that the intercept is (- 0.176), as performance, management and government's support coefficients are statistically significant ($p \leq 0.001$), meaning that these variables are significant predictors of Business Success. According to the results, the coefficients of employee & team environment and product & sales promotion are not significant predictors of Business Success according to the sample responses.

5. Discussion and Findings

It is interesting that the results of this research revealed that there is a significant relationship between the critical dimensions of success (management, performance, employees and team environment, product and sales promotion and government support) and success of small and medium enterprises in Bahrain, and that these critical success dimensions for small and medium enterprises' perceptions of Bahraini entrepreneurs are consistent and well recognized. So, we can say that the two hypotheses are supported.

This is understandable when we recognize that Bahrain is stepping up efforts to make small and medium businesses a major contributor to its growth through Bahrain vision 2030, and when we recognize also that Bahraini entrepreneurs are increasing their awareness through their membership in the entrepreneurs' organization in Bahrain that enables them to learn, grow and leading to greater success in business.

But surprisingly, some entrepreneurs who represented low percentages of the sample showed low importance (up to 20%) for the identified success elements (qualified staff and empowered decision makers 12%, product quality 15%, clear goals and sales promotion 16%, evaluation of performance and government support 17%, good communication and troubleshooting 18%, supplier good performance 19%,and management commitment 20%). This could be due to facing difficulties in running their business and not being able to achieve the goals, also perhaps the fast changes in technologies and not being able to cope with them due to cost issues and difficulties in adaptation of usage. Maybe due to not being able to afford costly promotion and the lack of experience of how to get use of the government support.

Also, for those who showed low importance (more than 20%) for the identified elements (Active listening to clients 25%, good leadership 28%, top management support 29%, continuous training 39%, employees satisfaction and team environment 47% and the use of technology 50%), this could be due to lack of experience and facing problems in realizing goals.

It is very necessary for Bahraini entrepreneurs to understand the importance of all the identified SMEs' success elements in order to be able to succeed and develop their enterprises coping with environmental changes effectively.

6. Conclusion

Small and medium-sized enterprises have a great contribution in socio-economic development, innovation and job creation not only in Bahrain, but also all over the world. SMEs' success is due to several elements, and identifying these elements for SMEs' success in Bahrain was the main object of this research.

The results identified five principle dimensions which contain eighteen variables that could be major contribution to the success of the small and medium sized enterprises in Bahrain. For Bahraini entrepreneurs to further develop their enterprises' success, they should focus on the success elements that positively affect their enterprises' profitability.

According to the results of this research Bahraini entrepreneurs are not considering all the success elements identified by various scholars. Some of them are discarded as elements of success. Further research is needed to investigate the reasons for this trend of opinion. However, they proved to be well aware of most of the elements, and the researchers think there is a crucial advancement in the overall progress of entrepreneurship due to the reasons mentioned earlier.

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The Impact of Government-Private Sector Collaboration on Innovation in a Developing Knowledge Economy

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Abstract

The purpose of this paper is to discuss the potential impact of collaboration between the government and the private sector on innovation activities in a developing knowledge economy. The emphasis in this paper is placed on the impact on and benefit to developing economies from building collaboration between their public and private sectors specifically to assist them in moving toward the new economy of this era known as a 'knowledge economy'. For countries to remain in the forefront of the global economy, they have to focus on building strategies and policies that will adapt their innovation ecosystem accordingly. This paper provides a descriptive assessment of knowledge, innovation, collaboration and knowledge economy and the relationship between the government and the private sector collaboration to advocate innovation to promote a developing country's growth towards a knowledge economy. Information in this paper provides an understanding of the importance of knowledge and innovation, their role in the new economy, and the hypothetical benefits that developing countries can achieve from focusing on these two elements, which are crucial in the development towards a knowledge economy.

Keywords: Knowledge, Innovation, collaboration, Knowledge Economy.

1. Introduction

Knowledge has played an important role in all aspects of human relations, including the economy. The development of a knowledge economy, globalisation, and international competitive pressure has increased the importance of creativity and innovation in local economies (OECD, 2007; Porter, 2001).

Most societies and administrative and commercial principles have comprehended the unique quality of information accrual and have tried to best form it to fit their basic needs. Adam Smith laid the groundwork for the modern evolutionary process of knowledge in his book 'The Wealth of Nations' which was published in 1776. Smith focused on creating a new understanding of economics by proposing an economic system based on human capital through developing the idea of the division of labour. He then went on to describe how this division added to the richness of a given society since the labourers' focus was intensely on a clear task and fuelled technological innovation creating vast oversupplies that were then reinvested and used in making new technologies. In this system, individuals learn by doing and develop new knowledge within the competitive market progression (Smith and Cannan, 2003).

According to Mokyr (2002), economic historians have come to recognise that before 1750 technology was not as important as institutional change in economic progress, and that the Industrial Revolution marks not only when growth begins, but also the time during which technology takes on a leading role and an ever-increasing weight in the production of financial development. To punctuate his point, Mokyr goes on to say that the pre-1750 world "was a world of engineering without mechanics, iron-making without metallurgy, farming without soil science, mining without geology, water-power without hydraulics, dye-making without organic chemistry, and medical practice without micro-biology and immunology" (p. 4).

Mokyr (2002) continues that the second stage of the Industrial Revolution, following 1820, added many new components to the ever-expanding possibilities of production in the West. These included less costly steel, electricity, manmade chemicals, pharmaceutical products, food processing, and substitutable parts manufacturing, to name but a few.

Similarly, Drucker (1994) states that world civilization was formed by capitalism and technology during the period 1750 to 1900, with change driven by radically shifting the meaning of knowledge from a personal commodity to a public good through "doing" and not "being". Knowledge, tied directly to action, started being applied to labour rather than to tools, procedures and products.

In today's world, the top developed countries' economies are knowledge based. A knowledge-based economy (KBE), more commonly referred to as a "knowledge economy" (KE), lies at the new frontline of economic theory and empirical analysis where knowledge has a crucial role in decision-making and is considered a principal asset to individuals and organizations (OECD, 1996). Iacovoiu's (2016) research provided empirical evidence that innovation and knowledge are key elements in developed countries that have reached a high stage of economic development.

For countries to remain in the forefront of the global economy, they have to focus on building strategies and policies that will adapt their innovation ecosystem accordingly (Schwab, 2017). The creation of the right conditions for the development of this economy cannot be left to chance. For this transition to happen, a collaborative and organized plan is required to attract skilled human capital, foster local talent and create effective networks between all the entities of the society. The process of developing a KE depends on many factors and goes through a long process. It needs the involvement and support of many sectors and agents of the society.

This paper aims to assess the factor of collaboration between the government and the private sector for the purpose of enhancing innovation activities in a developing knowledge economy. This paper provides a literature review on knowledge, innovation, knowledge economy (KE), and collaboration, with a focus on assessing past studies conducted in the concerned areas. As an understanding of these areas emerges, the relationship among them unfolds, deepening our recognition of the unique role government-private sector collaboration potentially plays in contributing to innovation in a developing knowledge economy. The authors conclude by giving suggestions for future research on this topic.

2. National Knowledge

The debate on knowledge is anticipated to get larger and more profound as empirical studies, particularly in developed countries, begin to show the constructive relationship between economic growth and the level of knowledge that countries can produce, distribute and use effectively (Al Rahbi, 2008). For purposes of this discussion, knowledge is defined as the capacity (potential or actual) to take effective action (Bennet and Bennet, 2004).

The lack of access to information and knowledge and bureaucratic governmental levels and structures are among the key obstacles to the national competitiveness of both developed and developing countries (Alwis and Hartmann, 2008). Although competitiveness has many definitions, it is usually defined as the ability of organisations or nations to generate a relatively high factor of income and employment on a regular basis (Nazari et al., 2009). In accordance with Ruscoe (2008), a country should develop specialisation in the first place to reach a world-class standard of living. However, this action requires significant financial investments in the creation of new knowledge as well as its diffusion (Schulze and Hoegl, 2008). In addition, the impact of the external environment should be considered by a country to achieve a higher level of competitiveness and productivity (Jasimuddin, Klein and Connell, 2005).

In one analysis, the role of knowledge in raising national competitiveness was investigated by Katić, Ćosić, Anđelić and Raletić (2012). The researchers were focused on a country in transition. De Waal and Sultan (2012) also indicated that a country's competitiveness depends not only on economic factors but also on its innovativeness, knowledge and the adoption of new technologies.

Katic et al. (2012) also arrived at the conclusion that knowledge and innovativeness were among the main requirements for the growth of a country's national competitiveness. Importantly, the researchers emphasised the inappropriateness of existing knowledge models for developing countries and believe that there is a need for a new framework, the key parameters of which would be innovation, the use of information technology, knowledge and education (Katic et al., 2012). It should be critically remarked that the findings produced by Katic et al. (2012) are limited to a single developing country, Serbia. Hence, their generalizability to other cultural contexts is limited.

According to Williams (2006), countries are becoming more committed to the KE as well as the development of their technological capacity. It should be noted here that the knowledge needed for a KE is broader than just pure technological knowledge (Ahmed and Al-Roubaie, 2012). It includes knowledge of culture, society and management, which is much more than the information written in the documents and hidden in the databases of organizations of a society (Al-Ali, 2008; Al-Roubaie, 2010; Al-Roubaie and Alvi, 2014). A society's knowledge includes its culture, the way its citizens co-operate with each other, and how they react to the information they gain from outside and adapt it to their local need (Al-Ali, 2008; Al-Roubaie, 2010).

Al-Roubaie (2010) investigated the role of local knowledge, "Indigenous Knowledge", capacity in developing countries. He emphasized the importance of local knowledge in promoting growth in unindustrialized countries to overpass the gap between them and the developed countries. In the new economy, knowledge is the main factor to obtain economic progress and sustain development (OECD, 1996). But in order for a developing country to advance, both the government sector and the private sector need to work together to raise awareness, accomplish research and development, make information available, provide finance assistance, and construct capabilities to create and disseminate knowledge by enabling the assimilation of global knowledge into the local knowledge ecosystem (Al-Roubaie, 2010).

3. Innovation

Innovation is a process full of diversity and risk for creating something new. To understand the important role of innovation in an economy, one has to first understand the concept of innovation, along with identifying innovation types.

In the early versions of innovation models Knight (1967) implied that there are four kinds of innovation: (1) product or service innovation which was concerned with the establishment's new product or service contributions (2) production-process innovation, related to alterations of the establishment's operations or inventions; (3) organizational structure innovation relating to the relationships, communication, or formal reward systems in the establishment; and (4) people innovation in regards to the change in levels, personnel, job allocations, culture, and conduct of employees of the organization.

Traditionally, innovation has been understood as an intervention, product, idea or process, which provides new pathways for dealing with acute problems or achieving objectives (Nazari et al., 2009), and it is commonly accepted in the existing literature that innovation is the key to cultural, social, environmental and economic progress (Galindo and Mendez-Picazo, 2013; Aubert and Reiffers, 2004). However, the recent shift from industrial economies to knowledge-based economies has also changed the innovation system paradigm (Schulze and Hoegl, 2008). According to this changed paradigm, sustained social and economic effects depend heavily not only on innovation in science and technology, but also on social innovation, which usually emerges from a unique combination of knowledge, techniques and practices (Nour, 2014). Schumpeter, the renowned Austrian economist of the twentieth century, is a key figure behind developing the idea of innovation as a foundation for economic change (Godin, 2008).

4. Innovation and Knowledge

According to the ABS (2002) report, empirical studies indicate that the movement of knowledge occurs in between and through all entities involved in innovation. For unique products, processes and technologies to generate a non-linear flow of knowledge is imperative amongst all bodies involved in the network called the innovation system.

As the action level for creativity, Bennet and Bennet (2017) describe knowledge as an idea generator, "the currency of creativity and innovation" (p. 126). See Figure 1. While when combined knowledge and creativity lead to innovation, this is not necessarily an immediate result. In his early work on the knowledge economy, Fritz Machlup (1962) noted that the movement from idea to innovation "is not a unidirectional flow from one stage to the next, from inception to development, to eventual adoption, but there are usually cross-currents, eddies, and whirlpools" (p. 179).

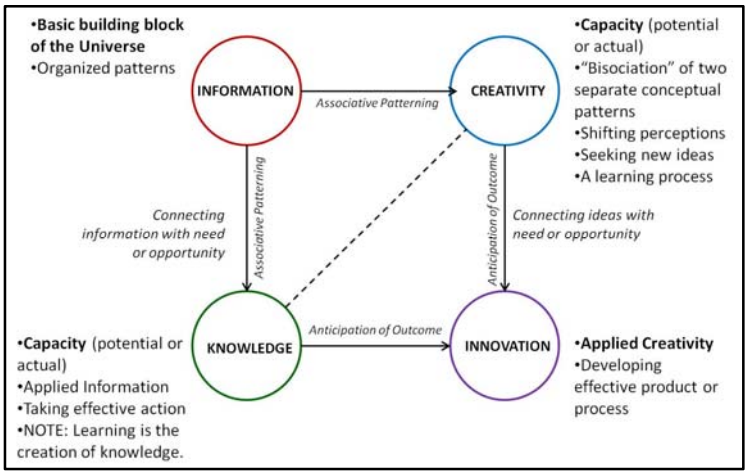

Figure 1 The relationships among information, knowledge, creativity and innovation (Bennet and Bennet, 2017).

Mechanisms linking social knowledge and innovation are given close attention in this literature review. Many knowledge scholars and researchers agree that innovation is a result of knowledge exchange and recombination (Bergek et al., 2008; Popidiuk and Choo, 2006). This perspective is consistent with Narvekar and Jain (2006) who argued that an innovation comes from a process of existing knowledge and capabilities reuse in a new application setting.

Gopalakrishnan, Bierly and Kessler (1999) attempted to link the characteristics of knowledge to innovation types and, examining the relationship between the two, and concluded that *process innovations integrated more complex and systematic knowledge in comparison with product innovations*. These outcomes indicate that innovation at the macro level is more complex and challenging than at the micro level. For example, reforms, which refer to the improvement of governmental processes and policies, can be attributed to process innovations (Galindo and Mendez-Picazo, 2013). At the same time, these innovations require significant financial and time resources to occur, while product innovations, which usually take place at the micro level, are easier and less expensive to introduce (Bergek et al., 2008). This paper addresses macro level innovations by examining how government-private sector collaboration on innovation activities impact a developing knowledge economy.

5. Knowledge Economy

A knowledge-based economy (KBE), or more commonly known as a "knowledge economy" (KE), lies at the new frontline of economic theory and empirical analysis, with knowledge now considered to have a crucial role in decision-making and regarded as a principal asset to individuals and organizations. In this new economy, knowledge has surfaced as a resource to be assessed, developed, and managed and is considered as a corporate asset. Today, the significance of knowledge is valued by what it can generate. Knowledge has become the main component of production, and is being used and advanced by knowledge itself (Drucker, 1994).

The Organization for Economic Co-operation and Development [OECD] (1996) coined the term "knowledge-based economy" and considered knowledge as the main element for economic development, which all OECD countries are now depending on producing, distributing, and using. As World Bank (1998) states,

> "Knowledge is critical for development, because everything we do depends on knowledge. Simply to live, we must transform the resources we have into the things we need, and that takes knowledge. And if we want to live better tomorrow than today, if we want to raise living standards as a household or as a country - and improve our health, better educate our children, and preserve our common environment – we must do more than simply transform more resources, for resources are scarce. We must use those resources in ways that generate ever-higher returns to our efforts and investments. That, too, takes knowledge and ever-greater proportion to our resources" (p.16).

Knowledge has always been the main factor in the development of economies (Aubert and Reiffers, 2004; Godin, 2008; Houghton and Sheehan, 2000; The World Bank, 2007), but *what makes the current knowledge different now is its quality, intensity, and the rate of its fast growth* due to the advancement of information and communication technologies and globalization (Godin, 2008; Houghton and Sheehan, 2000), and the increase of countries who are incorporating policies related to knowledge and innovation in order to grow and compete globally (The World Bank, 2007). However, even though the emergence of information technology (IT) has significantly contributed to the effective use and exploitation of knowledge, there is still a gap between developed and developing countries in the extent to which their economy is knowledge-driven (Smedlund, 2008; Madichie, 2013).

6. Collaboration of the Government and Private Sector

Collaboration can be defined as a cooperative arrangement in which two parties work jointly towards a common aim (Guzman and Sierra, 2012). Chun, Luna-Reyes, and Sandoval-Almazan (2012) loosely define collaboration as "a process or a set of activities in which two or more agents work together to achieve shared goals."

Bennet, Bennet and Lewis (2015) look at collaboration as a process in which two or more entities get together to create new knowledge by means of bringing their ideas and existing resources and knowledge together to share, compare, and leverage those ideas in order to create value to both entities. Considering the context of this paper, it is relevant to define collaboration as cooperative arrangement in which the private sector and the public sector work jointly towards a common goal.

Business leaders are making the conception of collaboration a part of their everyday routine as the world is moving more into the Internet age and globalization (Bennet, Bennet and Lewis, 2015). Sorensen and Torfing (2012) reported that collaboration was an effective tool that allowed for transferring knowledge among individuals and creating competitive advantage. Therefore, effective collaboration between the private and public sectors can facilitate the development of innovation as well as stimulate economic growth (Bommert, 2010).

The impact of innovation on a firm's success and financial sustainability in the private sector has been extensively studied in the existing body of literature (Yigitcanlar, Velibeyoglu and Martinez-Fernandez, 2008; Sorensen and Torfing, 2011). For instance, Sorensen and Torfing (2011) found that innovation helped private businesses cut their costs and expenditures, improve the quality of their goods, services and processes and open new markets. In turn, companies that fail to innovate gradually lose their competitive advantage and witness declining profits and market shares (Crosby and Bryson, 2010). In their attempt to become more competitive, large multinational corporations invest enormous financial and human resources in research and development (de Waal and Sultan, 2012).

In contrast to the private sector, there is a lot of scepticism concerning public organisations' need and capacity to innovate (Nardelli, Jensen and Nielsen, 2015). Indeed, the public sector is considered as a slow-moving bureaucracy incapable of making and taking prompt decisions and responding to changes in the external environment in a rapid manner (Guzman and Sierra, 2012). This statement is consistent with Weber (1978), who argued that stability was the primary goal of public bureaucracy.

The need for government-private sector collaboration stems from several challenges in the field of technology and science (Crosby and Bryson, 2010). For instance, improving the institutional frameworks to collaboration between private and public organisations, improving the attractiveness of a country as a location for research and development, and improving interdepartmental coordination were identified by Yigitcanlar, Velibeyoglu and Martinez-Fernandez (2008) as strong challenges that facilitated collaboration between the private sector and the public sector. By establishing a partnership with private companies, the government can successfully respond to these challenges, ensure sustained growth in productivity and improve the quality of its citizens' life (Sorensen and Torfing, 2011).

Furthermore, Kristensen, McQuaid and Scherrer (2015) reported strategic partnerships between the government and private businesses to provide innovation-relevant infrastructures and deliver innovation policies. According to Sorensen and Torfing (2011), government-private sector collaboration allows for fostering the generation of knowledge and innovation by providing the frame for producing innovative products, services and processes to the market.

Providing infrastructure is another major field of implementing government-private sector collaboration models in sectors such as health, transport and education (Brewer et al., 2013). This is also relevant to innovation-related infrastructure since private and public organisations have long been collaborating in building and operating infrastructure for the diffusion of knowledge and technology (Guzman and Sierra, 2012).

Crosby and Bryson (2010) acknowledged that cross-sector collaborations were formed more frequently in turbulent environments. This finding is in line with Yigitcanlar, Connor and Westerman (2008), who also argued that the inability of each sector to solve an important public issue on its own significantly fostered cross-sector collaborations. Existing cross-boundary groups as well as general agreements on the issue to be dealt with were reported by Erakovich and Anderson (2013) as another factor that added to the formation of collaboration between the public sector and the private sector.

Government-private sector collaborations change the way in which public services are produced and delivered to consumers (Nardelli, Jensen and Nielsen, 2015). Successful collaborations depend heavily on trust, respect and flexibility (Guzman and Sierra, 2012). Mutual benefits were also identified by Lember et al. (2014) as an important factor that impacted the degree to which public-private partnerships were successful.

At the same time, while public organisations can exchange knowledge and resources, their innovation capability is highly limited by different hierarchical levels (Yigitcanlar, O'Connor and Westerman, 2008). Because of the mentioned barriers, private firms have begun to pursue innovation by establishing strategic partnerships with other market players (Erakovich and Anderson, 2013). In turn, public organisations tend to flatten their structure. These larger strategic partnerships are consistent with expanded innovation opportunities. As Khorsheed (2015) states, the innovation capability in a society and its capacity to maintain growth is contingent to a large degree on the potencies of, and collaborations between, many institutions and the efficiency of diverse policies.

7. Conclusions and Recommendation

This paper makes a contribution by providing a review of the literature in the areas of knowledge, innovation, collaboration and KE and developing an understanding of the links among them with a focus on movement of developing nations towards a KE. The reviews and analyses have emphasized these connections.

In the new KE, manufacturing and exporting high-tech products and services for global markets are the backbone of balanced and sustainable economic development. To enable and enhance their KE environments, countries have to build environments capable of competitiveness, have high networking capabilities, encourage technology transfer, promote innovation, disseminate and absorb knowledge, and acquire skills (Ahmed and Al-Roubaie, 2012).

The researcher Nour (2014) arrived at the conclusion that in order for developing Arab countries to transit to a KE they have to recognise the central role of the private sector and the significance of collaboration between public and private sectors to produce clear strategies for this transition. Nevertheless, empirical evidence on the relationship between public-private collaboration and innovation is scarce, making this link poorly understood and examined (Nardelli, Jensen and Nielsen, 2015). Future research is needed to explore the role of collaboration between government and private sector to bridge this gap by identifying how government-private sector collaboration contributes to innovation activities in a developing knowledge economy.

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The Role of Entrepreneurship on the Growth and Development of the Palestinian Economy

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Abstract

For the past few years, the Palestinian economy has failed to absorb the annual increase in the labor force. As a result, in 2016 the unemployment rate in Palestine reached 26.9 percent. The relatively high unemployment rate is partially due to the shrinking industrial and agricultural sectors. The purpose of this paper is to determine the effect of Palestinian entrepreneurship on the economic growth and development of the Palestinian economy. The importance of the topic lies in assessing the performance of the entrepreneurs. This will aid in providing a solution to the rising unemployment problem. An econometric model and a time series analysis were utilized in order to help us measure the impact of Palestinian entrepreneurs on economic growth. The econometric analysis had asserted that the number of entrepreneurs in Palestine negatively impacts the GDP. Meanwhile, the time series analysis had indicated that the growth rate in the GDP is what stimulates an increase in the growth rate in the number of entrepreneurs. Thus, the Palestinian Authority (PA) should continue its efforts in creating an environment that encourages and nourishes entrepreneurs which is hoped to achieve sustainability in development and job creation.

Keywords: Entrepreneurship, Growth, Development, Economy, Palestine.

1. Introduction

In 1994, with the creation of the Palestinian Authority (PA), the Palestinian economy was partially broken away from the Israeli economy. The aim of the PA was to create an independent Palestinian economy that will engage in trade and cooperation with the Israeli economy.

In 1994, the agricultural sector formed 11.7 percent, the manufacturing sector formed 19.3 percent and the service sector formed 29.5 percent of the total Palestinian GDP (Research Department, 2017). Strengthening the industrial and the agricultural sectors would have been a good choice for the Palestinian people. The advantage of strengthening the industrial is that it has the largest backward and forward linkages, while the agricultural is due to the competitive advantage that the West Bank and Gaza have due to the fertile lands (National Expert Optimum for Consultations and Training, 2011, p. 18).

In the year 2016, the Palestinian economy comprised a small and open economy. It is characterized by being a family oriented economy, where the majority of the establishments are medium, small and micro economic establishments. These establishments are known as being facility establishments, of a simple management nature and utilize traditional and unsophisticated technological and production techniques. Most of the establishments operate in the production sector in order to produce consumer goods (National Expert Optimum for Consultations and Training, 2011, p. 8). Nonetheless, the agricultural sector formed 2.9 percent, the manufacturing sector formed 11 percent and the service sector formed 20.6 percent of the GDP in 2016 (Research Department, 2017). The service sector continued to be the largest in the Palestinian economy. The table below shows the different economic sectors that formulate the Palestinian GDP.

Table 1 Value Added by Economic Activities for the Palestinian Economy for Years 1994 and 2016 at constant prices with 2004 base year. Source: Palestine Monetary Authority (2016). Website: www.pma.ps

Economic Activity	1994	2016
Agriculture and Fishing	361.2	236.6
Mining and Quarrying	23.8	28.4
Manufacturing	593.5	887.2
Electricity, Gas, Steam, and Air Conditioning Supply	41.3	123.4
Water Supply, Sewerage, Waste Management and Remediation	47.3	75.5
Construction	218.7	601.1
Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles	476.2	1383.9
Transportation and Storage	147.1	180.1
Financial and Insurance Activities	30.5	320.7
Information and Communication Services	3	443.3
Services	907.3	1652.5
Public Administration and defense	225.9	1034.1
Household with Employed Persons	4	4

With a rising unemployment rate – where the unemployment rate had reached 26.9 percent in 2016 (Research Department, 2017) – the Palestinian economy had failed to absorb the annual increase in the labor force. Thus the economy failed to generate enough jobs to absorb the increase in the labor supply.

The Palestinian economy is currently suffering from a relatively high unemployment rate with a shrinking industrial and agricultural sector. In other words, the growth in the Palestinian GDP did not translate into a sustainable job creation. In addition, the cuts in foreign aid and other external and internal factors had led to a deepening fiscal crisis. This contributed to the financial instability. The PA had realized the importance of the private sector as an engine for economic development. It included the emphasis of the private sector in its 2008 - 2010 Reform Development Plan and made it a strategic priority to establish a business and investment friendly encouraging environment. Therefore, the private sector must direct its efforts towards creating sustainable growth and job opportunities (The Portland Trust, 2013). The purpose of this paper is to determine the effect of the Palestinian entrepreneurship on the economic growth and development. Hence the question is: can the Palestinian entrepreneurship play the role of boosting the economy and creating jobs for a sustainable development?

Is the Palestinian economy fortunate to be based on medium, small, and micro sized businesses? Over the past decades, the world economy had shifted from large to small size businesses in the manufacturing sector, due to two main reasons. The first reason dealt with the fundamental changes in the world economy from the 1970s onwards. These changes related to the intensification of the global competition, the increase in the degree of uncertainty throughout the globe, and the growth in the market fragmentations. The second dealt with the nature of the technological progression. The flexible automation resulted in a shift from large size firms to smaller ones (Carree & Thurik, 2003, p. 439).

Nonetheless, some argued "that the shift away from large firms is not confined to manufacturing industries" (Carree & Thurik, 2003, p. 439). This shift had occurred due to four reasons: An increase in the labor supply resulting in a decrease in real wages, this was associated with an increase in the level of education; an alteration of consumer's tastes; a decrease in the regulations causing easier entry into markets; and finally the world is experiencing creative destruction. This shift to small business will result in an increase in the role and importance of entrepreneurship, instigating routes of innovations, stimulating changes in the industrial dynamics and creating jobs (Carree & Thurik, 2003, p. 439). It is important to formally define the word entrepreneurships, "Entrepreneurship is the manifest ability and

willingness of individuals, on their own, in teams, within and outside existing organizations to perceive and create new economic opportunities (new products, new production methods, new organizational schemes and new product-market combinations), and to introduce their ideas in the market, in the face of uncertainty and other obstacles, by making decisions on location, form and the use of resources and institutions" (Carree & Thurik, 2003, p. 441). Thus small firms are the most outstanding channels for individuals to manifest their entrepreneurial ambitions.

Thus the fact that the Palestinian economy operates through medium, small, and micro sized establishments allows entrepreneurs to play a more crucial role in stimulating the economy. The table below shows the number of entrepreneurs present in the Palestinian economy since the year 2000 to 2016.

Table 2 Real GDP at constant prices with 2004 as Base year and the Number of Entrepreneurs Aged 15 Years and above in Palestine from 2000 – 2016. Source: Palestinian Central Bureau of Statistics, Website ww.pcbs.gov.ps

Year	Gross Domestic Product (GDP)	Number of Entrepreneurs
2000	4335.9	142,900
2001	3932.2	142,600
2002	3441.1	140,900
2003	3923.4	172,500
2004	4329..2	171,300
2005	4796.7	186,100
2006	4609.6	191,500
2007	4913.4	196,100
2008	5212.1	170,800
2009	5663.6	181,900
2010	6122.3	186,700
2011	6882.3	208,500
2012	7314.8	208,100
2013	7477.0	214,900
2014	7463.4	231,400
2015	7719.3	234,400
2016	8037.0	244,800

2. Literature Review

A considerable amount of economic literature was devoted to the role of entrepreneurship in the economy. However, we can summarize the role of entrepreneurship in economic growth through a list of pros and cons. The entrepreneurs can impact the economic growth process positively in the following manners:

1. Boost the economy by introducing innovative technologies, products, and services.
2. Increase competition by entering into existing markets, which furthermore provide competition to existing firms, i.e. forcing firms to become more competitive.
3. Create jobs in both the short and long run.
4. Entrepreneurial activities contribute to the rise in productivity of both the firms and the economies.
5. Accelerate structural changes by replacing existing firms.

Meanwhile, entrepreneurships have the following cons:

1. A few people have the drive to become entrepreneurs.
2. Entrepreneurs take risks, as a result they might fail and the costs are usually transferred to the taxpayers.
3. Entrepreneurs might lead to layoffs in the medium term, if the existing firms are shut-down.
4. A high level of self-employment is not necessary a positive indicator.
   (Kritikos, 2014)

Realizing the crucial and vital role of entrepreneurship in the economy, a Global Entrepreneurship Monitor (GEM) was established. The GEM measures country-level entrepreneurial activity rates, provides a class-country analysis of entrepreneurship related activities and identifies policies encouraging entrepreneurship. These indicators were used to explore the different dimensions of entrepreneurship on the Gross National Income (GNI), Gross Domestic Product (GDP), and the unemployment rates for eleven of the Middle East and North African (MENA) countries. These countries were Algeria, Egypt, Jordan, Lebanon, Morocco, Saudi Arabia, Syria, Tunisia, Turkey, United Arab Emirates and Yemen. Thus the impact of entrepreneurship on economic growth and unemployment was studied. It was found that the Established Business Ownership Rate and Total Early-stage Entrepreneurial Activity for Male Working Age Population negatively affects the GNI and GDP. However, the Perceived Capabilities and the Improvement-Driven Opportunity Entrepreneurial Activity had a positive effect on GNI and GDP (Saigh & Ben Zaid, 2015)

These findings are important since Palestine is located in the MENA region. However, the Palestine Economic Policy Research Institute (MAS) had launched the 2012 edition of the GEM. The report had found that in 2012 approximately 10% of Palestinian population aged 18-64 had been involved in starting or running a business at some stage during the previous 42 months. This is a good percentage when compared with other MENA economies such as Egypt having an 8.8% and Algeria having a 7.8%. The report had also indicated that entrepreneurship is one of the key drivers of the Palestinian economy, and entrepreneurship plays a crucial role in generating employment opportunities. Finally, the report had shown that approximately 77% of the Palestinian labor force was directly related to the development of the entrepreneurial activities (Palestine Economic Policy Research Institute , 2013).

A different side of the story is mentioned when looking at the high unemployment rate in Palestine among the youth. Youth, at their early career, generally do not desire to take risks and prefer being employees as they are seeking a steady and stable income. In addition, higher education further enriches the idea of stability and steadiness in income through the utilization of methods by the universities that do not foster the innovative and risk taking skills of its graduates. A gap also exists between the higher education institutions and the market needs (Maddallah & Al-Ajlah, 2012).

A major obstacle and a challenge to entrepreneurs in Palestine is the lack of stability in the economic environment due to the Israeli occupation and its policies. Israel insists not to grant Palestinians their independence, and give them total sovereignty over their land. Hence starting a business requires the entrepreneur to bid by the rules and regulations of both the Israeli government and the PA. In addition, the PA has limited sources of funding for entrepreneurial activities (Maddallah & Al-Ajlah, 2012).

Unfortunately, the Palestinian entrepreneurs are also faced with a limited source of capital for investment, the continuous rising costs of factors of production, its dependence on the limited self-funding and its difficulties in receiving affordable loans for funding from the Palestinian financial sector (Raslan & Abdel Karim, 2011).

Among the other major obstacles that faces the entrepreneurs in Palestine are primarily comprised in not following the latest management methods, but rather relying on interested family experiences, utilization of untrained labor and the use of old technological techniques. Such approaches will lead to high productivity costs, which prevent the Palestinian product from competing against the Israeli and the foreign product (Raslan & Abdel Karim, 2011).

This paper will adopt a more regress approach in measuring the effect of entrepreneurship on economic growth in Palestine. Unlike the previous papers discussing the entrepreneurship in Palestine, a more quantitative approach to measure the effects of entrepreneurial activities on the GDP will be used.

3. Methodology

This section will develop a number of regression models that identifies the cause and effect relationship between entrepreneurship and economic growth in Palestine. We will start our analysis with the utilization of the Cobb-Douglas production function represented by the following equation:

$$Y = A\,K^{\alpha}\,L^{\beta}$$

Where Y is the Gross Domestic Product (GDP), A is a parameter that represents the influence of factors other than capital and labor on production, K is capital stock, $0<\alpha<1$, $0<\beta<1$ and L is labor.

The name "Cobb-Douglas" came from Paul Douglas – a labor economist at the University of Chicago during the 1930s – and his research assistant Cobb. This function was used to study how the share of labor to the GNP had varied over the business cycle. Its functional form was also used extensively in econometric studies of the production function. In the case of the Cobb-Douglas, $\alpha + \beta = 1$. Thus there is a constant return to scale. If $\alpha + > 1$ then there is an increase returns to scale, and if $\alpha + \beta < 1$ then we have a decreasing returns to scale (Quirk, 1987, p. 151).

By definition the parameter A represents the total factor productivity (TFP). It is through the parameter an entrepreneurship will impact the production. Thus entrepreneurs will spur technological advances and thus shifts TFP upwards (Rivera-Batiz, 2002, p. 252).

Economists have traditionally associated changes in technological advances with changes in A, i.e. the changes in the technological advances are closely related to changes in A. Nevertheless, this coefficient reflects changes in any other forces such as wars, ethnic conflict, occupation, natural disasters, health and epidemics, etc… (Rivera-Batiz, 2002, p. 253)

However, there is a wide variety of variables that influence technological advances and innovations. We will include some of these variables in our econometric model to determine their effects on economic growth. Human capital is identified as a key determinant of technological changes, where it is most probable that the higher the educational level, the more likely this will contribute positively to research, development and innovation (Rivera-Batiz, 2002, p. 253).

As a result, we will add the EDUCAT variable to our model. This variable measures the percentage of Palestinian workers aged 15 years and above who have 13 years of schooling and above. We will also add the ENTRE variable that measures the number of entrepreneurs in Palestine. Again and Hewitt have succeeded in making the connection between the "purposive, profit-seeking investment in knowledge to the persons performing this task: Entrepreneurs." (Carree & Thurik, 2003, p. 456). Thus an increase in the number of entrepreneurs will positively impact the research and development, and this will lead to improvements in technology. This will finally lead to an increase in economic growth.

We will transform the Cobb Douglas production function for Palestine into a linear function by taking the log of both sides. So, we will have the following linear function:

$$logY = \log A + \alpha\, logK + \beta\, logL$$

That is, logA is a function of EDUCAT and ENTRE:

Log A = f (ENTRE, EDUCAT)

Our econometric model is then given by the following equation:

$\log Y = \beta_0 + \beta_1 \log k + \beta_2 logL + \beta_3\, EDUCAT + \beta_4 ENTRE$ + E

Where βs are the parameters to be estimated and ε represents the random error term that is assumed to be normally distributed with a mean of 0 and a constant standard deviation. The dependent variable is measured in terms of the log of real GDP in US dollar at constant prices with 2004 as a base year. The log (K) is measured by the log of the capital stock in US dollar with a base year of 2004. The EDUCAT and ENTRE variables are as defined earlier.

Now let us turn our attention to the time series analysis. In the time series analysis the regressors are stochastic and the disturbances are autocorrelated. Hence we have the general form:

$y_t = \beta_1 + \beta_2 x_t + \beta_3 y_{t-1} + \ldots + \varepsilon_t$

Where, y_t is the dependent variable, x_t contemporaneous (and perhaps lagged) factors are ε_t the disturbances, and y_{t-1} is its own past. Thus the path of the dependent variable, y_t is described by the above variables including the disturbances. Here the time series is a single occurrence of a random event (Greene, 1995, p. 413).

In a stochastic time series model the generating process is a combination of a starting value and a sequence of a purely random component. Thus having a zero-mean "innovations" ε_t in a dynamic structure that produces the YT variable (Greene, 1995, p.559). The history of innovations of ε_1, ε_2, the observations of the variable YT are realizations of a random variable

where we assume these random variables are a part of an infinite sequence of random variables. This sequence is called a stochastic process (Greene, 1995, p.415).

The Unit Root Test will determine the stationarity of a variable. Assume y is an ARMA (pique) processes that are polynomials of a lag operators L, then the model for y is written as follows:

$y_t = \beta_1 y_{t-1} + \ldots + \beta_p y_{t-p} + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \ldots + \theta_q \varepsilon_{t-q}$

The above equation can be rewritten as

$(1 - \beta_1 L - \ldots - \beta_p L^p) y_t = (1 + \theta_1 L + \ldots + \theta_q L^q)\, \varepsilon_t$

Hence $\beta(L)Y_t = \theta(L)\varepsilon_t$, where $\beta(L)$ is the pth order polynomial in L which recaptures the dynamics of AR in the process and $\theta(L)$ is the qth order polynomial that captures the MA dynamics. Since we are dealing with polynomials we calculate their roots λ. The roots are interpreted as the value of L such that $\beta(\lambda) = 0$ or $\theta(\lambda) = 0$ (Greene, 1995, p.556).

To determine the stationarity of a series we are interested in the roots of AR polynomial $\beta(L)$. We calculate the modulus of the root $\lambda = a \pm bi$. The modulus is equal to the $(a^2+b^2)^{1/2}$. Nonetheless, if λ is real, then $b = 0$ and the modulus is equal to the absolute value of a. The Unit Root Rule for stationarity states that if the modulus of any root of $\beta(L) \leq 1$ then the series is nonsationary. Thus for the series to be stationary all the roots of $\beta(L)$ must lie outside the unit root circle in the complex plane (Greene, 1995, p.556). In this paper we are interested in the first difference, the growth rate of both the GDP for Palestine and the number of entrepreneurs.

There exists a long-run relationship between the two variables were the two variables drift together. This relationship is distinguished from the short-term dynamics that is measured by the relationship between the deviations of y_t from its long-term trend and deviations of x_t from its long-term trend. Nonetheless, cointegration test does not determine the direction of the causality (Greene, 1995, p.567). Therefore, we are interested in knowing whether the growth rate in GDP is cointegrated with the growth rate in the number of entrepreneurs in Palestine.

Time series analysis tries to answer whether one economic variable can assist in forecasting another economic variable. Thus can we conclude that the growth rate in the number of entrepreneurs cause the growth rate in the Palestine GDP? This answer to this question can be tackled by the method used by Granger (1969) and popularized by Sims (1972). Granger had utilized F-tests to test for causality. He tested whether lagged information on a variable Y provides any statistically significant information on regarding another variable X in the presence of lagged X. Th.ere are many methods in order to implement Granger causality test (SAS Support , n.d.).

The Fully Modified Least Squares regression method (FM-OLS) will be used to determine the sign of the relationship between the two cointegrated variables. The FMOLS regression method was developed to determine the optimal estimates of cointegrating regressions. As the name implies, the Least Squares method was modified to take in consideration the serial correlation effects and the endogenity of regressors resulting from the existence of a cointegrated relationship (Phillips, 1995, p. 1023).

4. Results

The data was collected from the Palestinian Central Bureau of Statistics, where the data covered the years from 2000 to 2016. The Statistical Analysis System (SAS) and Eviews were used to conduct the different statistical analysis.

Using the SAS software, the Durbin-Watson test statistic value was 1.974. From the table we find that dL is 0.583 and dU is 1.710. Since the test statistic 1.974 is greater than 1.710 (dU), we fail to reject the null hypothesis of non-autocorrelated errors.

Then we test whether the parameters are significant. Using $\alpha = 0.05$ and the p-value of the f-test from the SAS output is <0.0001 –thus $\alpha >$ p-value, we reject the null hypothesis. That is at least one of the betas in the model do not equal to zero and thus at least one of the betas is significant.

Now we carry out the t-test, using $\alpha = 0.05$ and the p-value of the t-test is 0.3719 – thus $\alpha <$ p-value, we fail to reject the null hypothesis and thus the beta is not significant. The p-value for the t-test for β_1, β_2, β_3 and β_4 is 0.1346, <0.0001, 0.0397, and 0.0295 – thus $\alpha >$ p-value for β_2, β_3 and β_4, we reject the null hypothesis and thus the betas are significant. As for β_1 the < p-value, and thus we fail to reject the null hypothesis and the beta is not significant. Hence we have the following model:

$$logY = 1.221\ logL + 0.134\ EDUCAT - 0.003\ ENTRE$$

This model has an R^2 of 0.9845, thus 98.45 percent of the variations in the output are explained by the model. This is considered an excellent fit, the data is an excellent fit for the model.

Now we will run a unit root test to determine whether the variables are stationary or non-stationary at the first difference. We will start by testing the GDP variable. Thus we have the following hypothesis:

H_o: The rate of change of the GDP has a unit root

H_A: The rate of change of the GDP has no unit root

Using $\alpha = 0.05$ and the p-value of the t-test for the Augmented Dickey-Fuller test from the Eviews output is 0.0493 – thus $\alpha >$ p-value, we reject the null hypothesis and thus the rate of change of the GDP has no unit root at lag length of 0.

Now we will repeat the root test for the number of entrepreneur's variable (ENTRE) at the first difference.

H_o: The rate of change of ENTRE has a unit root

H_A: The rate of change of ENTRE has no unit root

Using $\alpha = 0.05$ and the p-value of the t-test for the Augmented Dickey-Fuller test is 0.0017 – thus $\alpha >$ p-value, we reject the null hypothesis and thus the rate of change for the number of entrepreneurs has no unit root at lag length of 0.

The rate of change for both the GDP and the ENTRE share a common stochastic drift, thus they are cointegrated.

The Pairwise Granger Causality Test will be used to determine the direction of the causality relationship. We have the following null and alternative hypothesis:

H_o: Growth rate in GDP does not Granger cause growth in ENTRE

H_A: Growth rate in GDP does Granger cause growth in ENTRE

Using $\alpha = 0.05$ and the p-value of the f-test from the software output is 0.0469 – thus $\alpha >$ p-value, we reject the null hypothesis.

Now we test the other way around:

H_o: Growth rate in ENTRE does not Granger cause the growth rate in GDP

H_A: Growth rate in ENTRE does Granger cause growth rate in GDP

Using $\alpha = 0.05$ and the p-value of the f-test is 0.4936 – thus $\alpha <$ p-value, we fail to reject the null hypothesis.

Since the two variables are cointegrated and the growth rate in the GDP granger causes the growth rate in ENTRE, we run the Fully-Modified Least Squares Method. At a 5% significant level and with a p-value of 0 we reject the null hypothesis that beta equal to 0. Thus the 1 unit increase in the growth rate in the GDP will result in a 0.017732 units in the growth rate of ENTRE. Clearly, there is a positive cause and effect relationship between the GDP and ENTRE.

5. Conclusion

Our econometric analysis had asserted that the number of entrepreneurs in Palestine negatively impacts the GDP. Taking a closer look at the data in Table 2, we notice that the number of entrepreneurs fluctuated up and down from one year to another. Meanwhile, the GDP had an increasing trend, i.e. monotonically increasing from 2003 to 2013 and then from 2014 to 2016. Clearly, this is the reason for the negative effect. However, the impact was very small, where a one unit increase in the number of entrepreneurs will lead to 0.003 unit decrease in GDP. Thus the increase in the number of entrepreneurs is not stimulating the increase in GDP.

Since the capital was not significant, we were not able to continue our analysis and develop a growth model from the Cobb-Douglas production function. As a result, we moved to the time series analysis. This analysis had indicated that the growth rate in the GDP is what stimulates

an increase in the growth rate of the number of entrepreneurs. Thus, the growth rate in the number of entrepreneurs is not stimulating an increase in the growth rate of the GDP.

Intuitively, this means that the growth rate in the GDP is stimulated from other economic variables, and the role of entrepreneurship is still somewhat absent in Palestine.

This is clearly realized by the PA, thus the Higher Council for Innovation & Excellence was established in June of 2012. Its main objective is to create a Palestinian society rich in knowledge, innovation and creativity. This council targets entrepreneurs in all sectors of the economy. However, it gives special emphasis to technological breakthrough in both the industrial and agricultural sectors. A number of incubators – in cooperation with companies from the private sector – were created in the West Bank to aid and support research conducted by entrepreneurs. In addition, the council supports entrepreneurs in all stages of the business (Samara, 2017).

Looking at Table 2, we notice that the number of entrepreneurs was monotonically increasing from the year 2012 to 2016. This increase might be due to the PA partial success in creating an environment that encourages and nourishes entrepreneurs that are then hoped to achieve sustainability in both development and job creation.

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The Role of Business Incubators in Supporting Sustainable Development for Women Entrepreneurs in the Kingdom of Bahrain

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Abstract

Business incubators have recently become very popular approaches amongst governments in the development of their economic strategies. Incubators have been highly documented as important tools to support businesses and their growth particularly for new and young entrepreneurs. However, only few studies have dealt with business incubator and their important role to support women particularly in the Kingdom of Bahrain. Homebased entrepreneurs face some constraints to the sustainability and growth of their small businesses, this makes access of incubator services limited.

The purpose of this study is to examine the role of incubation services for women home-based entrepreneurs in the Kingdom of Bahrain.

The study used survey questionnaire method; a conceptual framework was developed to examine the following research dimensions; (a) business incubators, financial and facilities support, (b) business incubation and effects on the standards of living, (c) business incubation and improving individual level on strategic activities for sustainable future.

The study indicates that there is a high level of women entrepreneurs that face some difficulties in borrowing money from financial institutions and in the repayment of their loans by installments.

In general, women entrepreneurs who managed to run projects successfully also managed to have more income while progressing in their projects, they became more involved in the family budget spending decisions, and they had also an improvement in the ability to secure some special savings from their income. The research showed that business incubators help women in understanding how to market their products or service, how to develop them according to customers' needs and how to become sustainable in their activities.

Keywords: *business incubators, sustainable development, entrepreneurs*

1. Introduction

Women have a significant role in the society of the Kingdom of Bahrain. They play a major role in building the society and serving it by offering their energy through home based projects and by being effective workforce. The Bahraini government support women entrepreneurs in different initiatives such as financial and advising through the Supreme Council for Women, Tamkeen, and Bahrain Business Incubators, the latter being the core subject of this research paper.

In the kingdom of Bahrain there are 651 projects that are registered at the ministry of labor and social development as home based projects, 85% of them are owned by women. Those women are unfortunately not able to work outside home for different reasons, mainly due family commitment. Therefore, they prefer to work on developing their SMEs from home.

The main hypothesis of this research is 'Business incubators play an important role in supporting women entrepreneurs to sustain their SMEs in the kingdom of Bahrain'.
This research questions are as follows:

- What is the role of business incubators in empowering women entrepreneurs in the Kingdom of Bahrain to access financial institutions?
- What is the role of business incubators in empowering women entrepreneurs in the Kingdom of Bahrain to improve their life style?
- What is the role of the business incubators in improving the performance of women entrepreneurs in economic activities in the Kingdom of Bahrain?

The aim of this research is to investigate the role of incubators in supporting sustainability of women entrepreneurs in the Kingdom of Bahrain and what kind of support do existing incubators provide for sustainable entrepreneurship.

2. Literature review

2.1 Incubators

Business incubators are one of the most important tools of economic development in many countries. The investment in entrepreneurial skills and creative ideas trigger the potential of people, enhance the competitive advantages of the economy and thus help achieve sustainability at the national level.

Incubator is a physical location that provides a defined set of services to individuals or small companies. This may include specific types of office space, flexible lease terms, access to technology, financing, and technical assistance (such as marketing, legal, finance, HR, and other business development services (Davies, 2009).

Similarly Oweis (2016) added that the concept of incubators appears to be an integrated system of different mechanisms of support for the small and medium enterprises chosen to be affiliate to the incubator. These enterprises satisfy all needs of the project in its beginnings, including the financial, marketing, technical and administrative support, provision of communication network in the research centers, labs, universities and supporting authorities whether government or nongovernmental so that the focus of entrepreneurs who own projects focus on the planning of the project steps and overcoming the difficulties of beginnings with provision of diverse experiences and employment of number of experienced consultants to provide proper guidance to the entrepreneurs in order to achieves the project's tangible and rapid success as compared to those similar projects that are established out of the incubator.

Business incubators' main goal is to produce successful firms that will leave the program financially viable and freestanding, usually within the first two to three years. These incubators graduates have the potential to create jobs, revitalize neighborhoods, commercialize new technologies, and strengthen local and national economies. Typically, 30 percent of incubators clients graduate each year. It was reported that in 2012, there were more than 1,250 incubators in the United States compared to only 12 back in 1980. The International Business Innovation Association (IBIA) estimates that there are more than 7,000 business incubators worldwide (Small Business Incubator Certification Program Annual Report, 2016)

The role of the business incubators is to encourage the development of new business within the local community. By assisting a local entrepreneur to start a company in the area, the community is likely to benefit from an increase in the number of available jobs in the area and the additional revenue that is brought to the city or town as a result of the new business activities. Both elements can help to revitalize a local economy and thus enhance the quality of life for everyone who lives and works in the area (Lesakova, 2012). He added that there are two kinds of business incubators namely non-profit and profit or known as private incubators. The non-profit ones are actually organized by the government to help new business startups. The profit led business incubators are managed and funded privately. They offer clerical staffing, phone systems, office furniture as well as office space and they may also provide mentoring or right to capital. Their main role is to accelerate as the company started to offer its product or services to the market. Mostly, it may just be just in the period of 6 months and not over 90 days, private incubators are basically setup by venture corporations, entrepreneurs and capital. The incubator company would also usually take ownership position in every company it handles. (Shahzad et al. 2016)

McMillan Woodruff (2006) explained that there are many types of incubators that vary by the duties and interests that the incubator tends to implement and the difference of the goals that the incubator tends to achieve, so incubators of small enterprises take several types including finance and profit incubators, governmental incubators financed by government and not for profit that aim at promoting economy and developing the local communities. Private sector incubators, which are profit investment incubators that shall be financed by entities or groups of industrial companies. - Mixed incubators financed by the governmental organizations and private authorities. - Incubators financed by some private authorities to the international organizations and corporations or chambers of commerce. University incubators can be annexed to universities and educational institutions.

2.2 Entrepreneurship

Since the start of the nineties, the era has become the age of entrepreneurs. Educational institutions, government organizations, businesses and society have been interested in entrepreneurship. As per the pioneers suggestions, the most successful economies are those that support the economic growth through entrepreneurship at all levels individual and institutional or even regional and national. Drucker (1985) argued that entrepreneurship reflects merely the creation of a new organization and that any individual who starts a new business venture is an entrepreneur; even those that fail to make a profit. According to Onuoha (2007), "*Entrepreneurship is the practice of starting new organizations or revitalizing mature organizations in response to identified opportunities".*

The factors that influence entrepreneurship and likely success of entrepreneurship are frequently tied up to the local demands, creative policy both local and governmental (Belak 2011). The factors which influence the initial entrepreneurial decision are used to develop a theory for female entrepreneurs. The model describes three broad groups: "Antecedent Influences" include those aspects of the entrepreneurs background which affect motivation, perceptions, and skills and knowledge. These include genetic factors, family influence, education, and previous career experience; The "Incubator Organization" describes the nature of the organization for which the entrepreneur worked immediately prior to the start-up. Relevant factors include the specific geographic location, the type of the skills and knowledge acquired, the degree of contact with possible fellow founders, and the extent to which the entrepreneur gained experience of a small business setting. Beyond these, there are particular motivations and triggers to stay with or to leave an organization - the push versus pull factors; "Environmental Factors", external to the individual and to their incubator organizations, provide an important setting within which the individual entrepreneur is able to flourish. Important factors here include the prevailing general economic conditions, but more specifically the accessibility and availability of venture capital, role models of successful entrepreneurs, and the availability of supporting services (Ambepitiya, 2016)

David J. Storey (1994) identified six significant influences on new firm formation which can vary from region to region. These six factors are: (1)demographics – regions with young populations tend to produce more firms, and rates of start-up are generally higher in urban than in rural environments; (2) unemployment – through different routes this can both encourage or diminish business start-up rates, (3) wealth – it is expected to produce in wealthier areas more business startup owing to higher levels of demand and greater availability of capital; (4)the educational and occupational profile of the workforce – may have contradictory effects on business start-up, as persons with superior qualifications will more likely find employment but may also have superior means with which to create their own enterprise; (5)the prevalence of small firms – it is argued that employees in small firms will aspire to own other small firms; (6)the extent of owner-occupied housing property is viewed as a frequent source of start-up capital for entrepreneurship

2.3 Women as Entrepreneurs and Projects Sustainability

In the 1970s, women left house work and entered the workforce in masses. These women opted to work from home not as homemakers, but as job-making entrepreneurs. Many women started businesses that align with their personal values (Ambepitiya, 2016).

Sustainable development can be viewed as a social movement, *"a group of people with a common ideology who try together to achieve certain general goals*" (Kates et al., 2005)

The objectives of sustainable development are shown in Figure 01. Sustainability development aims to make an influential effort on Ecology, Sociology and Economy. Ecological focus includes genetic diversity, resilience, and ecological productivity which endeavor to stabilize environment. Sociological focus includes cultural diversity, cultural sustainability, social justice and participation. Building a fair and free society is the base of sustainability. Reducing poverty, quality enhancing and production of useful goods and services are the objectives of a sustainable economy

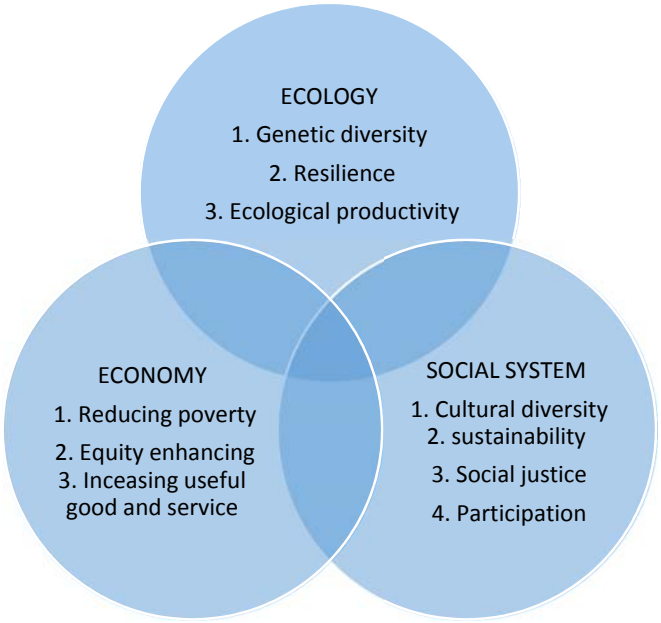


Figure 1 The Role of Women Entrepreneurs in Establishing Sustainable Development in Developing Nations. Source (Kalpana R. Ambepitiya, 2016).

Sustainable development can only be achieved through long-term investments in economic, human and environmental capital. At present, the female half of the world's human capital is undervalued and underutilized. As a group, women and their potential contributions to economic advances, social progress and environmental protection have been marginalized. The use of the world's female population could increase economic growth, reduce poverty, enhance societal well-being, and help ensure sustainable development in all countries. Closing the gender gap depends on enlightened government policies which take gender dimensions into account. (OECD 2008)

Pareek (1992) defines women entrepreneur as a female who plays a captivating part by repeatedly interacting and keenly adjusting herself with financial, socio-economic, and support spheres in society. Globally the impact of women entrepreneurs is gaining recognition intensely. The number of female business owners continues to increase steadily as women entrepreneurs are making positive impact in the global economy. (Oluwole, Dominic2014)

Women for example, produce over 80 percent of the food for sub Saharan Africa, 50-60 percent for Asia, 26 percent for the Caribbean, 34 percent for North Africa and the Middle East, and more than 30 percent for Latin America (Ali and Ali, 2013). Women entrepreneurs around the world are major contributors to the economy, as they are making a difference in the socio-economic arena. They contribute numerous ideas and a great deal of energy and capital resources to their communities, and generate jobs as well as create additional work for suppliers and other spin-off business linkages. (OECD, 2004)

As a consequence, equal opportunity between men and women from the perspective of entrepreneurship is still not a reality. To facilitate progress, more work needs to be done in order to better understand the function of women's entrepreneurship in society in economic development. It is known that women entrepreneurs play a vital role in the economy, women face challenges and obstacles different from those faced by men. The larger the difference between men and women in a society, the larger one can expect the difference to be between entrepreneurs and the more difference in their relative contribution to economic development. The impact of women's entrepreneurship in different economic contexts, meaning, both the economic level of development and the societal level of development when it comes to the role of women in society.

2.4 Statistics and results

This part of the research paper represents the statistics and the results of the data collection carried out to study to role of women entrepreneurs in supporting sustainable development of incubators in the Kingdom of Bahrain. In this study the primary data collection was based on quantitative research method, questionnaires survey were randomly distributed amongst women entrepreneurs in Bahrain. 250 questionnaires were distributed and the number of participants that successfully completed the questionnaire was 191, resulting in 72% response rate. The list used of women entrepreneurs in Bahrain was the latest version provided by the Ministry of Labor. The selected descriptive variables were; (1) age of the woman entrepreneur, (2) the level of education of the woman entrepreneur, (3) the type of project undertaken that varied between; commercial, industrial, agricultural, services and others, (4) the number of successful projects undertaken, (5) the duration of the undertaken projects.

A list of 21 dependent variables were clustered into 3 themes and covered (a) business incubators, financial and facilities support, (b) business incubation and effects on the standards of living, (c) business incubation and improving individual level on strategic activities for sustainable future.

As part of the survey questionnaire, all women were offered the choice from 5 pre-codes responses with a Likert scale to express their opinions on the variable statements.

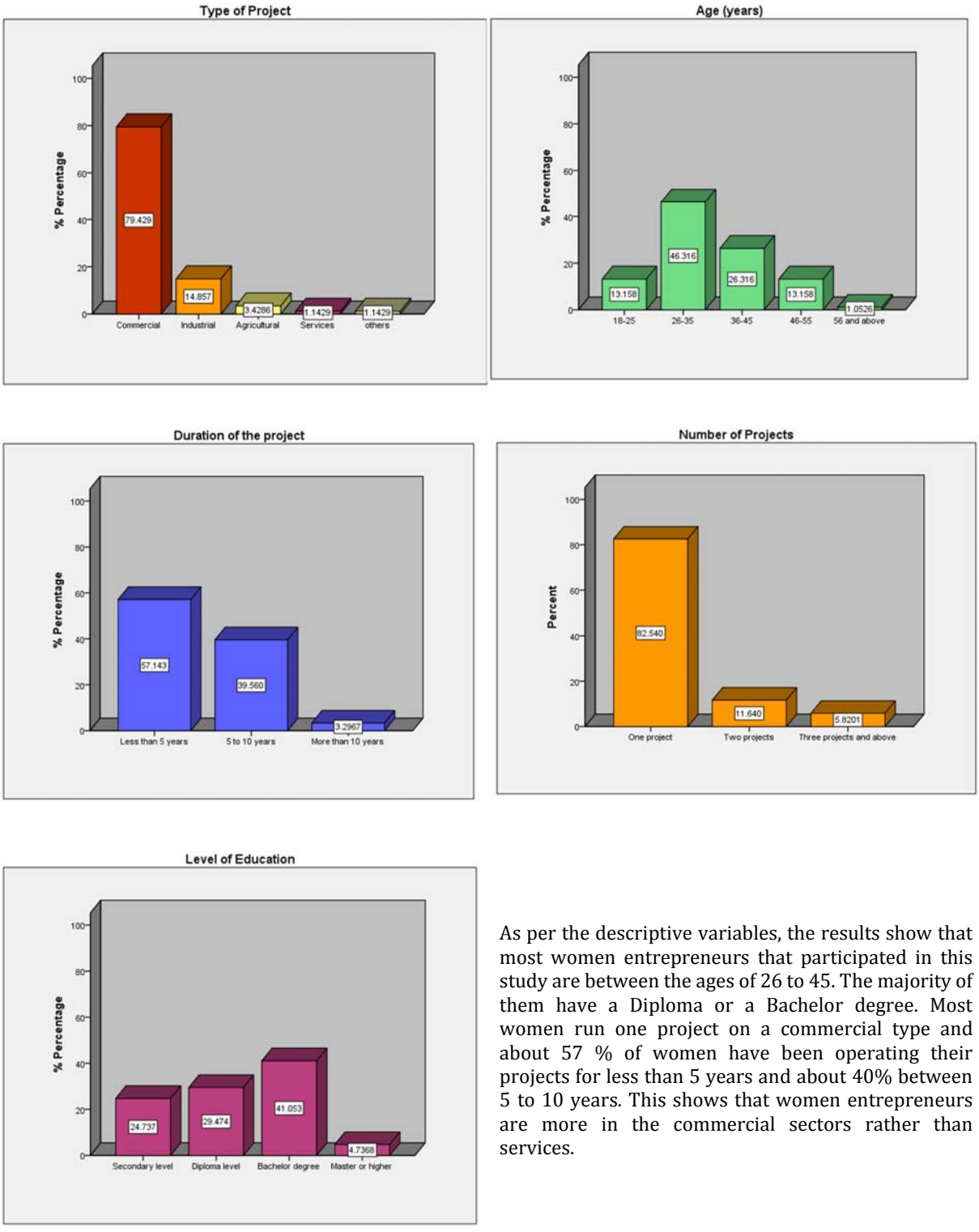
The results represented in figure 1 show the percentage of the responses per statement and they reveal that the majority of women work on commercial projects followed by industrial projects. Most of women entrepreneurs were between 26-35 years old with a percentage of 46 %, followed by more mature women between the age of 36-45 years with a percentage of 26% and equality with percentage of 13 % for younger women (below 25 years) and older women (above 45 years). The majority of women entrepreneurs worked on one project for less than 5 years and most women had bachelor level, and only few had a master or higher education level.

The results in table 2 present the averages of the descriptive variables per statement, and show that in general the majority of women entrepreneurs agree with the listed statements since the averages were above 4 within the Likert scale (1= strongly disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree).

The schematic representations from graph Q1 to graph Q21 show the results of the analyses of the cross tabulation between the type of projects (i.e. commercial, industrial, agricultural, services and other) and each statement of the listed variables (Q1-Q21) at a reference point that is the duration of the project less than 5 years. This period was selected based on the fact that the initial period during the incubation process is so important for the success of any project.

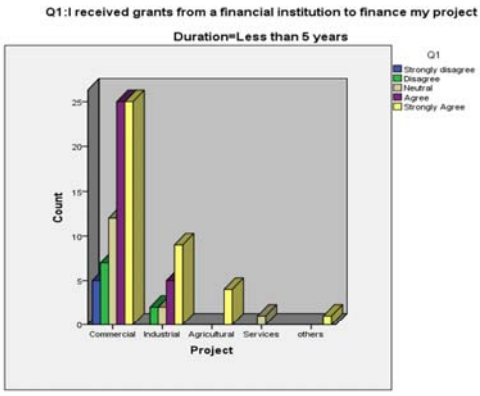
Table 1 Statement of the questionnaire survey.

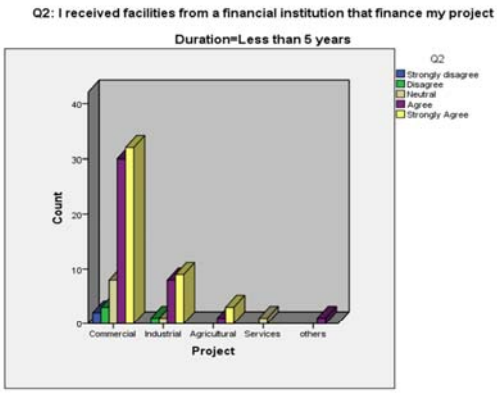
Theme 1: the business incubation, financial and facilities support	
Q1	I received grants from a financial institution to finance my project
Q2	I received facilities from a financial institution to support my project
Q3	The type of project helped me in obtaining financial institutional loan
Q4	I had difficulties to pay by installments in the event of a loan
Q5	Loan repayment period is appropriate in the event of a loan
Q6	I had difficulties in case of borrowing from financial institutions
Q7	There is insurance in the case of obtaining a loan for small projects
Theme 2: the business incubation and effects on the standards of living	
Q8	The establishment of the project reflected an improvement in the quality of the housing I live in
Q9	There is an improvement in my ability to pick up durable goods after running the project
Q10	There is an improvement in my ability to secure special savings after running the project
Q11	There is an increase in my spending on educational services after the establishment of the project
Q12	There is an increase in my spending on health services after the establishment of the project
Q13	I got an income after running the project
Q14	I have become more involved in family budget spending decisions
Q15	There is an improvement in the quality of my food consumption after the establishment of the project
Theme 3: the business incubation and improving individual level on strategic activities	
Q16	I have a strategic plan to expand the project
Q17	I learned about attracting an employee from abroad
Q18	I have improved my ability to complete project finance transactions in regards to good project income
Q19	I worked on developing the product according to my knowledge of customers
Q20	I have enough knowledge about suppliers for the requirements for the project
Q21	I have a group of employees who market a product or service project

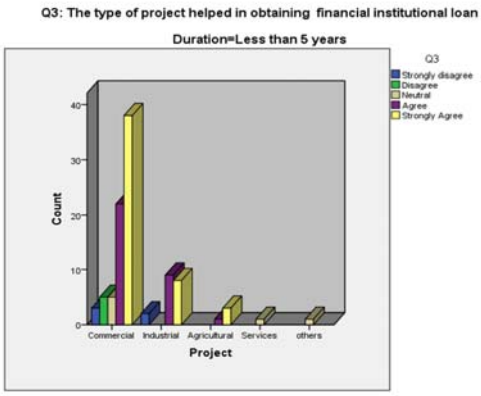


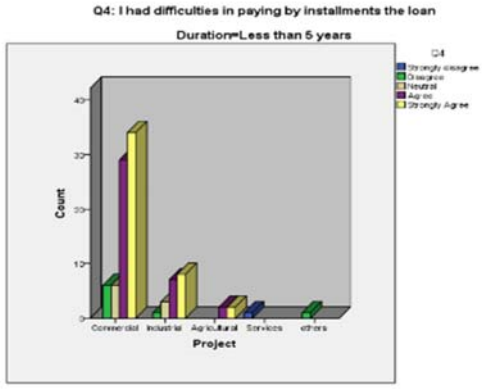
As per the descriptive variables, the results show that most women entrepreneurs that participated in this study are between the ages of 26 to 45. The majority of them have a Diploma or a Bachelor degree. Most women run one project on a commercial type and about 57 % of women have been operating their projects for less than 5 years and about 40% between 5 to 10 years. This shows that women entrepreneurs are more in the commercial sectors rather than services.

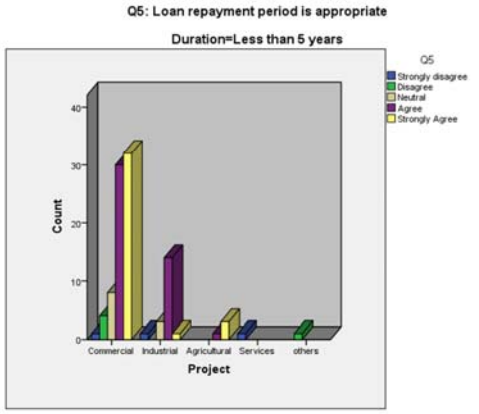
Figure 1 The percentage of responses per descriptive variable.

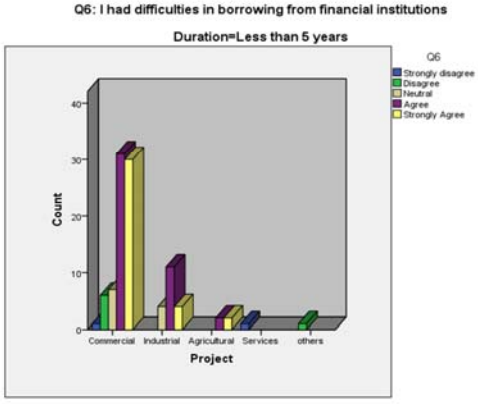


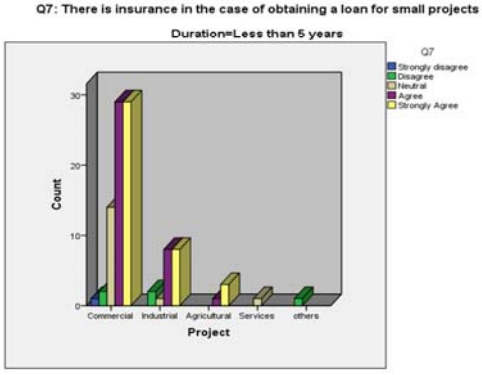






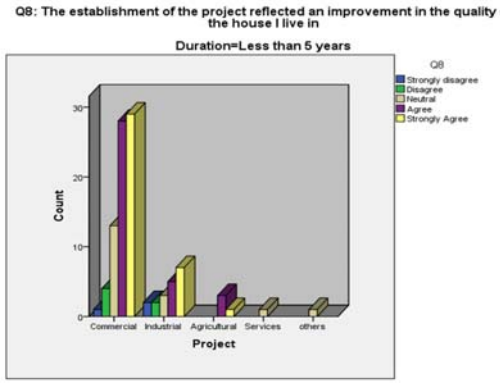


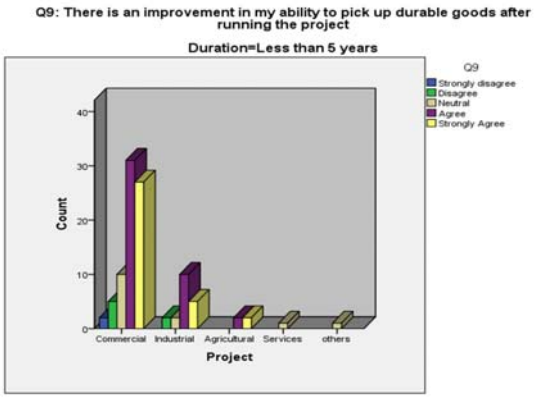


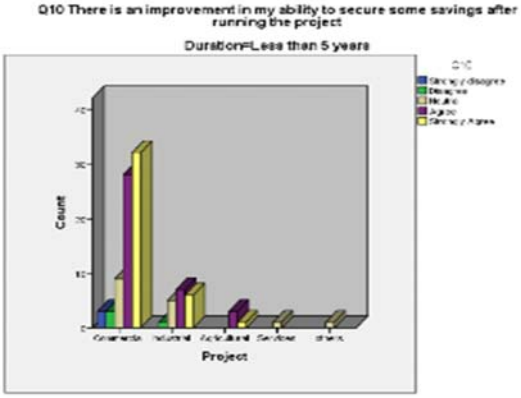


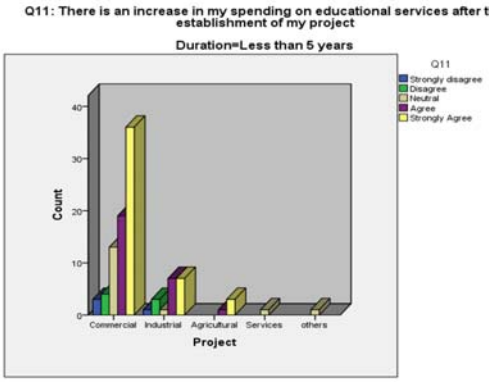
Theme1; The results on the business incubation, financial and facilities support show clearly that the majority of women entrepreneurs had financial support for their projects and received grants from financial institutions to finance their projects they added that the type of projects helped them in obtaining financial support. However, the majority of women agree to strongly agree that they had difficulties to repay by installments even though the repayment period was over 5 years.

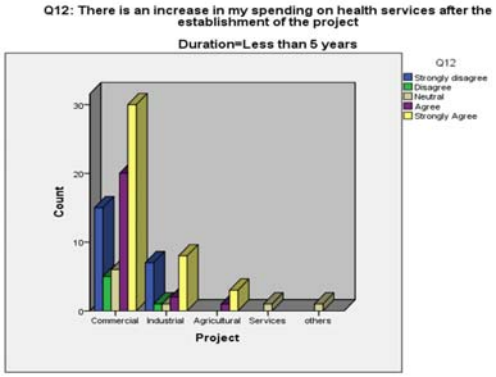
Theme 1 the business incubation, financial and facilities support Q1-Q7.

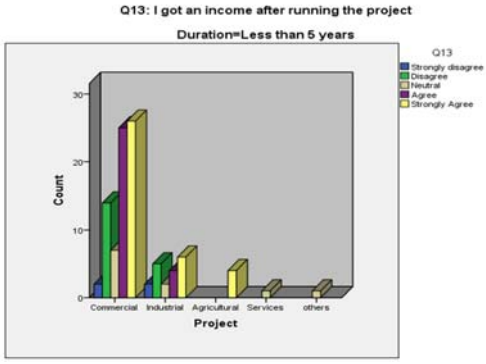


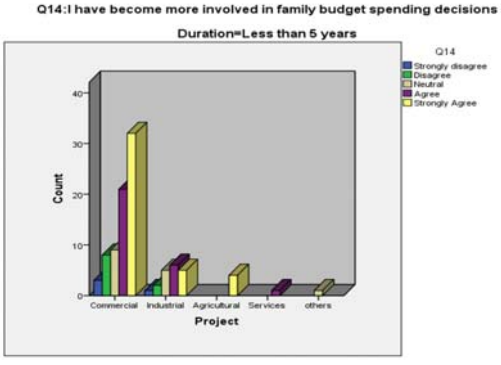


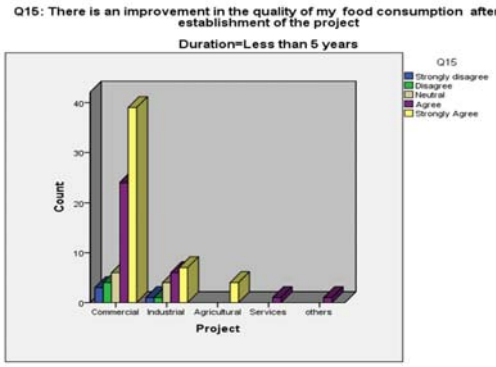






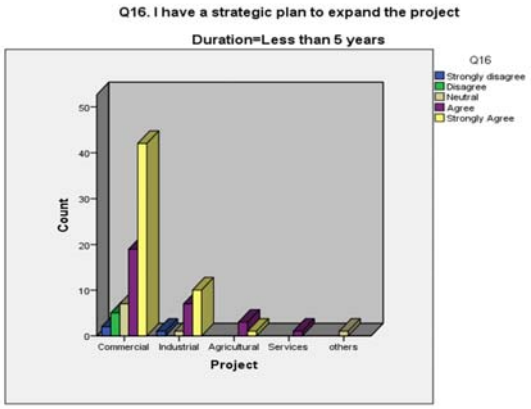


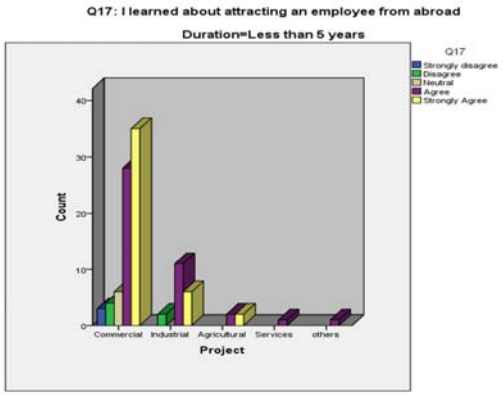


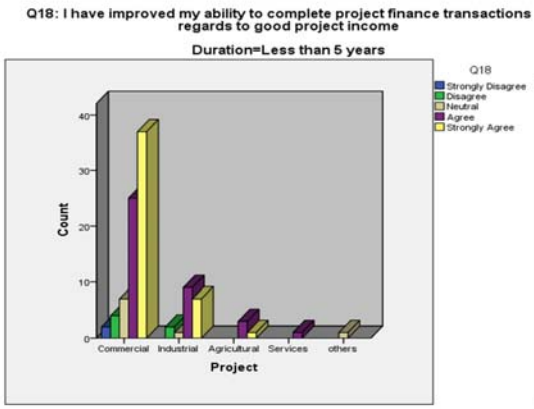


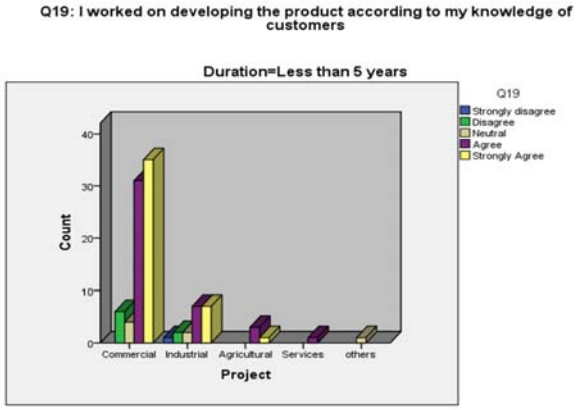
Theme 2 the business incubation and effects on the standards of living Q8 – Q15.

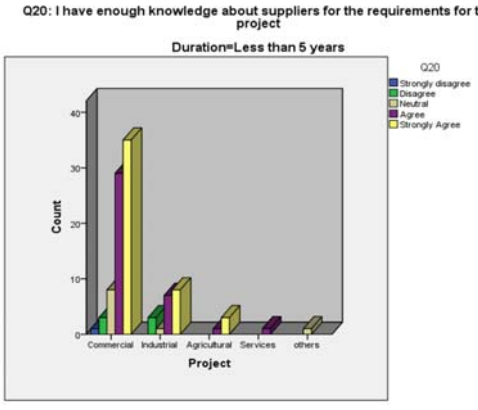
Theme 2; The results on the business incubations and effects on the standards of living of women entrepreneurs show clearly that the majority of women agree to strongly agree that the incubators reflected an improvement in the quality of the housing they live in, they purchased better quality goods and better quality of their food consumption. In addition, they spent money on the educational services and on health services .The majority of women entrepreneurs also managed to secure some savings after successfully running their projects and getting income. On the personal level, as women earning money, they have become more involved in family spending decisions and in getting more confidence within the community.

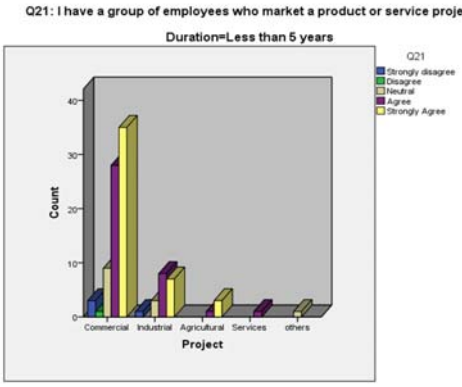












Theme 3 the business incubation and improving individual level on strategic activities Q16-Q21.

Theme 3; The results show clearly that business incubation improved individual level of women on strategic activities, most women agreed that they have learnt how to develop their strategic plan, and improved their ability to complete project finance transactions. Most women learned to develop products or services according to the customer needs, and they gained experience on suppliers' requirements. Most women gain knowledge on market research to attract international ventures.

3. Implications and Conclusions

The study indicates that in the initial period of the process of business incubation, that is in the first 5 years, most women entrepreneurs either strongly agree or agree with the positive support the business incubation provide to them from the loan, financial support, and technical support. However, there is a high level of women entrepreneurs that face some difficulties in borrowing money from financial institutions and in the repayment of their loans by installment.

The study reveals that business incubators play an important role in providing support and facilities to women entrepreneurs particularly in the first 5 years of their establishment. The study also demonstrates that business incubators have a great effect on improving women entrepreneurs' lives. In general, women entrepreneurs who managed to run projects successfully also managed to have more income while progressing in their projects, they became more involved in the family budget spending decisions, and they had also an improvement in the ability to secure some special savings from their income.

Business incubators supports provide to women entrepreneurs many benefits including a better standard of living, hence the quality of their houses has been upgraded, and also the quality of their goods consumption and the quality of their food consumption have improved.

The study reveals that women entrepreneurs' spending has increased in two important sectors that have a great impact on sustainable futures, namely; more spending in the education sector and the health sector.

This research work concludes that business incubators support women entrepreneurs in becoming more strategic in their activities as they expressed their opinion by mostly agreeing or strongly agreeing to the research statements and this trend is across the various projects undertaken, regardless the number of projects or the type of project. Women seems to hold similar views on business incubators in supporting sustainable development for women entrepreneurs regardless their age or educational level. It is clear that business incubators help women in understanding how to market their products or service and to develop them according to customers' needs. Women started to understand the market needs and requirements, the financial implications to successfully run their businesses. This concludes that women entrepreneurs contribute in sustainable future by thinking strategically to expand their businesses and by employing more people to work for them and hence providing opportunities to others , this will helps them to improve their projects' sustainability .

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Section 7

Sustainable Economies and Islamic Finance

Creative and Innovative Financing – An Approach to Financing a Sustainable Real Estate Project Environment

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Abstract

The aim of this study is to provide insight into how creative and innovative financing can be used to develop sustainable real estate project environment. Giving the fluid and dynamic nature of the built environment, the three (3) pillars of sustainability (social, environment and economics) are continually changing amidst a huge scale of challenges with accessing funding for real estate's projects, especially in the emerging economies. This shortage in funding has created a need for some financial engineering to be able to provide sustainable projects for the society. Through comprehensive review of literatures, and a number of case studies. The findings show that in contemporary times, sustainable projects are realisable only through the usage of creative and innovative financing. Equity and debt instruments are often, no longer used in the traditional sense; instead they are structured to suit the characteristics of each project's life cycle and asset /receivable cycle; this in effect could be termed a form of creative and innovative financing. The findings show that sustainable projects are more in existence in the developed economies because of their usage of creative and innovative financing in executing projects. This study contributes to the field by presenting one of the first studies of its kind focusing on creative and innovative finance as propellant for sustainable real estate projects. The study recommends more usage of creative and innovative financing in the real estate's sector in both the developed and emerging economies as a means to provide sustainable projects. It also developed a, "project sustainability funding matrix", which can be used as a guide by decision makers in financing decisions for sustainable real estate projects.

Keywords: creative finance, innovative finance, financial engineering, sustainable environment, project lifecycle.

1. Introduction

Countries around the globe are faced with immense pressure from population growth, economic development and unfavourable events like wars and natural disasters. This has generated great demand for sustainable real estate's projects (Zhang et al, 2014). To address these challenges of shortages in real estate projects, especially housing, the built environment must develop smart and sustainable projects (Huston et al, 2015). However, such an undertaking demands resources at a level almost untenable for real estate firms to afford. Furthermore, many economies around the globe are continually slashing infrastructure investment (Loh, 2010). Governments are reducing investments in this sector because of budgetary constraints while, financial institutions have also cut their infrastructure lending. This situation creates a need for creative and innovative financing as a platform to provide sustainable projects (Zang et al, 2014).

2. Study Methodology

The fundamental aim of this study is to showcase the effectiveness of creative and innovative financing as a platform to develop sustainable real estate projects (Zhang et al, 2014).

The available option for collecting data is qualitative (Miles & Hubermann, 1999). The study did this by interrogating relevant and discerning variables using a mix of desk based study and review of case studies (Zittoun, 2017). The methodology used encompassed extensive review of literature on sustainability and different creative and innovative finance options from various journals. These journals are oxford academic journal; academic journal of business, law and social sciences; international journal on project management; international conference on global economy, commerce and service science; journal of financial management of property

construction; journal of property investment and finance. They were sourced from different databases, which include Sprngerlink, Elsevier, Emerald and Science direct. A summary of the study concept is contained in figure *1.*

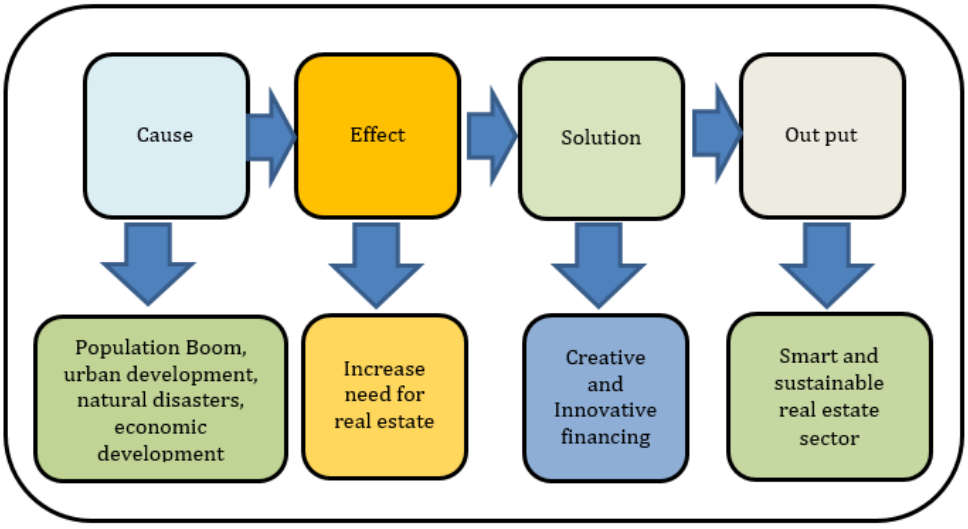

Figure 1: Concept of the study.

3. Sustainable Environment

Sustainable development can be seen as finding better ways of doing things to improve both the future and the present (Dresner, 2008). Arguably, the steady flow of financial resources is a prerequisite for sustainable development and hence a sustainable environment. Sustainable construction is a process of creating buildings that that meets up with the defined purpose, is environmentally friendly, in operation and management of which is there is high efficiency of resources (Vanags & Butane, 2013). Sustainability is about the balance of harmony between economic, social and environmental sustainability. It is a combination of the 'triple bottom line' which is people, planet and profit (Silvus, et al, 2012; Edward and Turrent, 2000). This study defines sustainability as developments and projects whose outputs meets up with the United Nations seventeen (17) sustainable development goals.

Maintaining sustainability in the real estate sector requires a deep understanding of how projects in this sector can be financed. Financing real estate projects which for the purpose of this study are large-scale commercial housing, is usually of great concern because of the reduction in financing from the banking sector and the associated risk factors (Quercia & Riley, 2017). This has created a renewed appetite for creative and innovative financing. The world requires innovative financing to support sustainable development hence a sustainable environment (Medda et al, 2011).

3.1 What are the measures of a sustainable project?

To measure if a project is sustainable or not, you will have to determine if it had positive social, economic and environmental impact on humanity both in the short run and potentially long-run (Murray, 2011) *see figure 2*. This in other words encompasses the impact of the project on the three pillars of sustainability which are people, planet and profit (Silvus et al, 2012).

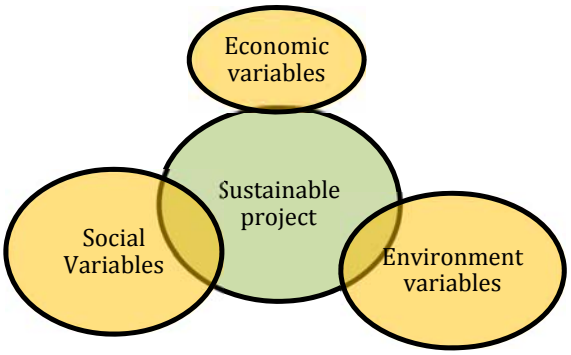

Figure 2 Pillars of a sustainable real estate project.

This study adopts the United Nation's seventeen (17) sustainable development goals as its measure of sustainability for real estate projects. These goals were adopted by countries on September25th 2015, as a measure to end poverty, protect the planet and ensure prosperity for all as part of a new sustainability development agenda. To attain these goals in order to make the world a better place, everyone needs to do their part: government, private sector and individual's (United Nations, 2015). This study looks at how creative and innovative finance can support the built environment to create sustainable projects.

Figure 3 Seventeen (17) sustainable development goals. Source United Nations sustainable development platform.

This study will classify these 17 sustainable development goals into six and then use ten creative and innovative funding options to develop, "a sustainable project funding matrix". However, the concept of creative and innovative financing has to be fully understood first.

4. What is creative and innovative financing?

The terms innovative and creative financing can be said to be synonyms. The slim difference is that which relates to creativity, as a sense of creating capacity or ability to conceive something original and/ or uncommon. Innovative on the other hand is the inventiveness akin in the implementation process. For the purpose of this paper, despite the distinctive names of innovative financing and creative financing, they will be termed innovative financing.

There are various definitions of innovative financing. The World bank defines innovative finance for real estate development as involving non-traditional forms of funding through private mechanisms, solidarity mechanism, public-private partnership (PPP) mechanism and catalyst mechanism (Grishankar, 2009). Therefore, innovative financing hinges on the three headings as considered by the World Bank:

- Innovative finance is a way of generating additional development funds by tapping new funding sources beyond conventional machineries such as established traditional and international operations allied to financial institutions such as banks.
- Innovative financing is a platform to enhance efficiency of financial flows, by reducing delivery time and/or cost, especially for emergency needs and in crisis.
- Innovative financing enables financial flow to function on a result-oriented modus; it proffers a distinctive link between funding flows and measurable performance observed on the shop floor.

In real estate financing, innovative is best conceived as a hub, which encapsulate various novel ideas in real estate financing which could impact on another society. Consequently, it encompasses the bringing of existing options in readiness for a new market or in a market where their maximal effect is yet to be utilized.

"innovative financing is a mechanism to raise funds in addition to conventional methods as well as a mechanism to improve the use of the funds" (Gargasson & Salome (2010, pp 13)

The innovative real estate financing option that left a bitter taste on people's tongues in the not distant past was the securitization and its commercial mortgage backed securities (CMBS) which was a major contributor to the 2007/2008 global financial crisis (Mamun, 2017). This was because it was abused in the sense that subprime mortgages where availed to the beneficiaries who could not make good their obligations (Yandle, 2010). This was because fundamental risk assessment reviews were not done or rather not enforced and loans were given to people who did not have the capacity to repay.

This study cogitates and reflects on the impact of creative and innovative financing that were used for large real estate projects in the past and how it contributed in making these projects sustainable. It will further show-case the need to develop greater interest in securitisation and other innovative finance options which, among portfolio asset managers, are widely received as strong sources of funding for a sustainable commercial real estate sector *(figure 4)*.

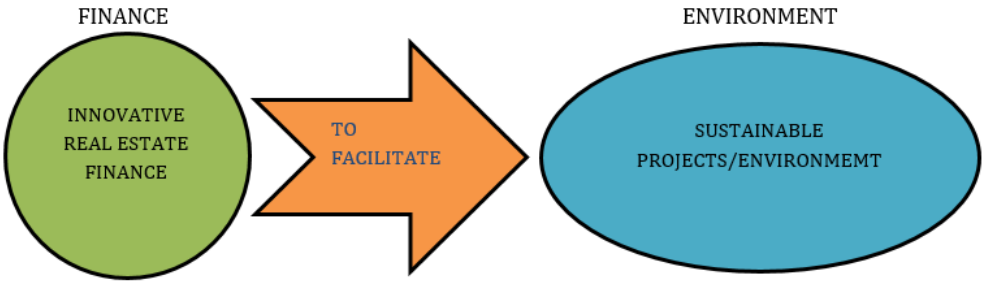

Figure 4 Innovative financing as a facilitator of a sustainable environment.

4.1 Why do we need creative and innovative finance?

Ratio of capital to loan: Most lenders across the globe are under pressure to improve the ratio of capital they hold to loans given. Consequently, the lenders are restrained from giving adequate financing to the likes of commercial real estate's firms. The Federal Reserve and the bank of England low interest rates have kept interest rates historically low (Brunnhuber,2015). Despite this, the supply of credit is still very low because banks are giving top consideration to borrowers considered less risky (Guercia & Riley, 2017). However, creative and innovative real estate financing can reduce this pressure on investors and developers, thereby enhancing the development of sustainable projects.

Housing gaps: The global demand in the real estate market is higher than the supply. This is evident in London and other big cities of the world (Tilford, 2015; Tustin, 2017). McKinsey

Global Institute (MGI) study (2014) suggests 1.6billion people across the world which is about one third of the urban population could be living in substandard housing or foregoing essentials to pay for their home by 2025. British Broadcasting Corporation (BBC) in 2015, while analysing the scale of housing shortage in England, explained that the Government wants a million homes built by 2025. Despite all that the government is doing to ameliorate the housing problem, it is still persistent. One of the very evident solutions is financing.

Creative and innovative financing is profitable for all stakeholders: Innovative financing is profitable for all the stakeholders if properly structured. A notably example is China which expanded their securitisation portfolio to $31.6Billion in December 2013 signifying how profitable it is (Ngwu & Cheng, 2016). Furthermore, lenders made $94billion from commercial mortgage backed securities which were sold off as bonds in 2014 (Wallace, 2015). This does not only enhance the investors but create jobs, activate economic growth there by making the environment as well as projects more sustainable.

4.2 How does creative and innovate finance create sustainable projects?

To understand how creative and innovate finance support and /or create a sustainable project. This study will develop a real estate project sustainability funding matrix. This will be done by classifying the seventeen (17) sustainable development goals into six (6) and matching then with ten (10) creative and innovative funding options that if used will develop a sustainable project and hence a sustainable environment.

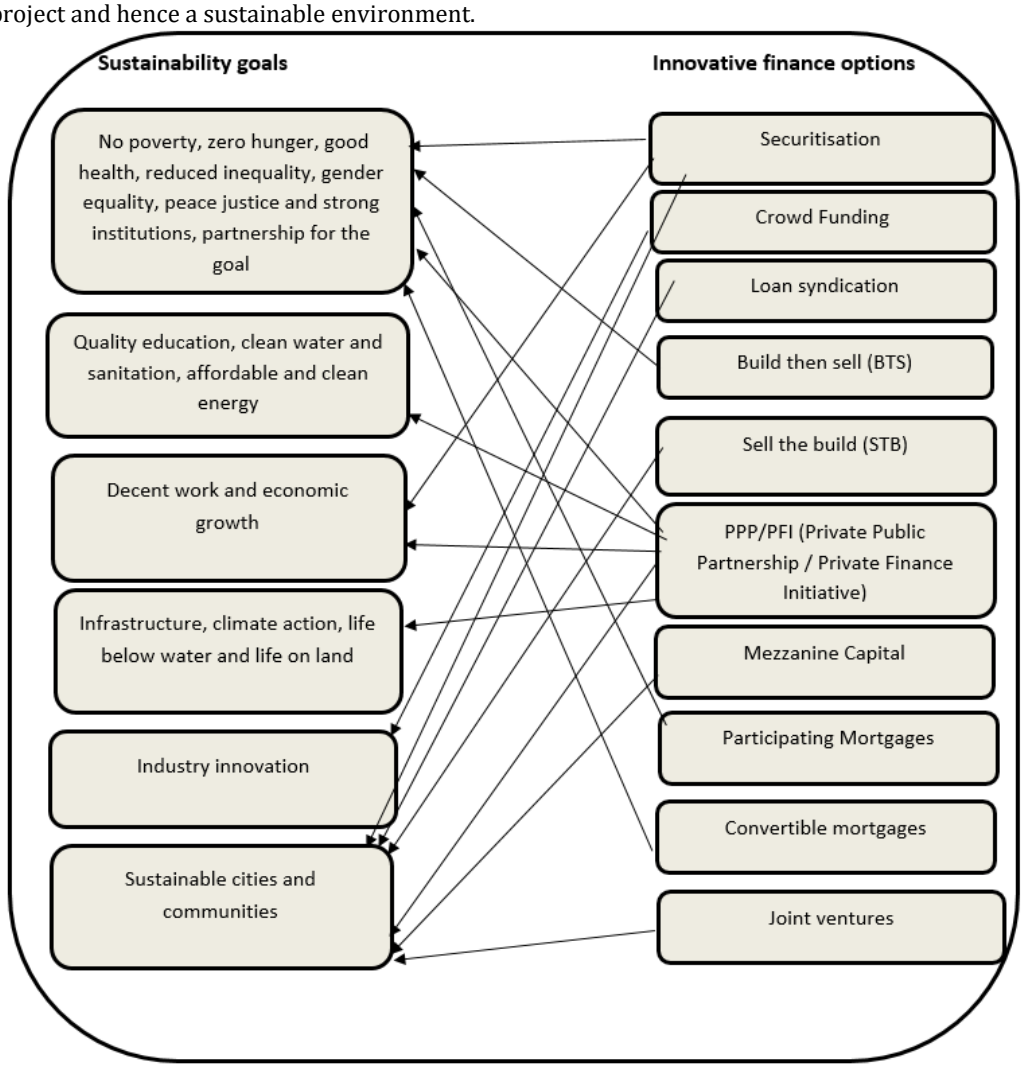

Figure 5 Project sustainability funding matrix.

4.3 Justifications for the project sustainability funding matrix

I. **It provides funding over the life cycle of the project:** The creation, operation and management of real estate's projects especially ones as large as commercial real estate projects over its life cycle involves the owner (sponsors) and a wide range of professionals (Sing, 2002). It also involves firms in the architecture, engineering, constructions and facilities management (Kamara, 2012). The funding decision for these types of projects is what makes it successful and hence impactful (sustainable). Funding options like Public Private Partnership (PPP) if used will make these kinds of projects sustainable. This is because such projects are long-tenured and often needs very large sums, consequently PPP will adequately take care of materials, payment of salaries for both skilled and unskilled workers; the covenants could incorporate government policies such as bridging of inequalities by employment of minority indigenes, as well as bridging gender inequalities. This makes such projects socially sustainable because adequate funding is sourced to fulfil the mission of sustainability.

   Public Private Partnership (PPP)/ Private Finance Initiates (PFI) do not only meet with the social needs of the society through projects. It also provides funding for large commercial real estate's projects that will accommodate interactive economic nodes such as airports, highways and communication, ultimately making the aggregates of such projects, smart or intelligent cities (Gibson et al, 1992). This leads to decent work and economic growth, sustainable cities and communities, interdisplinary collaborations and ultimately reduced hunger and poverty.

   PPP/PFI funding since it is a project lifecycle funding also takes care of environmental sustainability because it makes adequate provisions for clean water and sanitation as well as affordable clean energy.

II. **Provides funding for innovation and infrastructure:** Crowd funding is a creative and innovative finance option that can be used at the start off a new project before other means of innovative funding such as venture capital is sourced. This type of financing enables developers to commence projects with some degree on independence that is commonly not considered for bank financing or investment by large financial institutions (Lam & Law, 2016). Crowd funding is relatively new as compared with most other types of innovative financing. The use of social media and the internet as a whole has enhanced its effectiveness and popularity in contemporary times. The risk is widely spread because it taps relatively small contribution from a large number of individuals using internets, without assistance of financial intermediaries. It is a relationship between the entrepreneurs, investors (crowd funders) and the intermediaries (crowd funding platforms).

   Crowd funding can be used to develop more innovations in the contemporary developments in the real estate sector which are technological based innovations. This includes research and development (R & D) into lean, internet of things, cost effective and resource efficient technologies over a wide range that can be sold to real estate firms to enhance projects as well as protect returns to the investors. This kind of outputs through Crowd funding makes projects more sustainable.

III. **Provides decent work and economic growth:** Securitisation is a good funding option that can facilitate decent work as well as economic growth. Securitisation is a finance technique where debts are sold to investors. Despite how profitable securitisation is to all the stakeholders, it could be very dangerous if backed by poor credits, inadequate valuation methods and insufficient regulatory oversight. This was the danger the world was thrown into because of actions and inactions of the rating agencies; regulatory agencies and financial institutions with large and unrestrained risks appetite (Smith, 2017). However, all of these excesses are now being contained by the regulatory authorities. The Bank of England wants to encourage investors and banks back in to the securitisation market. It expedient to provide long -term housing lending with long-term savings and loans through securitisation to avoid funding mis-match. This position by David Rule, was concurred to by former Chancellor, George Osborne when he welcomed the proposal to improve business funding through securitisation (Wallace, 2015).

   Securitisation does not only provide funding for the real estate projects but makes good returns for the investors, provides funding for jobs for people in the construction

and other associated sectors. The ripple-effect of securitisation improves economic growth and hence a more sustainable environment.

IV. **Provides Sustainable cities and communities:** Creative and innovative finance such as mezzanine finance , joint ventures , sell then build (STB), public private partnership (PPP), securitisation and loan syndication could facilitate the building of projects that will make up smart cities and communities**..**

Sustainable projects are integral parts of smart cities (Gibson et al, 1992). Smart cities are sometimes referred to as, "intelligent cities". These are network cities of dispersed, highly interactive nodes linked by networks such as airports, highways and communications. These types of projects are highly capital intensive and can only be accommodated by a blend of different financing (Gargasson & Solome, 2010).

Mezzanine finance is very important for these kinds of large projects because it does not require highly liquid collateral like bank financing. It is accompanied by an increased rate of return for the investors. Mezzanine loan is different from Mezzanine finance. Mezzanine finance is broader and also includes financial instruments such as stocks, bonds and options used in securities market (Sazonov et al, 2016). Mezzanine finance is flexible and could take the form of bridge finance. Mezzanine finance can be sourced from a country and used in another for real estate's projects. Especially in the emerging economies where there is shortages of sustainable projects (Jayanti and Gowda, 2014). The usage of Mezzanine finance could cover every phase of the project, from working capital requirement (payment of salaries and purchase of raw materials), business expansion and capital investment. Hedge funds, pension funds, private equity funds, insurance companies and banks with the relevant departments usually act as mezzanine investors (Sazonov et al, 2016).

Furthermore, Syndicated loans are also a very viable innovative finance option that can be used to finance the establishment of sustainable projects hence sustainable cities and communities. Syndicated loans are parcelled amongst a number of banks, ranging from two (2) lenders to more than thirty (30) in some cases (Berlin, 2007). Large real estate's development firms that are involved in the building of sustainable communities can borrow very large sums at lower rates and longer tenures when no single lender is too heavily exposed.

Other sources of funding such as sell then build (STB), joint ventures, participating mortgages and convertible mortgages are innovative finance options that could support the creation of sustainable cities and communities. Sustainable cities are communities are usually well equipped with good infrastructure, quality education, clean water and sanitation and clean energy which are all indicators of a sustainable environment. All of these sustainable provisions are only feasible through the right choices of funding.

5. An Evaluation of Empirical Literature on Case Studies of Sustainable Projects That Used Creative and Innovative Financing

Research has showed that there is an increasing use of creative and innovative financing for large mix use properties in Europe (Iblher & Lucius, 2003). There is a great blend of equity and debt, which can be considered innovative finance

The Battersea project (*figure 6)* which is a mix of residential and commercial scheme used debt-equity from non- domestic investors and pension funds along with international banks (loan syndication). This project has 600 houses, as well as commercial space hence was to meet great need in the housing sector. However, the development took between 10 to 12 years with a gross development value of £8billion (Squires et al, 2016). . There were series of re-financings before the completion of this project. This project is economically viable because London where it is situated has a buoyant housing market

Figure 6 Battersea power station project. Source https://www.batterseapowerstation.co.uk.

Another interesting project that used creative and innovative financing is the Leipziger Plaz, in Berlin (*figure 7*). It is a large residential development covering 76,000m^2 . It used a mixture of debt and equity financing and land assembly finance. This project also show- cased the flexibility in contemporary real estate financing. The debt finance was syndicated loan from a consortium of banks. There were also private investors and institutional investors who part-financed this project.

Figure 7 Leipziger Plaz. Source http://www.leipziger-platz-berlin.org

Build then Sell (BTS) and Sell then Build (STB) were used Malaysia where the Government intervened to tackle the problem of abandoned housing project. In the STB, the buyer often makes down payment of about 10% and makes further payments for the different phases of the projects as development continues. This is innovative as it is not conventional and provides the capital needed for project. In the BTS the government provides concessionary credit by waivers of deposit for developer's license and provides fast track planning approval process (Yusof et al, 2011). This model of real estate financing is very effective for commercial real estate projects.

5.1 What made these projects sustainable?

These projects were all sustainable projects because they contributed individually to meeting some and sometimes all the United Nations sustainable development goals (*see figure 3*). This was possible because the developers and investors used different creative and innovative finance to actualise the projects (*see figure 5*)

6. Conclusion and recommendation

This study shows that we can only say a project is sustainable when it meets some or all of the United Nation's seventeen (17) sustainable development goals (*see figure3).* Furthermore, in contemporary times, it is only possible to achieve sustainability in real estate projects through the usage of creative and innovative financing. This is because the world is facing reduced real estate project funding from the financial markets and the governments. Despite this short-falls in funding, there is an increasing real estate's projects shortage, especially in the emerging economies. This gap in the real estate's sector must be met in a manner that will engender sustainability.

This study recommends more usage of creative and innovative financing for real estate projects in the developed economies where it is increasingly being used as well as replicating this best practise in the emerging economies. The study further developed a, "sustainable project funding matrix", (*see figure 5*). This matrix can be used as a guide by decision makers with respect to project funding decisions that can enhance different areas of sustainability.

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Macroeconomic Factors Affecting Islamic Banking Share of Profits in Turkey

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Abstract

As an alternative to conventional financial system, the Islamic finance has been rapidly growing in the last decade. Turkey, as an emerging country listed in the largest 20 economies in the world is one of the early adopters of Islamic banking. Although there is a considerable development of Islamic banking in Turkey recently, also named as participating banking, with its 2.9% global share, the size of the industry is very small compared to the pioneers of Islamic finance such as Iran, Malaysia, Saudi Arabia and UAE. In that context, in this research, it is aimed to examine the selected macroeconomic factors affecting the average returns participating banking share of profits in Turkey, and in the lights of the results bringing some recommendations to grow the size of the industry. As macroeconomic factors, central bank overnight lending interest rates, gold prices, oil prices, inflation (consumer price index-CPI) and exchange rates (USD/TL) were selected and Vector Auto Regression (VAR) model, together with Augmented Dickey-Fuller and Granger causality tests were employed for the monthly data covering from 2004 to 2016. According to the results of the study, while inflation, gold prices and central bank overnight lending interest rates have an impact on the participating banking share of profits, the effects of oil prices and exchange rates are found statistically insignificant.

Keywords: Islamic Finance, VAR model, macroeconomic factors, sukuk, Turkey

1. Introduction

The Islamic banking, also known as participating banking is an important research area due to its growth rate and contribution to world finance industry. Islamic banking started in the early 1960s in Egypt in its modern form. Islamic Development Bank (IsDB) was established in 1975 just after the establishment of the Dubai Islamic Bank which is the first major Islamic commercial bank in the United Arab Emirates. (Hussain et al, 2015). Main financial markets are discovering Islamic finance as a trending phenomenon has already been mainstreamed as an alternative to traditional finance within the global financial system. Today, Islamic finance is an important tool for the development of finance industry including in non-Muslim countries such as the UK, Luxembourg, South Africa, and Hong Kong.

Turkey is one of the top emerging markets with a dynamic and strong growth market that offers a wide range of profitable investment opportunities. Specifically Istanbul, due to its geographical and political position integrating the east and west, is believed to be an international financial center. Especially in terms of capital markets including Islamic side of the capital markets is also very important for Turkey in terms of diversifying the range of products and in order to reach more local and global investors.

There are many researches that cover different aspects of Islamic finance. Mohamad et al. (2014) examined the Islamic hedging instrument as a risk management tool and identified the factors that influence the demand for Islamic hedging, and their results exhibited that price, documentation, bank reputation, awareness, and ownership affect the demand for Islamic hedging products. Hammoudeh et al (2014) studied the dependency of global Islamic equity market index (represented by the Dow Jones Islamic Market Index) to three major global conventional equity indices (Asia, Europe, and United States), and their result exhibited that oil prices, stock market implied volatility, the U.S. 10-year Treasury bond interest rate, and the 10-year European Monetary Union government bond index) commonly affect the world financial system and Islamic financial market. Xian et al (2015) investigated the performance of Sukuk and conventional bond in Malaysia by choosing inflation, interest rate, GDP and openness of economy as macroeconomic variables. The results exhibited that there is a significant negative relationship between interest rate and inflation and performance of conventional bond and

Sukuk whereas, GDP and openness of economy were found to have significant positive relationship with performance of conventional bonds and Sukuk.

Wasiuzzaman and Termizi (2010) analyzed the profitability of Islamic banks in Malaysia by using GDP and inflation. Their results exhibited that both inflation and GDP have positive influences on the bank profitability. Said and Grassa (2013) examined the effects of the macroeconomic factors on sukuk market in different countries. Their results exhibited that GDP per capita, economic size, trade openness, and percentage of Muslims have a positive influence of the growing of the Sukuk market. Sensoy et al (2015) analyzed the predictability dynamics of Islamic and conventional equity markets and their results showed that Islamic markets depend mostly on market quality, institutional characteristics, liquidity and the country/continent specific investment behavior.

In that context, in this research, it is aimed to examine the selected macroeconomic factors affecting the participating banking share of profits, and in the lights of the results of the analysis bringing some recommendations to grow the size of the industry. Central bank overnight lending interest rates, gold prices, oil prices, inflation (consumer price index-CPI) and exchange rates (USD/TL) were selected as the macroeconomic variables, and Vector Auto Regression (VAR) model, together with Augmented Dickey-Fuller and Granger causality tests were employed for the monthly data covering from 2004 to 2016. According to the results of the study, while inflation, gold prices and central bank overnight lending interest rates have an impact on the participating banking share of profits, the effects of oil prices and exchange rates are found statistically insignificant.

2. Islamic Finance and Banking Industry

Islamic funds provide socially responsible and ethical investment opportunities to many institutional investors by using many Sharia-compliant financial tools (IFSI Stability Report, 2016). In Islamic finance, being converted into a productive activity is the main condition for money to make money (Alrifai, 2015).

According to World Bank Report 2015, the rate of the bank users among 1.6 billion Muslims is just 14%. Islamic finance is an option and opportunity to respond the requirements of the people who don't prefer to use conventional systems due to religious concerns.

Prohibiting riba, which means the payment and receipt of all kinds of interest, materiality which is defined as linking the financing and returns with real assets, not engaging in corrupt or unethical industries such as pork meat or alcohol production and linking the return to risks, prohibiting the uncertainty or asymmetrical information (gharar) and gambling and speculating (maysir) are the key rules of Islamic finance which is required to follow the Islamic Law (Shariah). The risk sharing and speculation free rules of Islamic finance protected Islamic financial establishments from 2008 global financial crisis. This situation enhanced the interest-free investment vehicles (World Bank, 2015).

Murabaha, ijara, mudaraba, ijara, musharaka, bai'muaccal, bai'salam and sukuk are the main tools of Islamic financing.

In many majority Muslim countries, the growing rate of Islamic banking assets are faster than conventional banking assets. Islamic finance is backed by assets and is considered an ethical and sustainable finance tool. Islamic finance supports risk sharing, connects the financial sector with the real economy by emphasizing social welfare with its environmentally and socially responsible perspective.

When the Islamic Financial Market is analyzed, it is observed that despite a smaller asset size with fewer components and lower market capitalization, the Sharia-compliant benchmark equity index outperforms the comparable conventional index (the Dow Jones indices). In Figure 1, Islamic banking shares is shown.

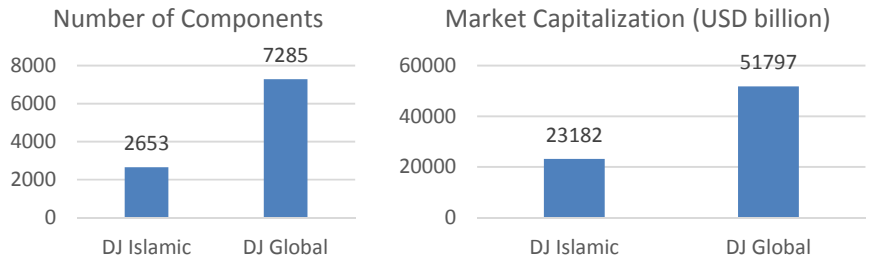

Figure 1 Islamic Banking Shares Globally (IFSI, 2016).

Table 1 The Total Returns of Dow Jones Global vs. Islamic Market World (IFSI, 2016).

	Dow Jones Global Index	Dow Jones Islamic Market World Index
2015 YTD	-4,23%	-3,08%
3 Years	23,50%	25,70%
5 Years	32,80%	37,60%
10 Years	37,50%	59,90%

The Islamic finance industry, by growing at 10-12% annually has expanded rapidly over the past decade. As shown in Table 2., as of the end of 2015, Sharia-compliant financial assets reached to 1.88 trillion USD, covering banking assets, sukuk, Islamic funds' assets and insurance (Takaful) (IFSI Stability Report, 2016, World Bank, 2015). Iran (37.3%), Saudi Arabia (19%), Malaysia (9.3%), UAE (8.1%) and Kuwait (5.9%) are the top 5 countries which adopted and widely use Islamic banking. As shown in Figure 2, although its 2.9% share from the pie, Turkey is considered as one of the major countries that Islamic financing will grow in the next decades.

Table 2 Breakdown of Islamic Finance by Region (Million USD, as of 2015 YTD) (IFSI, 2016).

Region	Banking Assets	Sukuk Outstanding	Islamic Funds' Assets	Takaful	Total
Asia	209,3	174,7	23,2	5,2	412,4
GCC	598,8	103,7	31,2	10,4	744,1
MENA (exc. GCC)	607,5	9,4	0,3	7,1	624,3
Sub-Saharan Africa	24,0	0,7	1,4	0,5	26,6
Others	56,9	2,1	15,2		74,2
Total	1.496,5	290,6	71,3	23,2	1.881,6

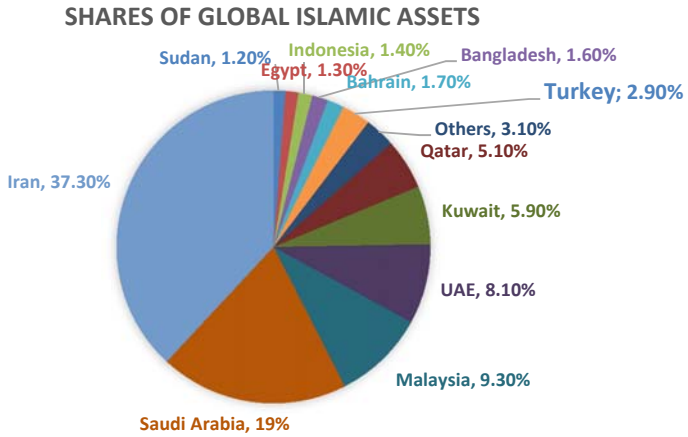

Figure 2 Dow Jones Islamic Banking vs. Global (IFSI, 2016).

As of October 2015, there are 1220 publicly available Islamic funds with a total value of 71.3 billion USD. The average fund size is 58,4 million USD. Saudi Arabia is the main country for Islamic fund assets. Islamic funds invest in real estate and sukuk 6% and 7% respectively. (IFSI, 2016)

Participation banking has a history of nearly 30 years but its development has been limited. However, current regulatory environment that is established with the Banking Law in 2008 enabled more efficient functioning of participation banking.

Participation accounts are defined in the Banking Law as:
"Accounts constituted by funds collected by participation banks that yield the result of participation in the form of loss or profit to arise from the use of funds by these institutions, and which do not require the payment of a pre-determined return to their owners and that do not guarantee the payment of the principal sum" (Participating Finance Report, Undersecretariat Turkey, 2016)

From 2005 to 2016, the total assets of participation banks reached from 10 billion TL to 133 billion TL. The participating banking assets cumulative average growth is 24.78% in the last 12 years (2005-2016), but the share of participation banking industry with only 5 established banks counts only for 4,87% of the total banking sector of Turkey. (Participating Banking Report, 2016).

Despite its large Muslim population and its long presence in the international capital markets arena as an issuer of conventional bonds, Turkey did not take a significant share from the Islamic finance market for Shariah compliant instruments prior to 2010, principally due to the lack of legislative infrastructure in place to accommodate Islamic finance. In Table 3, the total assets and growing rate of participating banking industry is shown.

Table 3 The Total Assets and Growing Rate of Participating Banking Industry (TKBB, 2016).

Years	Participating Banks Total Assets (thousand TL)	Growth Rate (%)	Banking Industry Total Asset (thousand TL)	Participating Banking Total Share (%)
2005	9.945.431	36,28	406.915.000	2,44
2006	13.729.720	38,05	498.587.000	2,75
2007	19.435.082	41,55	580.607.000	3,35
2008	25.769.427	32,59	731.640.000	3,52
2009	33.628.038	30,50	833.968.000	4,03
2010	43.339.000	28,88	1.006.672.000	4,31
2011	56.076.929	29,39	1.217.711.000	4,61
2012	70.279.000	25,33	1.370.614.000	5,13
2013	96.086.000	36,72	1.732.413.000	5,55
2014	104.319.000	8,57	1.994.329.000	5,23
2015	120.253.000	15,27	2.357.453.000	5,10
2016	132.874.000	10,50	2.730.942.000	4,87

3. Research Model, Data and Hypotheses

3.1 Research Model

In this research, the impacts of the macroeconomic variables are evaluated in a specific period. In such studies, the most appropriate and common method used is time series analysis which is defined as the sequence of mathematical data in a sequential order which tracks the movement of the chosen data points, such as a security's price, over a determined period of time at regular intervals. (Investopedia, 2017)

In time series, there is no upper or lower limitation of time that must be included, and they are good tools to find out the changes of a given asset, security or economic variable over time. (Investopedia, 2017)

Financial time series analysis is focused on the theory and practice of asset valuation over time. Financial time series analysis are distinguished from other time series analysis by uncertainty. For instance, asset volatility has many definitions and it is not directly observable for stock return series. In financial time series analysis, due to their focus on uncertainty, statistical theory and methods are important. (Tsey, 2010)

Time series methods are used when they are stationary, that is why it is important to make stationary tests.

3.1.1 Stationary Test (Augmented-Dickey Fuller Test)

When mean, variance, autocorrelation, etc. are constant over time in a time series, it is called as stationary time series. In time series, it is important to obtain meaningful sample statistics such as means, variances, and correlations with other variables. These statistics are useful as descriptors of future behavior only if the series is stationary. For example, if the series is consistently increasing over time, the sample mean and variance will grow with the size of the sample, and the mean and variance in future periods will always be underestimated. If the mean and variance of a series are not well-defined then its correlations with other variables will not be well defined as well.

Unit root tests are used to determine more objectively if differencing is required. These are statistical hypothesis tests of stationarity that are designed for determining whether differencing is required. There are many unit root tests which are based on different assumptions and may lead to conflicting answers. Among these tests, Augmented Dickey-Fuller (ADF) test is one of the most well-known and widely used test. The regression model of the test is shown below:

$$y't=\phi yt-1+\beta1(y't-1)+\beta2(y't-2)+\cdots+\beta k(y't-k),$$

where;
$y't$: the first-differenced series,
$y't=yt-1$
k: the number of lags to include in the regression (often set to be about 3).

If the original series, yt needs differencing, then the coefficient ϕ should be approximately zero. If yt is already stationary, then $\phi<0$.

David Dickey and Wayne Fuller developed the Dickey-Fuller test in 1979 in order to test the null hypothesis of whether a unit root is present in an autoregressive model. Augmented Dickey–Fuller (ADF) test is used for a larger and more complicated set of time series models. In ADF test, the alternative hypothesis is different depending on which version of the test is used, but is usually stationarity or trend-stationarity. The ADF statistic used in the test is a negative number. The more negative it is, the stronger the rejection of the hypothesis that there is a unit root at some level of confidence. (Tsey, 2010)

3.1.2 Vector Autoregression (VAR) Model

The vector autoregression (VAR) model is an important multivariate time series analysis method which is very widely used, successful, flexible, and user friendly model. The VAR model describes the dynamic behavior of economic and financial time series and for forecasting. Since they can be made conditional on the potential future paths of specified variables in the model, forecasts from VAR models are quite flexible. VAR model is also used for policy analysis.

The vector autoregressive model of order 1, denoted as VAR (1), is as follows:

$$xt,1=\alpha1+\phi11xt-1,1+\phi12xt-1,2+\phi13xt-1,3+wt,1$$
$$xt,2=\alpha2+\phi21xt-1,1+\phi22xt-1,2+\phi23xt-1,3+wt,2$$
$$xt,3=\alpha3+\phi31xt-1,1+\phi32xt-1,2+\phi33xt-1,3+wt,3$$

Each variable is a linear function of the lag 1 values for all variables in the set.

3.1.3 Granger Causality Test

The Granger causality test, first proposed in 1969 is used for determining whether one time series is useful in forecasting another. It is developed by Clive Granger who argued that causality in economics could be tested for by measuring the ability to predict the future values of a time series using prior values of another time series. Multivariate Granger causality analysis is usually performed by fitting a vector autoregressive model (VAR) to the time series. VAR Granger causality use to examine the causal relationship among the variables.

3.1.4 Impulse Response Function

Impulse response function describes the impact on the endogenous variables and the current value of future values when a one-time shock is added to the disturbance term. In VAR model, the impulse response functions is also analyzed.

3.2 Data

As shown in Table 4, the study covered the period between 2004 and 2016 monthly data of our dependent variable; the participating bank average share of profits were collected from Participation Bank Association of Turkey web sites. All the data of our independent variables except for the oil prices which was obtained from US Energy Information Administration was collected from Central Bank of Turkey Republic database.

Table 4 The Collected Data.

Variables		Data Source	Period
Dependent	Participating Banks	Participation Bank Association of Turkey	2004-2016
Independent	Inflation (CPI)	Central Bank Republic of Turkey	2004-2016
	Central Bank Lending Interest Rates	Central Bank Republic of Turkey	2004-2016
	Exchange Rates (USD/TL)	Central Bank Republic of Turkey	2004-2016
	Gold Prices	Central Bank Republic of Turkey	2004-2016
	Oil Prices	US Energy Information Administration	2004-2016

3.3 Hypotheses

Inflation is an important economic indicator for all economies. Most of the monetary policies are designed and revised based on the inflation rates announced every month. Exchange rates and central bank overnight lending interest rates are also important parameters, especially for emerging countries that affect and is affected by the economic conditions. On the other hand, gold and oil prices are two other important factors in global economy. Gold, has a special value for participating banking industry as it is an important tool for interest free investments. Oil prices is shaping the economies of the countries which are dependent to the up and downs of the oil prices such as Iran, Saudi Arabia, as well as Russia. Although Turkey is not an oil exporter, due to its high energy dependency to oil imports, the impact of oil prices to participating banking industry was also analyzed in this study in order to check if the banking industry is affected from oil industry.
We claimed that except for the oil prices, all the selected macroeconomic variables affect the share of profits of participating banks and formed our hypotheses as shown in Table 5.

Table 5 Hypotheses of the Study.

Number of Hypotheses	Independent Variables	Dependent Variables	Claim
H1	Inflation (CPI)	Participating Banking Average Share of Profits	Affect
H2	Central Bank Overnight Lending Interest Rates		Affect
H3	Exchange Rates (USD/TL)		Affect
H4	Gold Prices		Affect
H5	Oil Prices		Does not Affect

4. Results and Discussions

Before we employed the Granger causality test, we tested the stationary status of the time series. As a result of the ADF test, participating bank average share of profits as well as all the selected macroeconomic variables are found stationary which enable us to use time series analysis. Table 6 shows the ADF test results.

Table 6 ADF Test Results.

Null Hypothesis: Participating Banks has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 10 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.139219	0.5193
Test critical values:	1% level	-4.022586	
	5% level	-3.441111	
	10% level	-3.145082	

Null Hypothesis: D Participating Banks has a unit root
Exogenous: None
Lag Length: 10 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.359913	0.0009
Test critical values:	1% level	-2.581120	
	5% level	-1.943058	
	10% level	-1.615241	

Null Hypothesis: Gold prices has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-13.81481	0.0000
Test critical values:	1% level	-3.472813	
	5% level	-2.880088	
	10% level	-2.576739	

Null Hypothesis: Exchange Rate (USD/TL) has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.417042	0.0000
Test critical values:	1% level	-3.473382	
	5% level	-2.880336	
	10% level	-2.576871	

Null Hypothesis: Inflation (CPI) has a unit root
Exogenous: Constant
Lag Length: 13 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.618017	0.0002
Test critical values:	1% level	-3.476805	
	5% level	-2.881830	
	10% level	-2.577668	

Null Hypothesis: Central Bank Lending Interest Rate has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 2 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.056946	0.5651
Test critical values:	1% level	-4.019151	
	5% level	-3.439461	
	10% level	-3.144113	

Null Hypothesis: Central Bank Lending Interest Rate has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.08680	0.0000
Test critical values:	1% level	-2.580065	
	5% level	-1.942910	
	10% level	-1.615334	

Null Hypothesis: Oil Prices has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.466418	0.0000
Test critical values:	1% level	-3.473382	
	5% level	-2.880336	
	10% level	-2.576871	

The results of the analysis exhibited that, as shown in Table 8, three of the selected variables (gold prices, central bank lending interest rate and inflation) affect the return of participating banking average share of profits, while the effects of oil prices, and exchange rates are found statistically insignificant. The effects of the central bank lending interest rates and inflation are not surprising and both of the results validate our hypotheses.

Gold prices were also evaluated as a factor that affect the participating banks share of profits due to its link because of interest free transactions. This tie is also validated in the findings of the VAR results. Although it is assumed that the oil prices has an effect on Turkish economy, its link to participating banking industry was considered ineffective, and the hypotheses was structured as the oil does not have an impact on the share of profits, and the results of the study confirmed this assumption. One different result than our hypotheses was obtained for the insignificancy of the impact of exchange rates on the share of profits which may need to be furtherly investigated.

The impulse response reactions of the participating bank share of profits to shocks occurred in the macroeconomic variables that has an effect on the share of profits were also analyzed. The response of the participating banks average share of profits to shocked changes in gold prices is negative for 5 months, then it turns out to be positive thereafter. The dynamic shocks at central bank overnight lending interest rates also have a positive impact on the response of the participating banks average share of profits for 9 months, for a very small period of time, about a month, it turns out to a negative response, and then it again gives a positive response. The response against inflation is found very interesting. In the first 5 months, it is positive, then one month it becomes negative, later until the 10th month it becomes positive again, and after the 10th month it turns out to negative. Table 7 shows the Granger causality test results, and the impulse responses are shown in Figure 3.

Table 7 Granger Causality Test Results.

VAR Granger Causality/Block Exogeneity Wald Tests Date: 04/27/17 Time: 00:33 Sample: 2004M01 2016M12 Included observations: 149			
Dependent variable: D Participating Banking			
Excluded	Chi-sq	df	Prob.
Gold Prices	12.89214	6	**0.0448**
D Central Bank Interest Rates	28.20160	6	**0.0001**
Exchange Rate (USD/TL)	1.672444	6	0.9472
Inflation	11.34866	6	**0.0782**
Oil Prices	10.46267	6	0.1065
All	119.6805	36	0.0000

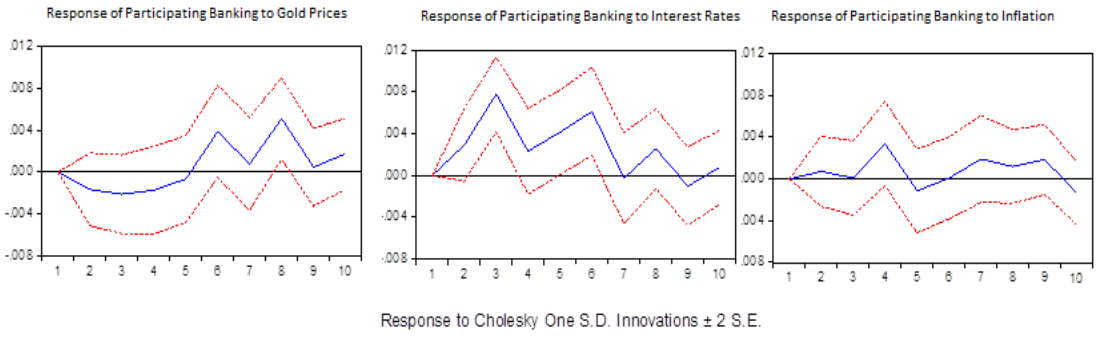

Figure 3 Response of Participating Banking Share of profits to the Impacts of the Macroeconomic Factors.

Table 8 The Results of the Hypotheses.

Number of Hypotheses	Independent Variables	Dependent Variables	Claim	Result	Hypotheses
H1	Inflation (CPI)	Participating Banking Average Share of profits	Affect	Affect	Accepted
H2	Central Bank Overnight Lending Interest Rates		Affect	Affect	Accepted
H3	Exchange Rates (USD/TL)		Affect	Does Not Affect	Rejected
H4	Gold Prices		Affect	Affect	Accepted
H5	Oil Prices		Does not Affect	Does not Affect	Accepted

5. Conclusions, Limitations and Further Studies

Turkey is a developing country with an increasing population and growing economy. Compared to its ranking in the world economy and its population, it can be said that the participating banking shares of Turkey is below from the level it should be. In order to make suggestions how to increase its global share, it is essential to investigate the macroeconomic variables that affect the participating banking industry. This study comprehensively examines the effects of selected macroeconomic variables including inflation (CPI), exchange rates (USD/TL), central bank overnight lending interest rates, gold and oil prices on the participating banking average share of profits by using vector autoregression (VAR), a very common econometric model. The Augmented Dicky-Fuller and Granger Causality tests were also employed.

Our findings exhibit that participating banking average share of profits are affected from inflation, gold and central bank overnight lending interest rates. Since gold is an interest free investment tool, this link is meaningful. Inflation, as one of the main variable that has impact on the general economies also effect the participating banking industry. Another expected result of the study is the influence of central bank lending interest rates on participating banking share of profits, as they are 94% correlated to each other as sub-parameters of the finance industry. The effects of oil prices, as assumed, do not have a significant effect. The results about insignificancy of the effects of exchange rates is needed to be investigated further as we had hypothesized that it does have an effect on the participating banking share of profits.

The Islamic banking is not just the focus of Islamic countries, but also the countries including the UK, Hong Kong, Luxembourg and South Africa. The non-Islamic countries, by using Islamic finance are diversifying their services, reaching to Muslim customers and creating an alternative tools. One of the main recommendation of our study for participating banks is focusing on providing interest free financing for long-term real estate projects. By supporting interest-free funds such as Islamic Real Estate Investment Trusts and Islamic Real Estate Investment Funds, by issuing long-term sukuk, by increasing alternative interest free pension fund options and by providing interest-free home loan financing for housing sector, the participating banks can increase their size, as a result, the industry will grow and the shares of Turkish Islamic banking will increase its shares globally. The more the people use interest free financing through these banks, the more the interest fee pension fund options increase and the more large real estate investment projects are financed through Islamic banks, the more their total shares in the banking industry will increase.

In our research, while evaluating the returns, we focused on selected 6 macroeconomic factors. This may be a limitation for this study. The number of the variables can be increased and GDP growth rate, money supply, other exchange rates such as Euro/TL, Euro/USD can also be included in further studies. If the alternatives of interest free pension funds increase, the future studies may focus on the parameters affecting the interest free pension funds and the real estate financing tools that the Islamic banks finance.

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The Role of Insurance Sector in Protecting the GCC Economies through Risk Management Practices: Impact of Climate Change

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Abstract

The purpose of this paper is to identify how climate change will affect the economy of GCC countries and how the insurance sector can help in creating economic stability of these countries. The Gulf Cooperation Council (GCC) countries have experienced remarkable social and economic advancement since the 1970s. The economic surplus from the energy segment has been directed into the infrastructure expansion and for the development of the private sector. However, the GCC countries still look for political, economic, social and environmental changes and development.

1. Introduction

Climate change is one of the biggest challenges that humanity is facing as it's not only a threat for biodiversity and food security, but is also impeding economic performance and growth. Likewise, climate change will have far ranging effects on GCC countries. Changes in climate may aggravate already existing challenges of water scarcity, food security, and above all population growth, in GCC countries. Loss of biodiversity, desertification, and rise in sea level are some of the other pitfalls that may accompany environment change. Scorching temperatures, extreme humidity, and damaged arid lands are the characteristic features of the region. Salt intrusion in the aquifers is a major consequence of these conditions having wide ranging impact on agriculture, particularly small scale agriculture, which in turn is aggravating the threat to food security in the region These threats to environment, livelihood, and economy have therefore impelled GCC states to participate actively in global consultations for environmental trepidations (Al-Maamary, et.,al., 2017). Climate change has already started to show its effects as even a few-day-rain floods bring life in various metropolitans of the region to a halt. Thus, these threats to GCC climate warrant immediate and necessary actions.

2. Climate Change Issues in GCC

2.1 Rise in Sea Level

As almost all the countries located in Arabian Peninsula border the ocean at least on one side, sea level rise is the major concern for countries of this region. Islands, both large and small, are particularly vulnerable to this threat. The Bahrain's island is a case in point as it has witnessed intense industrial and residential activity in recent years. This widespread commercial movement has come at the cost of extensive land reclamation in coastal areas. Coupled with its low-lying geology, the island is a peculiar example of serious threats that sea level rise is posing to this region. Bahrain Supreme Council for the Environment has revealed that large area of land may be inundated as a consequence of various climate changes. About five per cent (36 km2) of the total area of Bahrain may get inundated by 2100 even by a low sea level rise. The area under threat may increase to 11% of total Bahrain land (69 km2) in worst case scenario. The effect of inundation on the vulnerable infrastructure in five major islands of Bahrain will be uneven and may have disastrous effects on roads, cultivable land, as well as beaches and salt marshes. Even in other metropolises, like Dubai, increasing sea levels may harm coastlines if reinforcements measures are not implemented (Mills, 2014).

2.2 Water Availability

Groundwater reserves in GCC states are rapidly depleting mainly due to continued use of non-renewable water, thus exposing countries of this region to great harmful effects of climate change. The water in Saudi Arabia is drawn from four sources; groundwater from deep fossil aquifers, desalinated water, surface water, and reclaimed wastewater. Among these, reliance on groundwater from deep aquifers is most damaging for the environment as this source is non-renewable and is already overburdened and exhausted due to uncontrolled usage in the past three decades. The agriculture accounts for approximately 85% of water usage in Saudi Arabia thus any threats to water availability may lead to disastrous consequences for livelihoods and food security of people living in these areas.

The Bahrain was well-known for freshwater springs as well as its productive lands, however rapid urbanization has led to the loss of precious natural resources, more importantly the groundwater. Similarly, increasing water shortage has forced Qatar to rely on desalination plants for supply of freshwater. In addition to Qatar, majority of GCC countries have increasingly been installing these energy intensive plants. These plants have proved to be a heavy burden for atmosphere.

2.3 Food Security

Increasing food prices are a particular concern for the Middle East due to water shortage and nature of train, cultivation of new land is challenging. Currently, only about 2% of Saudi Arabia's vast land is arable, and that too after heavy investment in modern irrigation and farming technologies. According to estimates, population of Saudi Arabia may increase by as much as 77% by 2050 thus dwindling water reserves and difficult to cultivate land may prove to be insufficient to produce enough food for this number of people. (Middle East Institute 2010)

More than 6,000 people are employed in the fishing sector in Bahrain. Destruction of coral reef habitats will have devastating effects on fauna and fish stocks in this region, thus threatening the feasibility of fishing industry in Bahrain. Climate change may also impact Bahrain in another way. Even a one meter increase in sea level may lead to loss of 11% of the total cultivable agriculture land in the country.

2.4 Biodiversity

One of the mostly overlooked aspect of environment change is impact on biodiversity. Any potential damage to the nature in GCC region may also affect biodiversity in the region. The Arabian Peninsula is situated at a confluence of Indo-Pacific and Afro-European regions and is home to a diverse range of mammalian, avian, amphibian, and reptilian species.

Moreover, the comparative shallowness of Arabian Gulf also serves as a supportive coastal habitat for unique marine life including intertidal mudflats, sea grasses, mangroves, algae, coral reefs, and above all a wide variety of fish species. Climate change is likely to unfavorably affect all these species, some of which are already considered as endangered. Seasonal migratory birds and dugongs are also an important part of rich ecology of this region whose survival is being threatened by climate change.

From ecological point of view, the effects of environment change on Gulf region may be insignificant compared to other parts of the world, especially in terms of calamitous adversities like hurricanes, tsunamis, and floods etc. However, the economic bearing of climate change among countries of GCC region may be more severe due to high dependency on proceeds from oil and gas exports. As the other countries will shift towards the use of more renewable sources of energy due environmental concerns, the economy of GCC nations will be badly impacted due to decreasing oil and gas exports.

Fossil fuels are the foremost source of carbon dioxide (CO2) emissions and countries in the Gulf region are confronted with a problematic state of affairs as their economies are almost completely reliant on the oil, gas, and petrochemical productions. Although these countries enjoy high rates of development, scarcity of arable land and water resources impedes the development and expansion of carbon sinks, forests, and green areas that can curtail the harmful changes to climate (Asif, et., al., 2015).

Figure 1 GCC scenario. Source: (Weforum.org, 2010)

The desert spring depicts a situation where provincial dependability presents a test for the GCC nations and demands to accomplish generous institutional changes. The GCC nations cooperate to arrange conciliatory and monetary strategies through technocratic administration and a solid inward market. The over-direction moderates the procedure of globalization and affects the GCC nations. Although, they are a desert garden of security and flourish in a generally beset area.

The dust storm portrays a future whereas regional shakiness is a characterizing factor. This influences the capacity of GCC nations to do genuinely necessary institutional changes. The changes are very slow because of an absence of thoughtfulness in a discouraged worldwide condition regarding the main driver of inward issues. There is also inclination for governments to concentrate on soundness to the detriment of long haul arrangements. The GCC nations are blinded and unfit to explore out of the dust storm and distinguish open doors for flourishing for their populaces. The Fertile Gulf depicts the ascent of the GCC nations as development centers in a worldwide situation portrayed by solid interest for vitality and expanding globalization. The local strength gives the GCC countries the chance to concentrate on improving their human capital at all levels. This also put need of intense training and continuing deliberation with political and institutional changes to help their developing economies and social orders. (Reiche, 2010, Jammazi and Aloui, 2015; Tariq, 2015).

Table 1 Greenhouse gas emissions in the GCC countries. Source: (World Resources Institute (WRI), 2014).

Emissions (2000), $MtCO_2e$, self-reported	Emissions (2000), $MtCO_2e$ per WRI	Emissions (2010), $MtCO_2e$ per WRI	Share of global total (2010) per WRI	Per capita (2010), tCO_2e (global rank) per WRI	Emission growth / TPES growth, CAGR 2000-10	Population growth / GDP growth, CAGR 2000-10
Bahrain						
22.37	17.36	34.81	0.1%	27.58 (14)	7.2% / 5.3%	6.5% / 5.9%
Kuwait						
n/a	138.88	196.50	0.4%	71.80 (1)	3.5% / 5.9%	4.6% / 4.7%
Oman						
n/a	63.04	90.41	0.2%	32.49 (11)	3.7% / 9.5%	2.5% / 4.9%
Qatar						
n/a	26.97	74.69	0.2%	42.46 (6)	10.7% / 8.0%	11.4% / 12.4%
Saudi Arabia						
283.31[i]	296.73	542.10	1.2%	19.75 (22)	6.2% / 5.3%	3.1% / 5.4%
UAE						
119,89	110.56	256.27	0.6%	34.12 (9)	8.8% / 6.2%	10.8% / 3.9%
World						
n/a	38,224.71	47,182.61	100%	6.84 (-)	2.3% / 2.3%	1.2% / n/a

The latest emanations of information are absent for the examination in this regard. The analysis depends on information gathered by the World Resources Institute (WRI), the International Energy Agency (IEA), and the US Energy Information Administration (US EIA). In chronicled terms, the combined CO2 discharges of each of the six GCC states from 1850 to 2007 speak to just 0.04– 0.58 percent of the world total. In display terms as well, the GCC countries are little producers as far as aggregate current GHG outflows, with discharges of the five littler states signifying approximately 1.5 percent of aggregate worldwide outflows, as appeared in Table 1.1. As indicated by the WRI, in 2010, Saudi Arabia (1.2 percent) positioned as the world's seventeenth most elevated producer, in front of various nations with considerably bigger populaces, for example, Italy, Spain and Turkey.

3. Legislations in GCC regarding Climate Change

The Middle East governments are gradually considering the issue of environmental change. They are showing it as an uncontroversial point to a great extent that requires specialized arrangements of lethally imperfect "techno-positive thinking". The various substantial scale, squeeze neighborly ventures are being manufactured. They include Saudi Arabia's King Abdullah City for Atomic and Renewable Energy and Masdar City close to Abu Dhabi. They are "Intended to be zero-carbon and zero-squander, home to a populace of 40,000 individuals, 50,000 suburbanites, in a territory of six square kilometers". The Masdar city is "assuming a pivotal part in the improvement of maintainable plan and innovation", quoted by Susan Lee from the University of Birmingham. Huge numbers of the important changes will be troublesome for rulers in the Middle East. Professor Robert Looney from the Naval Postgraduate School in California dissected the Economic Intelligence Unit's Democracy Index and the World Energy Council's Energy Trilemma Index, clarified that popularity based governments "will probably consent to worldwide assentions that set particular focuses for carbon understandings" and "give ecological manageability need over either vitality security or reasonable vitality supplies". The administrations will constantly need vitality security since rising fuel costs hazard social agitation (Sinclair, 2016).

4. Role of Insurance Companies in GCC

This sector has encountered consistent development which is based on economic progress, populace extension, and enhanced regulatory conditions. The low insurance entrance offers plentiful chances to insurers in the GCC, regardless of solid fundamental development drivers. The region's insurance sector is likewise anticipating structural changes in the future. This is in accordance with positive regulatory advancements and endeavors towards achieving more noteworthy operational scale and productivity.

The Alpen Capital published a recent report on the GCC Insurance Industry and highlighted a number of opportunities for bigger players, leading to marginalization of smaller players in the industry. There are also, several foreign insurance companies who are creating their footmark in the sector.

4.1 The GCC Insurance Industry Outlook

“Alpen Capital” gauges the insurance business in the Gulf expanding at an compounded yearly growth rate (CAGR) of 18.1% in the vicinity of 2012 and 2017 to achieve a size of US$ 37.5 billion, divided between life (US$ 2.4 billion) and non-life (US$ 35.1 billion) sections.

The disaster protection share is required to advance at a yearly normal proportion of around 2% amid this period. The non-life portion is estimated to develop at a substantially higher rate of 20.0% every year. The market share in this way is increasing from 86.6% out of 2012 to 93.6% out of 2017.

The non-life insurance sector profits more due to persistent building and structure undertakings. The big share of oil incomes in the GCC nations is consumed for the improvement of the non-oil sector to support monetary broadening. This contributes to the development segment and to the non-life insurance sector. The greater entrance of health protection and development of vehicle cover are likewise liable to help the sector's development (Al-Amri, 2015).

The growth of insurance sector in GCC countries is expected to increase from 1.1% out of 2012 to 2.0% out of 2017. The industrial development serenely surpasses the growth of GDP extension. The non-life insurance is viewed as the primary driving variable, which is probably going to surge from 0.9% to 1.9% amid the period.

The insurance business in the Gulf by 2017 is foreseen to dramatically increase from the 2012 as the huge number of individuals and organizations are availing insurance cover. The density of insurance industry is probably going to rise from US$ 367.3 in 2012 to US$ 751.4 in the year 2017. Notwithstanding, the difference among the life insurance and non-life is anticipated to broaden considerably.

The major insurance marketplaces in the GCC are KSA and UAE. The Saudi Arabia may exceed the United Arab Emirates (UAE) as the chief insurance marketplace in the area. The Saudi insurance business is perceived as a foremost factor behind progression of the GCC insurance sector. The market projected to grow at Compound Annual Growth Rate of 26.5% between 2012 and 2017.

4.2 The UAE Insurance Market

The insurance market in the UAE is accounting to 44.1% of the region's GWP in 2012[2]. The annual growth rate is 9.6% between 2008 and 2012 which accounts for US$ 7.2 billion. The life insurance market in UAE is the most developed system but the non-life segment contributes major share of industry revenue. The recent years observe notable higher growth in life insurance segment than non-life. The penetration and density of life insurance and non-life insurance segment was 2.0 % which account for US$ 1298.8 respectively. The comparison of averages for these both industries indicates favorably against the GCC.

The main non-life insurance products in the UAE include property and motor insurance. The global financial crisis negatively impacted non-life insurance. The property insurance has still potential in person and commercial markets. The locals have invested in real-estate projects. The development projects of infrastructure continue to develop and cause increase in insurance coverage. The growth in cars ownership backed by the mandatory motor vehicle insurance makes insurance line to thrive. The life insurance mainly depends on the expatriate population in the country. The religious beliefs of locals also resist adoption of life insurance policy. The development of Takaful inspired the locals to show more demand in life insurance due to Sharjah compliant products.

Most of the insurance companies in UAE are public limited and owned by the government-holding. The regulations require these firms to be recorded as public joint-stock businesses and then registered by monetary markets like Dubai Financial Market or Abu Dhabi Securities Exchange. The rest of insurance market is private limited companies and branches of international firms functioning in the state from 2012. They include 61 chief insurers and 2 reinsurers. Oman Insurance Co., Abu Dhabi National Insurance Co., and Orient Insurance Co. are amongst the important insurance firms in the UAE.

The new entry of foreign players in the insurance market of UAE, is restricted by a number of stipulations by UAE Insurance Authority. This includes that already operating companies with branches are eligible to get the license of operation in UAE. This sets clear indication that new foreign insurer are ineligible for operations. The second requirement for the new insurers is to offer the products which are not being currently offered by the market. This is to make sure that that marketplace has a greater necessity for present insurance. The local sponsorship is also needed for the foreign company to setup and open branches. There is also a maximum permissible limit of 25% acquisition in domestic insurance market for overseas players.

There is another option for the foreign companies to setup branches and operate in UAE. This includes making offshore companies which are registered in DIFC. The civil and commercial laws are not applicable to the companies in these areas as compared to rest of the country. The companies can own 100% ownership regulated by Dubai Financial Services Authority. The companies in DIFC cannot retail insurance products in other emirates of UAE except in the free zone. These companies can offer insurance coverage for companies in DIFC and other GCC countries. The insurance companies mainly rely on reinsurance segment in the UAE and some companies need their complete threat cover to reinsurers. The limitations on DIFC-based external businesses for providing insurance services in the local marketplace have formed a noteworthy volume of reinsurance capability. The numerous global companies have developed reinsurance maneuvers in the free zone for getting access to the domestic marketplace.

The agents and brokers are mainly the distribution channels for insurance products. According to statistics of 2011 the numbers of insurance agents are 11 and 170 brokers in the country. The underdeveloped is Bancassurance due to legal uncertainly as compared to other well developed insurance markets in Dubai. Now it is becoming very popular and Bancassurance has observed durable development. The banking industry is now joining with the insurance firms to develop and provide a wide variety of insurance services.

The GCC Insurance industry has shown growth and upward trend. It is underdeveloped in comparison to world average and trail by large margin. The drivers of industry growth show strong future prospects for insurance industry. The expectations are positive in line with regulatory advances and struggles of key companies in reaching operative measure and high proficiency (Mills, 2015).

4.3 Key Growth Drivers

The population is expanding in GCC along with the huge number of foreigners. The increasing life expectancy leads to the demand of insurance products and services. The maintained financial progress will probably help growth of the general salary levels of individuals. The GDP per capital at purchasing power equality (PPP) in all the Gulf nations in the vicinity of 2012 and 2017 is anticipated to practice a encouraging progress of 2%-4% [1]. This growth will ultimately increase the capacity of residents to purchase the automobile and residential properties. This causes the increase in demand for insurance products. The government also promotes the diversification of economy and presents new opportunities (Asif, 2016).

The health insurance programs in different jurisdictions are made compulsory. This will probably generate robust development for insurers. The sales of the automobile are also high and this will cascade on insurance industry. The United Arab Emirates has implemented health insurance programs mandatory for many years specially the medical insurance for the residents and expatriates of Abu Dhabi. These insurance regulations will become model for rest of the states beginning with Dubai.

The Takaful segment is growing appropriateness for insurance in the Gulf States. The evolution of this industry will bring positive changes in regularity framework and operational metrics. Resultantly, the Takaful family products will generate higher demand in the gulf. The sector expects a durable regaining and growth at a CAGR of 23.0% between 2011 and 2016 to US$ 1.2 billion. The ambiguity of legislation in the state is the leading aspect obstructing development of the industry. The UAE marketplace will continue to increase regardless of weaknesses in other regional markets. The Saudi Arabia and United Arab Emirates are representing the 90% of the family Takaful in the Middle East and Africa in 2001.

The Dubai International Financial Centre (DIFC) and Qatar Financial Centre (QFC) have meaningfully subsidized to the development of local insurance business. These two centres are the hub of many insurance, reinsurance companies and insurance intermediaries (Mills, 2015).

4.4 Trends in Insurance Industry in GCC

Enterprise Risk Management (ERM) in the gulf region is in the developing phase. However, the insurance corporations practice very robust and enthusiastic risk management processes. The competition from foreign players will increase in the near future. The foreign insurers will further augment their presence in the Gulf by exhibiting advanced practical know-how, delivery competencies, client alignment, and monetary strong point (Muralidhar, 2010).

The adoption of a unified insurance system is the second uprising trend. The insurance rates are standardized now across the gulf region due to unified schemes of automobiles. This will further help in unification of insurance sector.

A new distribution channel is also a growing trend. The Banac assurance and online policy approval have become more popular as the modern distribution channels. The Islamic banks are emerging in Family Takaful products and becoming important medium for marketing and sales. There is another trend of changing investment mix. The regional insurance companies have invested more in low-risk instruments to reduce their exposure to equities. This will help to generate assured return on income and will reduce the risk and volatility in investment income.

4.5 Challenges to Insurance Companies in GCC

The insurance companies face number of challenges in GCC region. The size of the insurance market in the gulf region is limited and over-crowded by many domestic and international companies. There is high competition between automobile and healthcare insurance companies.

The governing policies are considered inadequate in Gulf insurance industry. The major irregularity is found in the context which is a lesser amount of refined solvency directives, stumpy principles of transparency and inadequate guideline to standardize the investment of the insurer. The overall region regulation found to have a wide range of discrepancies.

The GCC has shown downtrend in industry-wide profit for several years. This mainly indicates low productivity in practical procedures, an incompetent working model, little scalability, and dropping investment earnings. There is a lack of skilled workforce in the insurance sector. This deficiency affected the companies risk bearing capabilities and resulted in the increase of their operating over heads. The GCC consumers and small businesses have low awareness about the benefits of insurance. They are unable to realize that insurance is an effective means of protection of their wealth, health, savings and security.

The economic uncertainty of the world also presented great challenges to the insurance companies by creating uncertainty on returns. Further, the Eurozone's debt disaster prepared the request for maritime insurance. The Arab revolution has delicate apprehensions of general politically aware unpredictability in the Middle East area. The reappearance of such happenings may disturb the overall commercial and investment environment, and reason a unexpected point in insurance-related privileges.

5. Risk Management Practices in GCC

The marketplace regulation matters and policies will vary by industry to alleviate the effect of climate challenges. The solvency risks are very significant to all insurers. The financial constancy of insurer is reliant on investment portfolio. Therefore, insurance regulator has universal worry of solvency risk that environment-change-driven weather-related risks pose to insurer. This creates significance in order to inspect how environment change will influence the investments insurers hold and start appropriate regulatory standards for the investment performs of insurers.

The assets of all insurers are characterized by the direct and indirect investments in real estate share. The life insurers grasp most of the direct investment. The insurers have spent in real estate for the procedure of their own services and some indirect investments for making of revenue. These assets are mostly within the coastal zones, offering threat of environmental change in practice of hurricanes and flooding. The worldwide environment change and upsurge of sea levels put a risk to structures in this region. There is pronounced investment risk for the insurer to invest in the properties in these regions. The insurer regulators want to identify the difficulty of weather related sufferings on real estate. This comprises deteriorating asset values and also the costs of fortification, physical harm to structures, and related corporate interruption.

The reserves of the insurers are hold by the investments in real estate projects. These indirect investments include mortgage-backed securities and pass-through securities. The change in climate is the biggest risk to these investment based assets. The climate change causes catastrophes and leads the owners to mortgage defaults due to these stressful circumstances. Similarly, the premium increases or market withdrawal may also result in lack of affordable insurance coverage resulting in technical mortgage defaults. The investments of the insurer will negatively affect due to non-availability of property insurance coverage.

The mortgage lenders may develop the property insurers because they want insurance on property on which they grasp mortgages. The insurers also experience threat from investment in diverse sectors of economy like bonds, preferred stocks, and equities along with danger of investment in real estate in coastal zones. This industry has direct atmosphere and climate related damages to real estate properties along with extreme and over emission of pollution. The court has recognized the constraints of accountability of environment change to specific industry of economy. Municipal bonds, a momentous investment holding for many insurers, are another possible source of danger. The municipalities experience accumulative pressure and eventually accept the bearings of environment alteration.

6. Conclusion

The weather change can extremely influence the progress of the GCC nations. This enhances load on these states to accomplish the economic progression. The extreme hotness and abridged precipitation will aggravate the water shortage and upsurge the occurrence of droughts. This would unfavorably influence the food production and deteriorate the present condition of food security. The GCC area is anticipated to have more unembellished effects of Sea Level Upsurge than any other state. The worldwide warming up can put 6-25 million people and vital economic activities to coastal flooding. The area is one of the highly built-up states of the world. These metropolitan centers have meager structure and weather shift will affect them catastrophically. The GCC nations are vastly awarded with oil and gas assets. The area is also respected with extraordinary potential of renewable energy means mainly solar and wind that are less capitalized.

The threat managing interventions, monetary streams, study of change, knowledge transfer, knowledge economy are all vigorous to meet the tests of weather variation. The insurance firms can do great part to stimulate threat controlling strategies. The level of consideration of the situation of threat controlling differs meaningfully amongst the subjects and across the numerous segments of the object. The operative threat controlling necessitates an interdisciplinary methodology. Risk controlling necessitates competences to involve the specialists with a focus to advance and accomplish a portfolio of potential hazards. The threat controlling inventiveness performs, if correctly applied, will complete over time from strategic resolution to a tactical vital. The definitive objective of enhanced enactment is to defend the economic welfares of GCC nations.

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Perceptions of the Determinants of Auditor's Fees in Bahraini Listed Companies – An Empirical Study

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Abstract

The current study aims to examine the perceptions of financial managers, accountants, and internal auditors who are working in listed companies in Bahrain on the determinants of audit fees. To accomplish this aim, a questionnaire was developed and disseminated to a sample of 152 respondents. In addition to descriptive statistics, non-parametric tests such as the Chi-square Test were used.

The results of descriptive analysis showed that all of the questions in all groups (1-33) prove that they are considered as important determinants of audit fees in Bahraini listed companies with the average means ranging from 3.43 to 4.5 with standard deviations ranging from 0.47434 to 0.63851. The results of the Chi-square test confirmed the results of descriptive statistics that all questions were significant for the seven groups of the 33 questions ($p < 0.05$) indicating that respondents' answers for each question were not equally distributed among the different levels of agreement on determinants of auditor's fees in listed companies in Bahrain in all groups. Therefore, it is possible to say that respondents' answers were not equally distributed among the different levels of agreement on the determinants of audit fees in listed companies in Bahrain in all groups. Based on the above results from the Chi-square Test, all of the hypotheses formulated earlier (H1 - H7 are accepted.

The study recommended that future research is needed to investigate this issue in other developing countries in general and GCC countries in particular. The study also suggested that other respondent groups such as external auditors, shareholders, regulators and members of the audit committees might be included in future research.

Keywords: Determinants factors, auditor fees, Corporate complexity, audit firm status, Developing countries, Bahrain, company size, corporate risk, corporate profitability, Bahrain Bourse.

1. Introduction

Audit is defined by the American Accounting Association, AAA (1973 cited in Soyemi and Olowookere, 2014, p. 50) as a "systematic process of objectivity and evaluating evidence regarding assertions about economic actions and events to ascertain the degree of correspondence between the assertion and established criteria and communicating the results to interested users". Audit fee is defined as "the cost of conducting audit to express an opinion there on the conformity of financial statements with generally accepted accounting principles (GAAP)" (Soltani, 2007, cited in Hassan et al., 2014, p. 646).

Both companies and auditors are interested in the issue of audit service and audit fees paid to the auditors. "Companies are statutorily required to have their financial statements audited and want the fees they pay to be reasonable, auditors provide such services and want to ensure that the fees they charge are sufficient to enable a satisfactory service to be provided" (Gist, 1993, cited in Kikhia, 2014, p. 42).

The rest of this paper is organized as follows: Section 2 describes the audit environment in Bahrain. Section 3 elaborates the literature review. Section 4 presents the research methodology. Section 5 illustrates research analysis and results of the study. Section 7 offers a summary and recommendations.

1.1 Statement of the problem

The problem statement of the study may be highlighted by providing answers to the following questions:

1. Does corporate size of the client affects audit fees?
2. Does the size of audit firm affect audit fees?
3. Does the complexity of the client affect audit fee?
4. Does the profitability of the client affect audit fees?
5. Are the audit fees affected by the corporate risk of the client?
6. Do the corporate year end and the time lag of the client between year-end and audit report affect audit fees?

1.2 Motivation for the study

Bahrain was selected for the current study because it is in the center of the Gulf countries, enjoys a stable political and economic environment and runs a free market economy.

According to the best knowledge of the researchers, very few studies have been conducted in Bahrain regarding auditor fees which may result in a lack of information about audit fee determination in the literature review. This may give the motivation to conduct this study. This study is expected to narrow the gap in the literature review about the issue of audit determination between developed and developing countries.

1.3 Objectives of the study

As mentioned earlier, few studies have been conducted in Gulf countries in general and in Bahrain in particular to identify the factors that may influence auditor fees. Based on this conclusion, the current study aims to investigate the determinants of auditor fees charged by audit firms among companies listed on the Bahraini Bourse. The study also aims to reveal whether audit fee charges differ according to the factors examined in the study.

2. The Bahrain Auditing Environment

It is important to highlight some issues of the audit environment in Bahrain before undertaking this study.

In 2016, "audit services in Bahrain were provided by 23 accounting firms." Five of these are considered local; four are operating as foreign branches; and the remaining are linked to international forms. The Big 4, i.e., Ernst and Young (E&Y), Deloitte and Touche (D&T), KPMG and Price Waterhouse Coopers (PWC) have a strong presence in Bahrain. D&T and KPMG operate as a joint venture, whereas the other two operate as branches of international firms. Bahrain is a member of the Gulf Cooperation Council, which comprises six Persian Gulf Arab states with several economic and social objectives" (Joshi et al. (2009, p. 268). Bahrain Stock Exchange was established in June 1989. "The Big 4 dominate the audit services industry in Bahrain. A total of 82.5% of the listed companies in Bahrain Stock Exchange (BSE) that published their annual reports in 2006 are audited by one of the Big Four, and the other 17.5% are audited by non-Big four" (CBB, Bahrain, 2006, Joshi et al. (2009, p. 268). "Companies in Bahrain are required to comply with international Financial Reporting Standards (IFRS), whereas accounting firms must comply with the International Standards of Auditing. These requirements apply to all companies, including financial intuitions".

The findings of the study are expected to increase knowledge about how listed companies and audit firms in Bahrain reflect auditors' fees through their reporting practices.

Because Bahrain is a member of GCC, it shares a number of specific structural economic characteristics. The common characteristics that GCC countries share include a high dependency on oil and gas, young and rapidly growing national labor forces, and heavy reliance upon expatriate labor in the private sector. In addition, listed companies in GCC countries are subject to similar reporting requirements. All legal entities are required by companies' laws to submit their annual report including director's report, auditor's report, and financial statements, and have their accounts prepared according to International Financial Reporting Standards issued by the International Financial Reporting Standards (IFRS). Thus, GCC countries are expected to benefit a lot from the findings of the current study.

3. Literature Review

The most important determinants of audit fees highlighted in the literature review include: ﴿corporate size, audit firm status, corporate complexity, corporate profitability, corporate risk, and corporate year end and the time lag between year-end and audit report. It has been argued in the literature that increasing companies' size resulted in increasing audit fees (Simunic, 1980); risk (Stice, 1991); complexity (Hackenbrack and Knechel, 1997); and profitability (Hay, et al., 2006). Also, the same conclusion was reached in the literature review - that audit fees increase with audit firm size (Francis, 1984; Palmrose, 1986); reputation (Craswell et al., 1995; Collinan, 1998; Larcker and Richardson, 2004; Gonthier-Besacier and Schatt, 2007 ;); and whether is one of the Big Four (Palmrose, 1986; Francis and Simon 1987; Butterworth and Houghton, 1995).

Friis and Nielsen (2010) investigated the likelihood that applied IFRS standards may result in increased Danish companies' cost of auditing. Overall, the study found that using IFRS standards does not increased significantly audit fees. However, they found that combining IFRS with company size and complexity, large and complex companies play a vital role in determining audit fee compared with less complex and small companies that also use IFRS.

Ellis and Brooker (2011) examined the determinants of audit fees in the community. The results revealed "that the model is highly significant and explains the majority of the cross sectional variance in audit fees". Also, the study concluded "that the size and complexity variables explain the majority of variance in fees".

Hamid and Ali (2012) investigated the factors that may determine audit fees in Iran. The study concluded that "there was a significant relationship between auditing fees and its predictors". The study contributed some knowledge about understanding auditing fees.

Hallak and Silva (2012) examined the factors affecting auditing and consulting expenditures in Brazilian public companies. The results concluded "that audit fees are positively related to company size, corporate performance quality, and the Big Four status of the auditor, but had no significant relationship with corporate governance".

Akinpelu, et al., (2013), examined the determinants of audit fees in commercial banks in Nigeria. The results showed "that bank size, degree of bank complexity and transaction and saving accounts to total deposit ratio are positively related and significant to audit fees charged by the auditors".

Muni and Al-Hajeri (2013) conducted a study to examine the determinants of audit fees. The study shed light on the importance of the following factors in determining audit fees. The study found that the following factors are significant in determining audit fees: the number of transactions, the sum of accounts receivable and inventory, information technology, number of subsidiaries, and regulations. The study also found "that volume of transactions that originates across subsidiaries with international presence using sophisticated information technology systems significantly contributes to higher audit fees".

Monsuru (2014) investigated the determinants of audit pricing in the Nigerian commercial banking sector industry. The findings of the study revealed that there is a positive association of complexity, risk, but negative association between operating performance and audit fees.

4. Research Methodology

The study is an explanatory study, in which its purpose is to verify the hypotheses about the impact of independent variables upon a dependent variable. Cross-sectional linear ordinary least squares regression is used to test the hypothesis regarding the audit fees on corporate size, the status of audit firm, the corporate complexity, client profitability, client risk, corporate year end and the lag between audit report and end of accounting year.

4.1. Sample study selection

The sample of the study consists of all companies listed on the Bahrain Bourse for the year 2013. The total number of listed companies is 41 companies. However, commercial banks and insurance companies were excluded from the study because they have a special nature of their activities, as mentioned earlier, and they have a different fee structure from those of non-financial sector companies that may affect pricing of auditors.

4.2. Data collection

A questionnaire was developed and distributed to the sample study to collect data necessary to test the hypothesis. Nonfinancial companies listed on Bahrain Bourse were covered in this study. By end of 2013, the total number of companies listed was 41.

4.3 Hypothesis development

The current study investigates the distinguishing features in Bahrain where companies try to choose the auditor with the lowest audit fees. Therefore, the current study aims to test the relationship between auditors and clients regarding audit fees. These factors can be summarized as follows:

4.3.1 Corporate size

Corporate size was employed by many previous studies (Taylor and Baker, 1981; Francis, 1984; Firth, 1985; Barber, et al., 1987; Chan et al., 1993; Anderson and Zeghal, 1994; Pong and Whittington, 1994; Johnson et al., 1995; Gregory and Collier, 1996; Ho and Ng., 1996; Iyer and Iyer, 1996; Simon et al., 1996; WaresulKarim and Moizer, 1996; Zhang and Myrteza, 1996; Firth, 1997; Lengendijk, 1997; Mike et al., 1997; Joshi and Al-Bastaki, 2000; Chung and Narasimhan, 2002; Simon and Taylor, 2002; Ezzamel, et al., 2002). "Corporate size is considered an important factor in determining the audit fees", (Hay et al., 2006, cited in Kikhia, 2015, p. 43).

Using corporate size was justified based on the fact that auditors spent more time on auditing transactions of more complex businesses.

Joshi (1999); Al-shammari et al., (2008) and Xu (2011) provided exclusive evidence that "the size of the client is the most important variable in determining audit fees".

Based on the above discussions, the following hypothesis is formulated:

H1: There is a positive relationship between corporate size and auditor fees.

4.3.2 Corporate complexity

(Firth, 1985; Cameran, 2005) pointed out that "large companies require vast capital investment that may be raised through the stock exchange or by borrowing. Hence, they tend to embark on many transactions which may result in high-audit fees. Complexity is directly proportional to rigorous audit work hence higher audit fees".

Corporate complexity might be measured by a number of branches and subsidiaries of the firm locally and internationally (subsidiaries in foreign countries). It is important to note that "the more complex the company is, the greater the number and the more diversified the subsidiaries and operations are; which necessitate more audit work; therefore, audit firms charge higher audit fees" (Taylor and Baker, 1981; Gonthier-Besacier and Schatt, 2007; Tringgaard and Kiertzner, 2008)).

Based on the previous studies, the following hypothesis is developed:

H2: There is a positive relationship between corporate complexity and auditors' fees.

4.3.3 Corporate risk

"The degree of the risk involved in the audit work could be a consideration when determining the audit fee, as it could affect the auditor's responsibility. Therefore, the more the risk involved in the audit work, the greater the responsibility which deserves a higher fee to compensate the external auditor for taking such risk" (Kikhia, 2015, p. 44). Firth (1993 cited in Kikhia, 2015, p. 44) "discover that higher level of client risk will increase the auditor's effort which results in higher audit fees; therefore, the accounting firm will have to undertake detailed work to resolve or moderate the risk".

Based on the previous studies, the following hypothesis is developed:

H3: There is a positive relationship between corporate risk and auditors fees.

4.3.4 Audit size and international link

It has been argued in the literature that "There is a positive relationship between auditor size and audit fees" (Ibrahim, 2006 cited in Hassan et al., 2014, p. 646). Companies audited by audit firms affiliated to big international firms tend to publish high quality information. This is justified on the grounds that large international audit firms have audit quality and protect credibility which might entails extra cost. Audit firms with international affiliations are larger and supported by more technical experts than small local firms and hence tend to supply better auditing quality and expect to incur more cost; this in turn would be reflected in their charges to customers.

WaresulKarim and Moizer (1996) justified the existence of a positive relationship between the size of the auditor and the size of the audit fees as the big audit firms have access to higher quality staff and use advanced quality procedures and so are more likely to detect errors and omissions.

A binary variable is used to indicate whether an auditing firm is among the Big Five or otherwise (1 = Big Five firm, 0 = non-Big - Five firm.)

In light of the above arguments, the following hypothesis is developed:

H4: There is a positive relationship between the size of auditing firms and auditor fees.

4.3.5 Corporate profitability

"Corporate profitability is an important variable in determining audit fee and is regarded as a significant sign of management performance and its effectiveness in allocating variable resources" (Kikhia, 2015, p. 44). "Profitable firms pay more audit fees to their external auditors in view of the fact that higher profits may require accurate audit testing of the authority for the identification of revenue and expenses which require more audit time" (Joshi and Al-Bastaki, 2000 cited in Kikhia, 2015, p. 44).

Most of studies in the literature indicate that the size of audit fees is significantly influenced by profitability ratios (Sandra and Patrick, 1996).

In the light of the previous arguments, the following hypothesis is developed:

H5: There is a positive relationship between corporate profitability and auditor fees.

4.3.6 Seasonability

" A busy season is found to be a significant determinant of audit fees" (Francise, 1984; Francise and Stockes, 1986; Chan et al., 1993; Craswell et al., 1995; Che Ahmad and Houghton, 1996; Ezzamel et al., 1996). It was also found that "there is a difference in audit work performed during the 'busy season' and non-busy season" (Chan et al., 1993). This may be justified on the basis that "audit firms tend to charge a premium for the busy season" (WaresulKarim and Moizer, 1996). Consequently, it is assumed that companies with accounting periods ending during the busy season would be expected to pay a premium for the audit service provided.

In the light of the above discussion, the following hypothesis is developed:

H6: There is a positive relationship between a "busy season" and auditor fees.

4.3.7 Corporate's year end and the time lag between year-end and audit report

The literature also found the variable "lag between audit report and the end of the accounting year to be a significant determinate of audit fees" (Chan et al., 1993; Ezzamel et al., 1996). "A short time lag could be associated with either expensive audit fees or with efficient corporate accounting practices and internal control systems that could result in less audit work and hence lower fees. A longer time lag might suggest that a company is facing accounting problems that may require extra audit work and hence additional audit fees" (Naser and Nuseibeh, 2007).

Thus, the following hypothesis is developed:

H7: There is a positive relationship between corporate year end and the time lag between year-end and audit report and audit fees.

5. Data Analysis

5.1 Data Collection

Two sources were used to collect data (primary and secondary data sources). To achieve the objectives of the current study and in light of the literature review and theoretical background, a survey instrument (questionnaire) was used to solicit respondents' opinions and attitudes towards the determinants of auditors' fees in Bahraini listed companies. Since the main objective of the current study is to investigate perceptions on the determinants of audit fees, it would be difficult to conduct the research other than via a survey, as the data sources are persons themselves, rather than any other source. So the survey strategy was chosen to conduct this research. Survey is defined as "a procedure in which information is collected systematically about a set of cases (such as people, organizations, and objects)" (Thomas, 1996, p. 115). Questionnaire surveys are the most frequently used method of collecting data in such a type of research. The details of the questions used in the study are shown in Table 1 below. The questionnaire included a list of 33 determinants which are expected to have an impact upon audit fees. It has been argued that questionnaires are used because they are considered the main source of data collection (Sarantakos, 1997). The questionnaire consisted of two sections. Section One contained some personal data; Section Two included questions about the determinants of audit fees. These determinants were grouped into the following seven areas including: corporate size, corporate complexity, corporate risk, size of public auditing firm and international link, corporate profitability, seasonability and corporate year end and the time lag between year and audit report. The questions in the questionnaire were measured using a 5-point Likert scale, where 1 refers to "strongly disagree", 2 refers to "disagree", 3 refers to "no opinion", 4 refers to "agree", and 5 refers to "strongly agree". (A copy of the questionnaire is available upon request). 152 questionnaires were distributed to the sample study including financial managers; accountants and internal auditors of Bahraini listed companies and 116 questionnaires were collected. However, 2 questionnaires were excluded from the analysis because they contained numerous uncompleted questions. The remaining 114 questionnaires were used in the analysis, with a response rate of 75 %. The distribution of the questionnaires and response rates are shown in Table 1 below:

Table 1 Distribution of the questionnaires and response rates.

Respondents	No. of Questionnaire distributed and collected	% of Used Questionnaires
Financial managers	35	30.7%
Accountants	50	43.8%
Internal auditors	29	25.5%
Total	114	100%

5.2 Reliability of Study Tool

To prove the reliability of the study tool, a copy of the questionnaire was sent to many accounting professors in Bahrain University and other private universities in Bahrain. Also, some copies of the questionnaire were given to specific institutions in Bahrain. In addition, the questionnaire was given to some academic professors who are specialists in statistics. All their notes and comments were taken into consideration before finalizing the questionnaire.

5.3 Internal Consistency of the Questionnaire's Reliability

The internal consistency of the questionnaire's reliability was measured by using Cronbach's coefficient alpha statistical test as shown in Table 2 below. The analysis in the table provides an indication of the average correlation among all the items that made up the scale. The results demonstrate that all indices obtained regarding the questions in the questionnaire were considered to be high (above 0.70). A sample scale that shows an alpha value above 0.70 is considered as reliable. Therefore, the indices for the questionnaire's reliability are generally considered as adequate for this study.

Table 2 Reliability test.

Questions	Cronbach's Alpha
Questions 1-6	0.902
Questions 7-11	0.771
Questions 12-15	0.805
Questions 16-22	0.743
Questions 23-25	0.764
Questions 26-30	0.711
Questions 31-33	0.814

Table 3 below shows that all values of Chi-square were significant for the seven groups of questions ($p<0.05$). Therefore, it is possible to say that respondents' answers were not equally distributed among the different levels of agreement on the determinants of audit fees in listed companies in Bahrain in all groups.

Based on the above results from Chi-square Test, all of the hypotheses formulated earlier (H1 - H) are accepted.

Table 3 Descriptive statistics and Chi-square results of the seven groups of questions (the overall sample).

Groups of Q	N	Mini.	Maxi.	Std. Deviation	Chi-Square	Asymp Sig.
Group 1 (Q 1-6)	114	1.60	5.00	.52441	234.40	.000
Group 2 (Q 7-11)	114	2.00	4.71	.50443	157.71	.000
Group 3 (Q12-15)	114	1.20	4.92	.52544	329.10	.000
Group 4 (Q16-22)	114	1.71	4.33	.52785	130.60	.000
Group 5 (Q23-25)	114	1.32	4.63	.52212	241.30	.000
Group 6 (Q 26-30)	114	1.40	4.52	.53068	221.50	.000
Group 7 (Q 31-33)	114	1.70	4.38	.55340	131.40	.000

5.4 Descriptive analysis

Table 4 below presents the descriptive analysis regarding the determinants of auditors' fees.

Table 4 Descriptive analysis of the determinants of auditor fees in Bahraini listed companies.

	N	Mean	Std. Deviation	Std. Error Mean
Corporate size.				
Q: 1	114	4.6750	0.47434	0.07500
2	114	4.6000	0.49614	0.07845
3	114	4.4000	0.49614	0.07845
4	114	4.6000	0.49614	0.07845
5	114	4.5500	0.63851	0.10096
6	114	1.900	0.54538	0.08623
Average mean			**4.12**	
Corporate complexity.				
7	114	4.2500	0.54302	0.08586
8	114	4.6000	0.49614	0.07945
9	114	4.6500	0.48305	0.07638
10	114	4.6000	0.49614	0.07845
11	114	1.4500	0.50383	0.07966
Average mean			**3.91**	
Corporate risk.				
12	114	4.6000	0.48990	0.07651
13	114	4.6000	0.48990	0.07651
14	114	4.6000	0.62450	0.09753

15	114	1.4500	0.49749	0.07770
Average mean			**3.81**	
Size of public auditing firm (PAF) and international link.				
16	114	4.6000	0.54538	0.08623
17	114	4.6000	0.49614	0.07845
18	114	4.6000	0.49614	0.07845
19	114	4.5000	0.50637	0.08006
20	114	4.5000	0.50637	0.08006
21	114	4.6000	0.49614	.07845
22	114	2.3000	0.64847	0.10253
Average mean			**4.24**	
Corporate profitability.				
23	114	4.6000	0.49614	0.07845
24	114	4.2000	0.56387	0.08916
25	114	1.5000	0.50637	0.08006
Average mean			**3.43**	
Seasonability				
26	114	4.5000	0.50637	0.08006
27	114	4.5000	0.50637	0.08006
28	114	4.6000	0.54538	0.06823
29	114	1.4000	0.49614	0.07845
30	114	4. 5000	0.59914	0.09473
Average mean			**3.9**	
Corporate's year end and the time lag between year-end and audit report				
31	114	4.5000	0.55470	0.08771
32	114	4.5000	0.59914	0.09473
33	114	4.5000	0.50637	0.08006
Average mean			**4.5**	

The results in the table show that all of the questions in all groups (1-33) prove that they are considered as important determinants of audit fees in Bahraini listed companies with the average means ranging from 3.43 to 4.5 with standards deviations ranging from 0.47434 to 0.63851. Since the standard deviation for all items is less than half of the mean, this indicates that there is no dispersion among respondents' views about the questions of the hypothesis. According to the measurement scale any item with a mean of 3.50 or more is acceptable and since all the determinants get means above 3.50 except for group 5 where the average mean is 3.43 because of question 25 that is stated in negative way, then the respondents do not agree with it and thus, its mean is very low for this specific question. And therefore all the seven hypotheses are accepted.

The ranking of the determinants of audit fees according to its importance is shown in Table 5 below. The table shows that "corporate year end and the time lag between year-end and audit report" located on the top of the determinants with an average mean of 4.50 followed by "size of public auditing firm (PAF) and international link" with an average mean of 4.24 followed by "Corporate size" with an average mean of 4.12 followed by "Corporate complexity" with an average mean of 3.91. The next determinant was "Corporate year end and the time lag between year-end and audit report" with an average mean of 3.90, followed by "Corporate risk" with an average mean of 3.81. The least determinant was "Corporate profitability" with an average mean of 3.43.

Table 5 Ranking of determinants of audit fees.

Rank	Questions	N	Mean	Std. Deviation
	Determinants of audit fees			
1	Corporate year end and the time lag between year-end and audit report	114	4.50	0.5534
2	Size of public auditing firm (PAF) and international link.	114	4.24	0.5279
3	Corporate size.	114	4.12	0.5244
4	Corporate complexity.	114	3.91	0.5044
5	Corporate year end and the time lag between year-end and audit report.	114	3.90	0.5307
6	Corporate risk.	114	3.81	0.5254
7	Corporate profitability.	114	3.43	0.5221

6. Summary, Conclusions and Recommendations

The current study empirically investigated perceptions of three groups working in listed Bahraini firms in Bahrain Bourse namely, internal auditors, accountants and managers on the determinants of audit fees in Bahraini listed companies.

The study concluded that corporate year-end and the time lag between year-end and audit report; Size of public auditing firm (PAF) and international link and corporate size are the important determinants of audit fees in listed companies in Bahrain with the means of 4.50, 4.24 and 4.12 respectively. Most corporate complexity; corporate year end and the time lag between year-end and audit report; corporate risk with the means of 3.91, 3.90 and 3.81 respectively come second in importance. Corporate profitability appeared to have no impact upon audit fees.

The study recommended that future research is needed to investigate this issue in other developing countries in general and the GCC countries in particular. The study also suggested that other respondent groups such as external auditors, shareholders, regulators and members of audit committees might be included in future research. This study is limited to respondents in listed companies working in Bahrain. The question how the situation would be formed in case of privately held companies is another avenue for research. Also in order to generalize the findings of the study, there is a need to conduct the same study again over a longer period of time. Other factors can be considered in implementing the study such as market share of the audit firms and the economic conditions of the country. Findings of such research may not be generalized to different countries at different stages of development, or with different business environments and cultures.

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The Importance of the Agricultural Sector in Achieving Relative Food Security in Kingdom of Bahrain

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Abstract

Agriculture in the Kingdom of Bahrain has witnessed many changes recently affecting its role in the development and food security of the country. The urbanization of the green area, increasing depletion of groundwater and the reduction in the number of Bahraini agricultural workers, have directly affected the country's agricultural growth and food security.

The area of arable land in Bahrain amounted to 6400 hectares, of which the agricultural use does not exceed 4400 hectares, or 69% of the total agricultural land in the country is used. The value of agricultural output, both vegetable and animal, amounted to 16.2 million dinars, with a contribution of 0.23% of GDP. The value of food imports amounted to more than 202 million Bahraini Dinars. The trade balance deficit in Bahrain is almost BHD 173 million.

Because of Bahrain import more than 90% of its needs from food commodities, the aim of this research is to make Bahrain cover more than 50% of its food needs during next ten years and to benefit from other countries experiences in this field and increase agricultural sector contribution to the national economy. In this context, the importance of the National Strategy for Sustainable Agricultural Development as an integrated plan to improve the agricultural situation in the country, including objectives and programs that achieve agricultural growth.

The findings will be useful for achieving the Bahrain economic vision 2030.

Keywords: Agriculture, Agricultural Sector, Food, Food Security, Bahrain.

1. Introduction

The Kingdom of Bahrain has taken several steps to adopt the Sustainable Development Goals (SDGs) 2030 after building on its experience and expertise in achieving the Millennium Development Goals. It paid great attention to these goals and was strongly committed to achieving them since their endorsements in 2000. The goals were translated in four national reports to monitor the progress of achieving them. The fourth and final report, prepared with the support of the United Nations Development Programme (UNDP) office and United Nations Economic and Social Commission for Western Asia (UN-ESCWA) , reflected the progress achieved over the past decade to demonstrate the outcomes of the important steps Bahrain's Government has taken to diversify its economy in order to assist in increasing productivity, raising living standards and creating job opportunities for citizens.

This decade has witnessed great leaps and achievements in the formation of numerous institutions which have highly developed the citizen and provided systems for protection; social care and health care; development of education's quality and its outputs; addressed social inequality and supported vulnerable segments of the society as well as providing opportunities for economic empowerment for the younger generation. Others include the preservation of environmental resources ensuring sustainability of the development path in Bahrain. The fourth report of the UNDP office in the Kingdom included the extraordinary accomplishments of the past 15 years and the commitment of the office in achieving the Millennium Development Goals along with merging them in the national development plans and the consecutive government action programs.

Agriculture refers to forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. Agriculture Value addition as % of GDP in Bahrain is 0.300% & 0.315% during 2014 and 2015 respectively, which is one of the lowest among the GCC countries.

1.1 Objectives of the Study

- To determine the Importance of the Agricultural Sector in Achieving Relative Food Security in Kingdom of Bahrain
- To compile agricultural performance indicators related to Bahrain from different authentic sources, such as World Bank & Food and Agricultural Organization of the United Nations.
- To find new methods to increase a agriculture production and productivity

2. Bahrain Economic Review

Bahrain has grown successfully over the past 10 years, due its liberal economic policies, and the clear roadmap that aim to achieve prosperity for the society. The country's annual real GDP growth ranged between 2.1% and 8.3% over the period.

Table 1 The Economic Indexes for the Kingdom of Bahrain. Source: The Economic Development Board and the Information& eGovernment Authority.

The Index	The Value
The gross domestic product in current prices	31.1 Billion US Dollars (2015)
The gross domestic product in fixed prices	30.8 Billion US Dollars (2015)
The growth in the gross domestic product the percentage growth for one year after the other	2.9% (2015)
The inflation in the consumer price index (100= 2006) annual change	3.3% (June 2013)
Population	1,423,726 (2016)
Employment rate (the workforce as a percentage of the population between 20 and 64 years of age)	79.0% (2010)
Bahrainis	58.4% (2010)
Non-Bahrainis	89.7% (2010)
Unemployment rate	4.3% (2016)
Public sector debt (% of the gross domestic product)	37.6% (2015)
Current account	8.9% (2015)

The international credit rating agency Standard & Poors (S&P) affirmed a credit rating of (BB-) for Bahrain with a stable outlook, supported by the positive developments that have been achieved over the past two years.

3. Bahrain Food Security

3.1 Foods importing in Bahrain

Bahrain has experienced rapid population growth over the past two decades, linked to the discovery of the country's oil reserves and rising income levels. In 2014 Bahrain had an estimated population of 1.344 million people; with a total land area of 710 km2, the country has one of the highest population density rates in the world. Eighty-nine per cent of the population lives in urban areas and it is likely that Bahrain will be close to completely urbanized by 2025. Population growth and urbanization trends have placed considerable pressure on the country's natural resource base. Water consumption is much higher than available natural water resources and food demand far exceeds the production capacity of domestic agriculture. Projected population and income growth will exacerbate the mismatch between demand and supply and require the country to secure alternative sources of food and water. About 92 per cent of Bahrain's food products are imported. Trade-based food security is intrinsically linked

to the country's economic stability and wealth. Bahrain is heavily reliant on imports to meet the food needs of its population. According to the Bahrain Economic Development Board's White Paper, Bahrain on the Food Security Index 2013, 84 per cent of Bahrain's imported food products are supplied by 18 key trade partners. Saudi Arabia and Australia lead this group, supplying approximately 15 per cent of Bahrain's total non-oil import value each. Bahrain's reliance on trade as the primary basis for ensuring food security exposes it to significant price and supply risk.

Table 2 Statistics on Bahrain's Prices

Bahrain Prices	Last	Previous	Highest	Lowest	Unit
Inflation Rate	2.00	1.40	5.22	-2.06	percent
Consumer Price Index CPI	130.00	129.60	130.00	104.04	Index Points
GDP Deflator	101.13	111.58	131.30	88.58	Index Points
CPI Housing Utilities	117.40	117.50	117.50	87.80	Index Points
CPI Transportation	124.50	125.60	127.10	100.01	Index Points
Food Inflation	2.90	2.70	8.90	-7.10	percent
Inflation Rate Mom	0.30	0.30	5.60	-5.64	percent

3.2 Bahrain Food Inflation 2010-2017

Cost of food in Bahrain increased 2.90 percent in August of 2017 over the same month in the previous year. Food Inflation in Bahrain averaged 2.94 percent from 2010 until 2016, reaching an all-time high of 8.90 percent in October of 2015 and a record low of -7.10 percent in October of 2016.

4. Agriculture problems in Bahrain

The report of the Arab Forum for Environment and Development at its fifth annual conference on options for survival and environmental footprint in the Arab countries held on 29 and 30 November 2012 in Beirut revealed that Bahrain is considered one of the worst Arab countries in the environmental footprint. The report pointed out that the average per capita environmental footprint in Bahrain is 6 hectares globally, equivalent to two and a half times the global environmental footprint of 2.7 hectares globally.

Environmentalists have argued that this is due to the deterioration of the marine, agricultural and animal environment and renewable natural resources. Farmers pointed out that urban development, soil fertility, and limited availability of farmers are the main reasons for the deterioration of agriculture. Fishermen stressed that the lack of fish stocks is due to overfishing, coastal depletion and lack of interest in marine resources. They called for support for the advancement of the two sectors and attempts to find solutions to solve these problems to reduce risks. Which lead to poor environmental footprint.

4.1 Environmental footprint

The environmental footprint is a measure of the relationship between the demand for renewable natural resources in an area and the biological capacity of the ecosystem to renew those resources. Dr. Ibrahim Abdul Jalil, Professor of Energy and Environment at Gulf Arab University, said: Of renewable natural resources, with the ability of ecosystems to replenish such resources. For example, overexploitation of a particular species of fish may outweigh the ability of the marine environment to produce such a species and may result in the depletion or disappearance of this resource altogether.

The biological or ecological capacity of ecosystems is calculated using six types of productive land: agricultural land producing food products, fibers and pastures produced for animal food products, fisheries, timber forest areas and other products, carbon sequestration areas and finally built areas, They represent lost productivity from ecosystems (eg palm trees or pasture areas are removed for residential or commercial construction). The calculation of the environmental footprint of a country also takes into account the underlying resources imported from abroad, less the exports.

4.2 The contribution of the Agriculture economic sector in the gross domestic product

Table 3 The contribution of the various economic sectors in the gross domestic product (2015). Source: The Information & eGovernment Authority.

Sector	Contribution Percentage
Oil and natural gas	13.35%
Processing industries	17.34%
Transport and telecommunications	7.52%
Commerce	4.61%
Real estate and business services	5.70%
Financial projects	17.18%
Government services	14%
Agriculture and fishing	0.32%
Water and electricity	1.41%
Building and construction	7.39%
Hotels and restaurants	2.44%
Social and personal services	6.04%

The above table shows the low participation of the agricultural sector in the GDP of the Kingdom of Bahrain by 0.32%. This requires attention to this sector to contribute to food security.

4.3 Agriculture production problems

Approximately 11.17% per cent of Bahrain's total land is arable, two thirds of which is currently cultivated. The sector is a mix of traditional agriculture, protected agriculture and hydroponic production. The main crops produced in Bahrain are dates, alfalfa feed stock and a wide range of vegetables. There is no cereal production. (WB, 2016) In 2013 agricultural production represented approximately 0.3% of Bahrain's Gross Domestic Product (GDP). In order to increase the level of food self-sufficiency, the Bahraini government provides subsidies and economic incentives to improve crop productivity. Along with government loans, the main form of support is input subsidies. Farmers receive an 84 per cent subsidy on the cost of machinery services, 40 per cent on modern irrigation equipment and 50 per cent on the price of pesticides.

The agricultural sector in Bahrain is plagued by a number of structural problems. Urban expansion in recent years has caused a significant loss of traditional agricultural areas. Problems with water-logging and soil salinization have further reduced the availability of arable land. Issues also exist with insecure land tenure practices, the small size of farm holdings, which average 2.5 ha, labor shortages, an inability to compete with imports and a lack of financial incentives. These factors restrict investment in the sector.

By 1993 Bahrain's cultivated area had been reduced from 6,000 hectares before independence to 1,500 hectares. The cultivated land consists of about 10,000 plots ranging in size from a few square meters to four hectares. These plots are distributed among approximately 800 owners. A minority of large owners, including individuals and institutions, are absentee landlords who control about 60 percent of all cultivable land.. Absentee owners rent their plots to farmers, generally on the basis of three-year contracts. There are approximately 2,400 farmers, 70 percent of whom do not own the land they cultivate.

The small size of most plots and the maldistribution of ownership has tended to discourage private investment in agriculture. In addition, the number of skilled farmworkers progressively declined after 1975 because an increasing number of villagers obtained high-paying, nonagricultural jobs.

Despite the low rainfall and poor soil, agriculture in Bahrain historically was an important sector of the economy. Before the development of the oil industry, date palm cultivation dominated Bahrain's agriculture, producing sufficient dates for both domestic consumption and export. At least twenty-three varieties of dates are grown, and the leaves, branches, buds, and flowers of the date palm also are used extensively. From the 1950s through the 1970s, changing food consumption habits, as well as the increasing salinity of the aquifers that served

as irrigation sources, led to a gradual decline in date cultivation. By the 1980s, a significant number of palm groves had been replaced by new kinds of agricultural activities, including vegetable gardens, nurseries for trees and flowers, poultry production, and dairy farms.

Despite these impediments, official government policy since 1980 has aimed at expanding domestic production of crops through such programs as free distribution of seeds, technical assistance in adopting new and more efficient irrigation technologies, and lowinterest credit. Although these programs have contributed to significant increases in the production of eggs, milk, and vegetables, the circumscribed extent of Bahrain's cultivable area limits the island's potential productive capacity. Consequently, agricultural imports remain a permanent aspect of the country's international trade. the main food imports included fruits, vegetables, meat, live animals (for slaughter), cereals, and dairy product.

Figure 1 Bahrain GDP from Agriculture.

Table 4 Bahrain GDP from Agriculture. Source: Ministry of Finance, Bahrain. Constant prices 2010, NSA and World Bank. Current USD.

Bahrain	Latest	Reference	Previous	Range	
GDP	31.12	2015	33.39	3.05:33.39	USD Billion
GDP from Agriculture	34.95	2016	34.90	17.70:34.95	BHD Million

Bahrain GDP latest value is 31.12 USD Billion, Bahrain GDP from Agriculture was last reported at 34.95 BHD Million. It ranks as the world's 10th lowest recorded GDP from agriculture. GDP in Bahrain fell to 31.12 USD Billion from 33.39 USD Billion and GDP From Agriculture went up to 34.95 BHD Million from 34.90 BHD Million in 2015.

4.4 Agricultural credits in Bahrain

The total credit of the country has increased by 500% during 2001-2015, whereas the agricultural credit has increased only by 34%. It is not enough to support this important sector.

4.5 Water problems

A high rate of water consumption has led to over extraction from Bahrain’s aquifers; taking into account losses in the public distribution network, Bahrain’s per capita water consumption was between 273-318 litres per day in 2012. Municipal water demand represents approximately 47 per cent of Bahrain’s total water demand. The agriculture sector closely follows; demanding 44.5 per cent, and industry and the commercial sector requires roughly eight per cent.

Bahrain is one of the world's most water stressed nations and its groundwater abstraction is unsustainable in the mid to long-term. The country will need to expand non-conventional water sources significantly to meet demand to 2025 and beyond. Food supply is derived from both domestic and external sources.

Limited, erratic rainfall and high evapotranspiration rates characterise this arid country. The total annual surface run off is approximately four million cubic meters and there are no rivers, perennial streams or lakes. The three key water sources in Bahrain are groundwater, desalinated water and treated wastewater. The expansion of the latter two will be crucial in reducing groundwater abstraction and meeting long-term water demand.

An estimated 54 per cent of Bahrain's water is sourced from groundwater resources with a further 35.6% from desalination and 9.7% from treated wastewater. The over-abstraction of aquifers has caused deterioration in groundwater quality in some parts of the country. Salinisation, increased water pollution and the drying of freshwater springs in the north are all the consequence of unsustainable groundwater withdrawal.

Bahrain has faced on ongoing challenge in financing the development of its water and waste-water projects. Funding from neighbouring Gulf countries has driven much of the recent development in the sector but the capacity of treatment and supply facilities and infrastructure remain inadequate. The Muhrraq Sewage Treatment Plant was completed in 2014 and an expansion of the Tubli treatment facilities from a capacity of 200,000m^3 per day to 400,000m^3 per day has been planned. Increasing the supply of treated wastewater will allow for greater diversification of Bahrain's water supply, increasing the country's overall water security outlook to 2025.

The cost of water for municipal users is set at a block-rate tariff that fails to recover the cost of service and delivery. A report from Chatham House in 2014 highlights the financial burden of water supply delivery and expansion and the need to address water pricing to ensure the sustainability of the water industry.

4.6 Agricultural raw material

The agricultural raw material imports as percentage of merchandise imports is concerned, in 2014 Bahrain is ranked first with 1.043% followed by Saudi Arabia with 0.703%. However, in 2015 Saudi Arabia is ranked first with 0.768%, followed by Bahrain with 0.749%.

4.7 Bahrain's Agriculture Value Addition

It is evident that Bahrain's Agriculture Value Addition as % of GDP has increased from 0.298% in 2010 to 0.315% in 2015. However, this meager improvement is not sufficient. In 2013 and 2014, Bahrain's Agriculture Value Addition as % of GDP was 0.275% and 0.300 respectively. Bahrain's Ministry of Industry, Commerce & Tourism is promoting value addition in agriculture by encouraging food and pharmaceutical industries based on agriculture, especially herbal plants.

5. Agriculture and food security in Bahrain

Bahrain has experienced rapid population growth over the past two decades, linked to the discovery of the country's oil reserves and rising income levels. In 2014 Bahrain had an estimated population of 1.344 million people; with a total land area of 710 km2, the country has one of the highest population density rates in the world. Eighty-nine per cent of the population lives in urban areas and it is likely that Bahrain will be close to completely urbanized by 2025. Population growth and urbanization trends have placed considerable pressure on the country's natural resource base. Water consumption is much higher than available natural water resources and food demand far exceeds the production capacity of domestic agriculture. Projected population and income growth will exacerbate the mismatch between demand and supply and require the country to secure alternative sources of food and water.

Bahrain currently experiences a comfortable level of trade-based food security. Relying on food imports does, however, expose the country to a high degree of price and supply risk. To counter this, the government has created strategies to increase domestic food self-sufficiency. Scarce natural resources will limit any significant expansion of the agriculture sector. As population growth continues and consumption patterns shift toward more processed,

westernized products, Bahrain will become increasingly dependent on food imports. Consistent growth in foreign currency revenue is required to support trade-based food security and reduce the risks associated with a globalized food system.

6. Strategies to improve agriculture and make Food Security

6.1 The 2030 Economic Vision

The 2030 Economic Vision, launched by His Majesty King Hamad Bin Isa Al Khalifa in October 2008 embodies a comprehensive vision for the Kingdom of Bahrain that aims at creating a clear approach to develop the kingdom's economy while focusing on the main objective, which aspires to improve the living standards of all Bahraini Citizens.

The 2030 Economic Vision focuses on crystallizing an integrated socio-economic government vision and focuses on three basic principles which are competitiveness, integrity and sustainability.

After the launch of the vision, the Kingdom of Bahrain began an institutional economic reform program that is in line with the objective of the 2030 Economic Vision. This led to the preparation of a national economic strategy that represents a roadmap to achieve the vision. This strategy is continuously revised to adapt to the international changes and the government's work program. Following the global food price spikes of 2008 and 2011 and the continued volatility in price levels, the Bahraini government has undertaken a number of short and long-term measures aimed at improving future food and water security.

The National Initiative for the Development of Agriculture outlines a number of key objectives related to food security, including a strategy to increase domestic food production from 20 to 60 per cent of total demand. This will focus on the self-sufficiency of high quality fresh vegetables, an area in which Bahrain already performs relatively strongly.

Bahrain plans to intensify its farming practices and exploit the potential gains available in modernizing traditional agricultural sectors. A shift will be encouraged towards crops that have a comparative advantage, high value uses or that are low water consumers. In addition to intensified cropping, the strategy will aim to improve food processing facilities and develop the poultry, aquaculture and fisheries sectors. Expanding agricultural production will, however, place further pressure on overburdened water resources.

It may be possible to sustain this increase if desalination capacity is rapidly expanded to supply all non-agricultural consumption demands, and if increases in output are driven by the expansion of hydroponic production, which uses water efficiently. Both technologies have high costs and would require considerable government support and trade protection for output to remain competitive with imports. Thus while these measures entail more sustainable resource use, it would be difficult for Bahrain to meet their fiscal demands beyond 2025. Natural and fiscal resource constraints mean that it is unlikely that any more than a short term increase in domestic food production can be sustainably achieved.

7. Result and Conclusion

The agricultural sector in Bahrain is plagued by a number of structural problems. Urban expansion in recent years has caused a significant loss of traditional agricultural areas. Problems with water-logging and soil salinization have further reduced the availability of arable land. Issues also exist with insecure land tenure practices, the small size of farm holdings, which average 2.5 ha, labor shortages, an inability to compete with imports and a lack of financial incentives. These factors restrict investment in the sector.

Population growth and urbanization trends have placed considerable pressure on the country's natural resource base. Water consumption is much higher than available natural water resources and food demand far exceeds the production capacity of domestic agriculture. Projected population and income growth will exacerbate the mismatch between demand and supply and require the country to secure alternative sources of food and water.

The government has to increase its encouraging agricultural development in both the public and private sectors, encouraging towards crops that have a comparative advantage, high value The government should also encourage non-traditional agriculture and agriculture, encourage productive agriculture in the courtyards and the roofs of houses and government institutions, expand the production and investment of agricultural fertilizers, and expand credit facilities to

farmers and investors in this important economic sector. There should also be university specialties in various agricultural fields' uses or that are low water consumers. In addition to intensified cropping, improving food processing facilities and develop the poultry, aquaculture and fisheries sectors, providing facilities, and strengthening research and extension activities. In addition to fostering co-operation with the private sector, the policy to diversify the economic base and extend food production has focused on providing economic incentives to improve crop productivity through a broad system of subsidies for farming inputs.

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The Economic Development Board and the Information & eGovernment Authority

Ministry of Finance, Bahrain, several years

The Effect of Productivity, Market Capitalization and Profitability on Sustainability: An Empirical Study in Banking and Finance Sector in Oman

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Abstract

Sustainability is a social matter and a new strategic variable in terms of relationship between productivity and profitability. The banking and finance sector is one of the most important sectors in Oman. There are some Islamic banks in this sector, all of them listed in Muscat securities Market (MSM). Generally, this sector is profitable and attractive for many investors from Oman, GCC countries and foreign investors. This paper analyzed the relationship between productivity and capitalization as proxies of sustainability and profitability in banking and finance sector in Sultanate of Oman. The data were collected from the annual reports of 35 Islamic banks listed on MSM for 5 years from 20101-2015.

The regression analysis in this sector showed that the result of effect the market capitalization and productivity on sustainability is insignificant at 1%. The R-square is supporting the significance of regression where the model is dependable. On the other side, the regression model showed that the profitability does not have effect on sustainability at 1%. This means that the Banks and finance companies in Oman prefer to capitalize their profit.

The main recommendation in this study is that banking and finance sector should increase the productivity and market capitalization to increase the level of contribution in GDP in Oman.

Keywords: Productivity, Market Capitalization, Profitability, Sustainability, Banking, Finance, Oman.

1. Introduction

Private companies have different mission and objectives which reflected in their strategies. Some of their major objectives are size, growth, profitability and recently sustainability. There is a long debate that which factor size, growth or profitability becomes the major source of increase in sustainability. Lots of researches have been done to conclude this debate. Traditionally, as far as growth is concerned it is very critical factor for the success of the companies; more over it also become the source of evolution and development of a country's economy (Asimakopoulos, et.al., 2009). In the modern debates, there are two important factors have more attention as a source of evolution and development of company, sector as well as a country's economy. Those two factors are productivity and capitalization. Off-course, these two factors are not new, but the issue is the importance of them in relation to the sustainability and profitability in the banking and finance sector.

Sustainability and profitability has a long controversial debate between scholars in this area. According to the classical theories in economic, accounting and finance, the main objective of the firm in achieving profit. Recently, firms and society has a lot of effort move toward sustainable development. Sustainable means that firms will develop corporate strategies that include goals that go beyond just maximizing shareholders' interests such as social, environmental, educational in addition to economic goals. Attention is directed to the demands of a wider group of stakeholders, since the firm's success depends on stakeholder's satisfaction (Lopez and Sheu, 2007).

Many previous studies have examined the association between sustainability and financial performance in terms of profitability, productivity and capitalization. Most of these studies have yielded mixed results. Some studies indicated a positive association, others a negative association and several studies failed to find any correlation. Few studies had examined the association and effects of sustainability on financial performance, productivity and capitalization in the Middle East, particularly in the sultanate of Oman.

In this study an attempt has been made to investigate and analyze the association and effects of the financial performance, productivity and capitalization on sustainability of Omani Companies in finance and banking sector for the period 2011-20115. The study aims to get at the answer to the question: What is the effect of financial performance, productivity and capitalization on sustainability in the Omani banking and finance sector?

Sustainability is measured through the GDP of Omani finance and banking companies, financial performance is measured by the return on assets (ROA). Productivity is measured by the relationships between revenues and number of employees, while capitalization is measured by total market value of shares.

Our study contributes to the extant body of literature by providing additional evidence from one country in the Middle East on a relationship between sustainability and productivity, capitalization and financial performance or profitability.

The study is divided into five sections. In the first section, the study presents an introduction. Theoretical issues related to the main concepts of the study (sustainability, productivity, capitalization and profitability) are presented in the second section. A literature review is discussed in the third section. The forth section presents the model, data and methodology used in this study. Section five provides the results of the analysis, while section six presents a summary and conclusions.

2. Theoretical issues and Hypotheses

2.1 Productivity and Sustainability

Sustainability has many relations and effects on many variables in the companies. It can raise benefits in the long run namely through improved relations with stakeholders and reduced cost of conflicts with them, reputation creation, value creation and productivity. In relation to productivity, there are many studies demonstrated the relation between productivity and sustainability. Lourenço et al., (2010) explained that companies can increase the sustainability through enhance the skills of their employees and human resources management system. Capper and Bauman (2013) pointed out that the productivity is a mechanism to achieve sustainability through properly uses the resources.

According to Pekuri et al., (2011: 41) productivity means "a relationship between output produced by a system and quantities of input factors utilized by the system to produce that output". OECD defined productivity as “a ratio of volume measure of output to a volume measure of input use” (OECD, 2001, p.11). Productivity is closely connected to the use and availability of resources. The productivity will increase if the company properly use the resources and vice versa. On the other side, productivity is closely connected to the creation of value. The high productivity is achieved when activities and resources in the process add value to the products or services produced by the company (Tangen, 2002).

Productivity is one of the most important issues in the Gulf Cooperation Council (GCC) countries because it is a vital indicator of economic performance of an economic system. Also, productivity has a strong relation with sustainable development. Now, most of GCC countries, especially in the Sultanate of Oman, try to invest out of the oil and gas field. In Oman, up to the mid of 2014, there are (1468) industrial projects with 4.2% growth rate. On the other side, the amount of growth rate in the size of investment in the industrial sector amounted 27%.

In the banking and finance sector, the total assets for all banks working in Oman are 58.1 billion US dollar at the end of 2013 with notable increases in the products of these banks. Also, Omani government gave the private sector more freedom was most of services are provided by this sector. This is because the Omani government is depending on economic diversification principle since the collapse of oil and gas in 1986 and it encouraged the establishment of new projects in all economic fields out of oil and gas area (Rabobank Country Report Oman, 2014).

There are many concepts and definitions of productivity as applied in manufacturing industries and other sectors. For example, in the field of banking, the various products are accounts, drafts, exchange remittances, cheques, traveler’s cheques, credit cards, debit cards, services for guarantees, various kinds of loans like housing loan, education loan, car loan and so on. In addition, in the Islamic banks, there are many other products should be considered in the measurement of productivity such as Modarabah, Morabaha, and Musharakah. Identification and measurement of output in banking is very difficult exercise as it is not possible to bring various services to measure output.

In this study, and to avoid any practical problems, we are depending on the Productivity accounting model. This model was introduced by H. S. Davis. In 1955, Davis published a book titled "Productivity Accounting" in which he presented a productivity index model. This model is depending on the accounting information provided by accounting system which isolated all other external information such as price inflation.

Therefore, the first hypothesis is:

H1: high level of productivity will increase the level of sustainability.

2.2 Market Capitalization and Sustainability

The capital market in any country is one of the major backbones of long term economic growth and development. The market serves a range of users including different levels of government, corporate bodies, and individuals inside and outside the country. According to Khrawish et al., (2010) market capitalization is the total of market value of shares by multiply the price of the stock by the number of shares outstanding.

The relationship between Market Capitalization and Sustainability is move together. Until the late 1980s, business leaders typically employed the term 'sustainability' to mean a company's ability to increase its revenues steadily in the long term. Recently, the concept of sustainability encompasses every dimension of the business environment, including the social, economic and natural resource utilization by the company. This direction is appropriate with the idea market capitalization in achieving the growth in the long term. Mittal (2017) pointed out that the market capitalization enhances the economic growth and growth of market value of shares and this is exactly in the way of sustainability.

Thus, an increase in the market share of a public limited liability company through the sales of its shares increases its capital base and encourages expansion leading to a higher level of growth, productivity and sustainability (Oluwatoyin and Gbadebo, 2009).

Therefore, the first hypothesis is:

H2: high level of market capitalization will increase the level of sustainability.

2.3 Profitability and Sustainability

Adams et al., (2010) refer that a sustainability reputation should allow a firm to achieve above average profitability and increased shareholder wealth maximization. Sustainability efforts also serve to signal both the capital markets and consumer markets of the overall quality of a firm's products and services. As a result of this signaling hypothesis, not only consumers but the capital markets participants may be expected pay a premium for the shares of high-sustainability firms.

There are a number of analyses that demonstrate how the implementation of more sustainable practices can improve farmers' competitiveness and profitability. The arguments that for some time have been presented for CS arise, at least in part, from the classical idea that the objective of business is to maximize shareholder wealth and that a firm should engage in socially responsible activities only if it allows value to be created. Siegel (2009, p.14) contends that "firms should pursue green management practices only when it is in their self-interest to do so".

Therefore, the first hypothesis is:

H3: high level of profitability will increase the level of sustainability.

3. Literature Review

Empirical investigations of the link between sustainability and profitability through market capitalization and productivity have been relatively limited in Middle East countries, especially, the GCC region. Theoretically, the relationship between stock market development and economic sustainability and profitability has been a subject of controversy. Previous studies carried out have hardly come to a unanimous conclusion on the causal linkage between them. While some studies maintain that sustainability drives profitability, others are of the view that it stifles profitability.

Adams et al., (2010) examined the impact of sustainability on financial performance. This study used the Dow Jones Sustainability US Index (DJSI US) during 2008-2009. The result of the study indicates that sustainability contributed positively to shareholder value of the firm.

Perera et al., (2011) tried to answer the following question: Do sustainability practices influence the results of the company? Through their study, the answer was No; the sustainability did not make any significant changes in the profitability of the company. Eccles et al., (2011) investigated the effect of corporate sustainability on organizational processes and performance in a sample of 180 US companies. The study indicated that there is a positive relationship between sustainability and accounting profitability. Owusu (2016) examined the relationship between stock market evolution and sustainable economic growth in Nigeria. He concluded that sustainability has a mixed effect on economic growth. Piedra-Muñoz et al., (2016) analyzed the impact of different aspects of sustainability (socio-economic characteristics, environmentally respectful practices, and innovation) on profitability. They concluded that the sustainability has positive effects on the economic performance. Nnaemeka et al., (2017) evaluated the effect of sustainability accounting on the financial performance of listed manufacturing firms in Nigeria for a period 2010-2014. The study showed that sustainability reporting has positive and significant effect on financial performance.

It becomes especially worthwhile to examine the productivity, market capitalization, profitability and sustainability in Oman since there is a huge interest in these concepts in this country. This study tries to examine the relationships and effect between sustainability and productivity, capitalization and financial performance in Omani banks and finance companies listed.

4. Methodology, Data and Method

4.1 Sample Selection and Data

The population of this study is the banking and finance sector in Oman. In this sector, there are 36 companies including 8 banks, 6 insurance companies, 6 finance companies, 12 investment companies, 3 fund companies and 1 real estate company. We excluded 1 company because it's data insufficient. Therefore, the final sample subject to analysis is 35 companies during the period of study. In this study, we collected all data from annual reports of financial companies and banks in Oman during the period of study which is 5 years from 2011-2015. Also, some data were collected from Muscat Securities Market report published in 2016 for the same period of study. The type of collected data are related to the variables of this study; market capitalization, productivity and profitability. The data related to sustainability were collected from "world development indicators 2017".

4.2 Variables of Study

There are three main variables in this study were subject to analysis. The first one is market capitalization. This variable was measured by the total market value of shares for all companies in the sample. Second variable is productivity which is measured by the relationships between revenues and number of employees, while the profitability was measured by return on assets (ROA). All these three variables are independent variables whereas the dependent variable is the sustainability which is measured by real GDP. Table 1 presented all variables used in this study:

Table 1 Variables definition

Variables	Abbreviation	Formula
Independent variables		
Productivity	P	Total revenues/ Number of Employees
Market Capitalization	MC	Algorithm of total market value of Shares
Profitability	ROA	Return on Assets
Dependent variables		
Sustainability	S	Algorithm of Real GDP

4.3 Model Specification

This study examines impact of three independent variables (productivity, capitalization and profitability) on sustainability. The study employs an econometric method in formulating a regression model to be analyzed through pooled ordinary least squares method. The methodology employed in the study was to examine the annual report of the selected companies as in the following equation:

$$Sit = \alpha 0 + \beta Pit + \beta MCit + \beta ROAit + \varepsilon it \quad (1)$$

Note:
S= Sustainability
P= Productivity
MC= Market Capitalization
ROA= Return on Assets
α= Constant
β= Beta
ε= Error term
i= *i*th firm
t= *t*th period

The annual reports for the sample were checked then calculate the value of all variables for testing by using the statistical package for the social sciences (SPSS) software.

5. Research Findings

5.1 Multicollinearity Test

According to this test, it is very serious to ensure that the independent variables are not influencing by other independent variables. Table 2 indicates that multicollinearity is not a problem, as the correlations between all independent variables are insignificant.

Table 2 Correlations Matrix

			MC	**ROA**	**P**	**S**
Spearman's rho	MC	Correlation Coefficient	1.000			
		Sig. (2-tailed)	.			
	ROA	Correlation Coefficient	-.229	1.000		
		Sig. (2-tailed)	.185	.		
	P	Correlation Coefficient	.207	.125	1.000	
		Sig. (2-tailed)	.233	.473	.	
	S	Correlation Coefficient	.588**	-.123	.214	1.000
		Sig. (2-tailed)	.000	.482	.218	.
**. Correlation is significant at the 0.01 level (2-tailed).						

It seems that the problem of multicollinearity between independent variables is not significant because all correlations are insignificant. Based on these results, the multicollinearity is not a problem and we can depend on the model.

5.2 Regression analysis

Regression analysis, utilizing the pooled ordinary least squares method, is used to test the hypotheses. Table 3 showed the correlations between the variables as follows:

Table 3 Correlations in the model.

Sample	Variables	MC	ROA	P
Model 1	S	0.588**	-0.229	0.227
***Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).**				

As in the table 3, in the model, it seems that the correlations between dependent variable S and MC are positive and significant at 0.01. On the other side, the correlations between S and ROA and P are insignificant at 0.01.

Table 4 showed that R^2 is 0.526, which implies that independent variables included in the model explain 52.6 percent. It is obvious in table 5 that explanation power of Model 52.6%, which is supporting the model. This value means that the variable S can be explained by the variable MC only about 52.6%, while the remaining is explained by other variables (which is not contained in the model) and error.

Table 4 Model Summary of Sample.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.725a	.526	.480	.16694
a. Predictors: (Constant), MC,ROA, P				

Table 5 presented the regression results. These results showed that F-ratio is 11.451 for the model which is significant at 0.01. The results of the model statistically support the significance of the regression model.

Table 5 ANOVA model.

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	.957	3	.319	11.451	.000b
Residual	.864	31	.028		
Total	1.821	34			
a. Predictors: (Constant), MC,ROA, P					
b. Dependent Variable: S					

Table 6 indicated the definition of each variable in the equation of the model.

Table 6 Coefficients of the model.

Variables	B	T	Sig.
Constant	-1.270	-5.310	.000
MC	.248	5.624	.000
ROA	.192	.545	.590
P	.128	2.878	.007

Table 6 explains that the MC and P are significant variables in the regression equation of the model (Sig< 0.01). Based on these results, our model is supporting the hypotheses H1 and H2. This means that the S influenced by market capitalization and productivity, high level of capitalization and productivity will increase level of sustainability. Also, these results shows that the banks and finance companies are prefer to capitalize value of shares and increase the productivity and this will enhance the indicator of sustainability and will improve the contribution of banking and finance sector in Oman in the GDP. On the other side, these results showed that the profitability is not compatible with sustainability in this sector and H3 is rejected. This is because the mangers and investors in this sector believe that banks and finance

companies should invest their profitability in the long term which will enhance the productivity and capitalization instead of distributing all profit to the shareholders.

The information presented is an effort to enhance sustainability should be done by increasing the productivity and capitalization. This means that Omani banks and finance companies should increase their investments in these two variables reduce the dividends for stockholders.

6. Summary and Conclusion

In this study an attempt has been made to investigate and analyze the association and effects of the financial performance in terms of profitability, productivity and capitalization on sustainability of Omani Companies in finance and banking sector for the period 2011-20115. The study aims to get at the answer to the question: What is the effect of financial performance, productivity and capitalization on sustainability in the Omani finance and banking sector? This question is answered that positively partially for productivity and capitalization and negative for profitability.

Sustainability is measured through the GDP of Omani finance and banking companies, financial performance is measured by the return on assets (ROA). Productivity is measured by the relationships between revenues and number of employees, while capitalization is measured by total market value of shares.

One of the most important results is that the market capitalization and productivity have positive and significant effects on sustainability. This means that banks and finance companies tend to increase the productivity and capitalize the profit through market capitalization to increase the sustainability. Banking and finance sector in Oman should invest more investment in both productivity and capitalization which will increase the contribution of this sector in GDP.

The results of study showed that the profitability is not compatible with sustainability in this sector because the sector is interest with sustainability in the long term.

As in the other studies, there are some limitations in this study. First, the study used mixed sources of data. Some data collected from annual reports of the sample (accounting data) while other collected from MSM database (market data) and some of them collected from economic reports (economic data). Secondly, the period of study is only 5 years from 2011-2015 were the annual reports of the sample analyzed because only those reports are presented on the websites of these companies and MSM. Therefore, further research would be required in Oman and GCC countries. For example, testing other variables in the other sectors in Oman because of that this issue is not deeply researched. Another research area of interest is exploring the possible reasons explaining the differences between sectors concerning the sustainability. Finally, the sustainability is measured by using GDP despite there are many other indicators can be used.

Several policy implications can be drawn from the above mentioned results of the study. The banking and finance sector should enhance sustainability to increase the GDP. The study provides evidence to the investors and managers in this sector in regarding the variables impact on the sustainability in order to analyzed these variables and formulate the appropriate strategy of sustainability. Also, the policy makers in this sector should think carefully about the role of their sector in the Omani economy and they can do this through the increase the productivity and capitalization as a good source for economy diversification. Finally, the decision makers in MSM should provide a sustainability index for all companies listed in this sector and other sectors in MSM.

The main recommendation in this study is that banking and finance sector should increase the productivity and market capitalization to increase the level of contribution in GDP in Oman.

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Section 8

LEAN and Innovation

Leadership Effectiveness: Competencies Influence on Safety Leadership Behaviours

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Abstract

The effectiveness of leadership behaviours varies from one person to another. It depends on more than simply performing the leadership behaviours. In the safety context, as in any other context, leaders need to know *when* and *how* behaviours are executed beside their knowledge of *what* leadership behaviour is being performed. Leadership competencies have been claimed to provide leaders with the ability to perform their behaviour more effectively. Therefore, the aim of this paper is to empirically investigate the relationship between leadership competencies and leadership behaviour in the construction safety context. Such an investigation will assist leaders to better conduct their safety leadership behaviour(s) in the complex environment of construction site operations.

Keywords: Leadership Effectiveness, Behaviours, Safety, Construction.

1. Introduction

The construction industry is considered as one of the most complex work environments. Besides the numerous tasks, large number of employees, deadlines, and the use of hazardous materials and equipment, each construction project takes place in a different location. This means no two construction projects are alike. As a result, the construction industry is considered one of the most complicated and riskiest industries. Worldwide, this industry is considered the most hazardous among other industries (Khosravi et al. 2014). In Australia, 15% of all fatal accidents took place in the construction industry in 2015 (Safe Work Australia 2016). Similarly, in Saudi Arabia, this industry is considered one of the most unsafe local industries, enduring 51% of total injuries among all industries (Al-Haadir et al. 2013).

The importance of leadership has been well founded in the safety context. It is considered to be a key factor influencing safety performance as well as being essential for achieving safety targets (Wu et al. 2016). Leadership has been mainly conceptualised in a considerable number of practices. Often, these practices are grouped to form theories and styles based on how leadership is defined. Thus, many leadership theories and styles have been investigated in order to improve safety conditions. In complex work environments, managing safety is becoming more difficult; and sufficiency with following one or two effective leadership theories and styles, or simply practising leadership behaviours are not enough for leaders (Clarke 2013; Yukl & Mahsud 2010).

Leaders need to know *when* and *how* their behaviours are executed, alongside their knowledge of *what* leadership behaviour should be performed (Mumford et al. 2000). Leadership competencies can, therefore, assist leaders in achieving this need due to its value-adding in handling leadership behaviours. Put simply, it is qualifying leaders in order to be able to evaluate situations, which in turn will increase their capability to execute the most suitable practice(s) leading to better performance.

The aim of this paper is to investigate the relationship between a single leadership competency namely, *cognitive competency*, and safety performance indirectly through select leadership behaviours. In other words, the paper aims to examine the effect of *cognitive competency* on safety behaviour, and the mediating role of leadership behaviours. In doing so, the research objective is to achieve greater insight on the role of leadership behaviours in facilitating better safety performance. As described below, the paper empirically examines the impact of the cognitive competency on two kinds of leadership behaviours namely, *workforce involvement* and *relationship management*.

2. Literature Review

2.1 Safety Leadership Behaviour

Leadership is defined as "a process whereby an individual influences a group of individuals to achieve a common goal" (Northouse 2013). Thus, safety leadership behaviours are the behaviours that leaders perform in order to influence their followers to achieve the desired safety goals. To-date research studies in safety leadership are merely examining leadership behaviours as predefined leadership styles; with the most prominent are transformational, transactional, and empowerment leadership styles. However, these styles have many behaviours in common. Interestingly, leadership behaviours have been classified differently in the literature. A particular research study categorizes leadership behaviours into four main types namely, workforce involvement, relationship management, visibility and leading by example, and proactive management (O'Dea & Flin 2001). This paper focuses only on two of these four behaviours namely, *workforce involvement* and *relationship management*. Each of these two behaviours is briefly described below.

Workforce Involvement: Sanders et al. (1976) found that leaders who involve their workforce motivate followers to work more safely. In construction, Abudayyeh et al. (2006) endorsed the notion that the leader who participates with his/her followers and involves them in decision making, provides the motivation to followers to agree with decisions and attempt to improve on them. The 'involvement' behaviour includes defining roles and responsibilities, and participating in decision making with followers when defining their respective tasks.

Relationship Management: Building relationships is another behaviour that leaders should practise with their team members. According to Cipolla et al. (2005), the relationship between leaders and their followers is built by spending time together. This leads to improved discretionary behaviour on the part of the team members (Settoon et al. 1996). O'Dea and Flin (2001) assert that maintaining high levels of communication with followers, by listening to them and taking their suggestions into account, is needed to build honest, open, and trusting relationships. Having good communication skills is considered a basic element of strength because it leads to followers' trust (Vredenburgh 2002). Anantatmula (2010) argues that establishing open and trusting communications leads to innovation, team development, knowledge sharing, and collaboration. Conversely, according to Künzle et al. (2010), poor communication is a trap for leaders (Sugrue et al. 1995).

In construction, Abudayyeh et al. (2006) found that by practising 'communication' behaviour, safety leaders can steer their followers toward safety. Hence, improving the safety performance. This fully endorses the earlier findings of Mohamed (2002) and Chinda and Mohamed (2008) that trust and communication have a positive impact on safety.

2.2 Leadership competencies

Boyatzis (1982) came up with one of the earliest definitions of competency in the management context. He defined competency as "the underlying characteristics of a person that lead to, or cause, effective and outstanding performance". The importance of this definition lies in how it originated. According to Boyatzis (2008), the basic competency concept was extracted from the job performance theory. Therefore, the aforementioned definition aligns with the competencies that leaders need.

Based on the above-mentioned view of competency, Boyatzis et al. (2000) established a measurement for three leadership competencies. First, they identified emotional and social competencies, which have proven its effectiveness for leader performance. Then, they considered adding cognitive competencies to be an important addition for their leadership competencies' measures. However, Boyatzis (2008) asserted that these three forms of competencies provide a systemic view of a leader's personality as well. Boyatzis (2008) also stated that a suitable framework for leadership can be expressed by the presence of the emotional intelligence, social intelligence, and cognitive intelligence competencies. Many studies, such as Boyatzis (2008), Goleman (1998), and Palaima and Skaržauskiene (2010) contend that adopting these intelligence competencies could lead to outstanding performances. Despite the importance of all three competencies, this paper focuses only on the impact of *cognitive competency* that has been defined by Boyatzis (2008) as "the ability to think [about]

or analyse information and situations that leads to or causes effective or superior performance". Selecting this particular competency is based on its essential role in avoiding misdirecting other competencies' influence on performance (Boyatzis et al. 2012).

2.3 Safety Behaviour

There are two main methods that can be used to measure safety performance. The first method is a traditional one where indicators are used to measure safety events and accidents that have already happened (Sheehan et al. 2016). The second method is based on safety behaviour which mainly includes: safety compliance and safety participation (Neal & Griffin 2006). The literature contends that safety leadership behaviour impacts positively on safety behaviour (Clarke 2013). Therefore, this paper examines the impact of leadership competency and leadership behaviour on safety behaviour.

3. Research Hypotheses

In this study, *cognitive competency* will be recognized as enabler for leaders in performing their safety leadership behaviours. It supports leaders in understanding the overall situation, so they can be able to adequately assess the situation and its consequences. The conceptual model, shown in Figure 1, exhibits the potential relationship between cognitive leadership competency as independent variable and safety behaviour as dependent variable through safety leadership behaviours as mediator variables. Each of the two leadership behaviours is assumed to be positively affected by the cognitive competency which ultimately leads to better safety performance. Accordingly, this research study has the following three hypotheses:

- Hypothesis 1a: *Cognitive competency* positively impacts *workforce involvement*.
- Hypothesis 2a: *Workforce involvement* positively impacts *safety behaviour*.
- Hypothesis 1b: *Cognitive competency* positively impacts *relationship management*.
- Hypothesis 2b: *Relationship management* positively impacts *safety behaviour*.
- Hypothesis 3: *Cognitive competency* has a direct positive impact on *safety behaviour*.

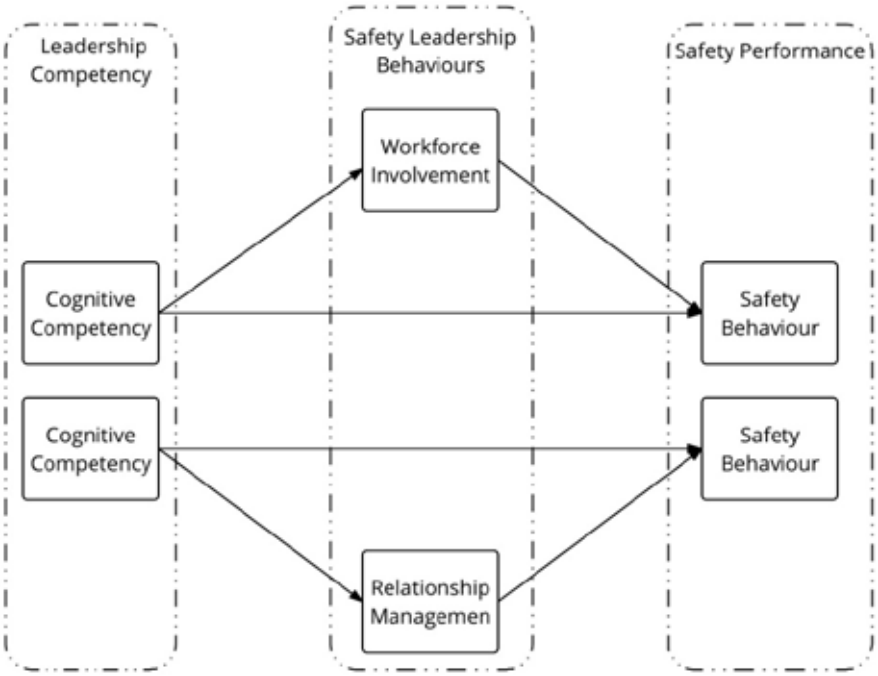

Figure 1 Conceptual Model.

4. Research Methodology

To empirically test the conceptual model, the quantitative survey was chosen as the most suitable method for this study. Data was gathered from individuals who work or have worked in the Saudi Arabian construction industry. They received invitations to voluntarily take part in the study and fill out a questionnaire that includes 36 items in total. The items are related to the four variables of the conceptual model. Regression statistical method was applied on the gathered data in order to test the proposed three hypotheses. More on the adopted research methodology is discussed in the following sections.

5. Questionnaire Design and Development

The questionnaire developed consists of three main sections. The first section measures leadership competency using a five-point Likert scale varying from 'Never' to 'Always'. A total of 10 items, belonging to *cognitive competency*, were adopted from the widely used the ESCI-U SAQ instrument (Boyatzis & Goleman 2007).

The second section measures safety leadership behaviours. A total of four items were adopted to measure *workforce involvement*. These items were selected from two previous surveys, developed by Vredenburgh (2002) and Yukl and Falbe (1990). The LXM7 instrument was chosen to measure the behaviour of relationship management. It consists of seven items developed by Graen and Uhl-Bien (1995). All these items have been validated and adjusted to suit this research, utilizing a five-point Likert scale varying from 'Never' to 'Always'. The third and final section measures safety behaviour. A total of 15 items were adopted, 12 items from Burke et al. (2002) and the remaining three from Neal and Griffin (2006). As with the previous 2 sections of the questionnaire, this section utilizes a five-point Likert scale varying from 'Never' to 'Always'.

6. Preliminary Data Analyses

A total of 104 completed surveys were collected, without any missing value, out of 322, representing about 32 per cent of completed surveys. The received responses were considered to be appropriate representation of the targeted populations' opinions. About 73 per cent of the respondents have shown to have more than five years of experience in the Saudi Arabian construction industry. Basic descriptive statistical measures, such as normality, were conducted to check the requirements of the basic assumptions.

To assess the distribution of all 36 items, data screening techniques and Skewness and Kurtosis analysis were carried out. Most of Skewness and Kurtosis values were less than |1| and no greater than |2|. Thus, the sample data is considered to be normally distributed. As for scale reliability, all constructs had Cronbach's alpha (α) greater than 0.7, which is the minimum accepted value of reliability (Pallant 2005). Finally, the conceptual model was tested by regression analysis, using SPSS program version 24, to test the hypotheses. The PROCESS macro (model 4) for SPSS was be used in order to conduct ordinal analysis (Hayes 2012).

7. Regression Analyses

7.1 Cognitive Competency – Workforce Involvement – Safety Performance

Multiple regression analyses were conducted to assess each component of the hypothesised mediation model. All three variables were significantly correlated. Namely, *cognitive competency* and *safety performance* ($r= 0.549$, $p < 0.001$), *workforce involvement* behaviour and *safety performance* ($r= 0.417$, $p < 0.001$). *Cognitive competency* and *workforce involvement* behaviour ($r= 0.395$, $p < 0.001$). Figure 2 displays the relevant standardised regression coefficients.

It was found that *cognitive competency* significantly predicts *workforce involvement*, $b= 0.438$, BCa 95% CI [0.238, 0.639], $p < 0.001$. The direct effect of *cognitive competency* on *safety performance* was found to be statistically significant, $b= 0.657$, BCa 95% CI [0.438, 0.921], $p < 0.001$. Specifically, *cognitive competency* accounted for 30.2% of the variance in *safety performance*.

When added to the regression analysis, *cognitive competency* and *workforce involvement* behaviour collectively accounted for 34.9% in safety performance overall, F(2, 101) = 27.13, p < 0.001. Also, it was found that the proposed mediator, *workforce involvement*, significantly predicted safety performance, b= 0.256, BCa 95% CI [0.073, 0.445], p = 0.009 and uniquely accounted for 4.8% of the variance in safety performance. When workforce involvement was added to the regression analysis, the effect of *cognitive competency* on *safety performance* remained statistically significant, b= 0.545, BCa 95% CI [0.338, 0.752], p < 0.001, despite the strength of the relationship being slightly diminished. This indicates that workforce involvement is partially mediating the relationship.

A PROCESS analysis was conducted and revealed that the cognitive competency significantly predicted safety performance via its relationship to workforce involvement b = 0.1122, BCa CI (0.0366, 0.2335).

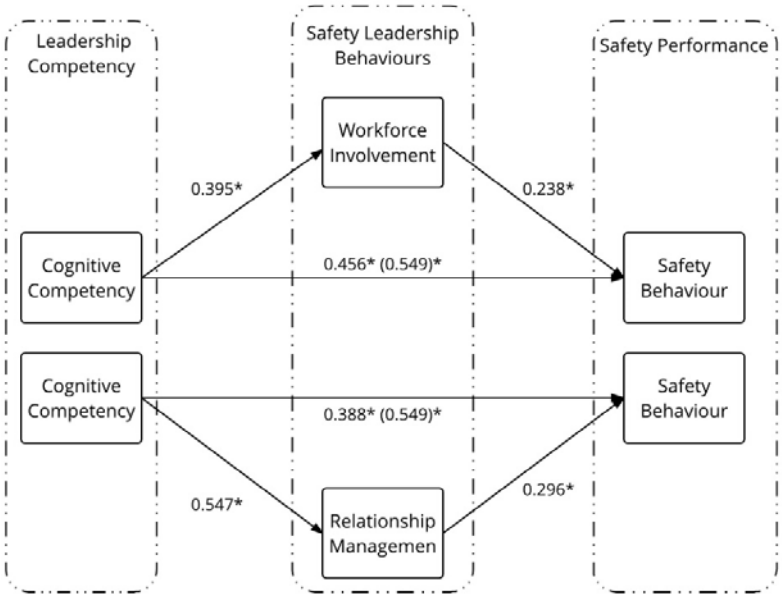

Figure 2 Standardised Regression Coefficients. (*p<.05)

7.2 Cognitive Competency – Relationship Management – Safety Performance

All three variables were significantly correlated. Namely, *cognitive competency* and *safety performance* (r= 0.549, p < 0.001), *relationship management* behaviour and *safety performance* (r= 0.508, p < 0.001). *Cognitive competency* and *relationship management* behaviour (r= 0.547, p < 0.001). Figure 2 displays the relevant standardised regression coefficients.

It was found that *cognitive competency* significantly predicts *relationship management*, b= 0.547, BCa 95% CI [0.428, 0.796], p < 0.001. The direct effect of *cognitive competency* on *safety performance* was found to be statistically significant, b= 0.657, BCa 95% CI [0.438, 0.921], p < 0.001. Specifically, *cognitive competency* accounted for 30.2% of the variance in *safety performance*.

When added to the regression analysis, *cognitive competency* and *relationship management* behaviour collectively accounted for 36.3% in safety performance overall, F(2, 101) = 28.789, p < 0.001. It was found that the proposed mediator, *relationship management*, significantly predicted *safety performance*, b = 0.316, BCa 95% CI[0.094, 0.544], p = 0.008 and uniquely accounted for 6.1% of the variance in *safety performance*. When *relationship management* was added to regression analysis, the effect of *cognitive competency* on *safety performance* remained statistically significant, b = 0.464, BCa 95% CI[0.239, 0.689], p < 0.001, despite the strength of the relationship being slightly diminished. This indicates that *relationship management* is partially mediating the relationship.

A PROCESS analysis was conducted and revealed that the *cognitive competency* significantly predicted *safety performance* via its relationship to *relationship management* b = 0.1934, BCa CI(0.0535, 0.3655).

8. Discussion and Conclusion

Safety leadership, as a topic, has gained and continues to gain much attention. However, the role of leadership competencies in complex work environments, as a subject, has not yet been thoroughly investigated (Alidrisi & Mohamed 2017). This research was conducted to fulfill this research gap by examining the impact of cognitive competency on safety performance, and test whether or not select safety leadership behaviour(s) mediates this relationship.

Effective leadership, as mentioned earlier, is beyond simply practising behaviours; it is about what and how leaders execute their behaviours at the right time (Mumford et al. 2000). To do so, cognitive competency has been adopted, in this study, to provide evidence-based leadership-safety behaviour relationship. As hypothesized, a significant correlation between cognitive competency and safety performance has been found. As for, the mediators, *workforce involvement* and *relationship management*, both were accepted as partial mediators. Therefore, cognitive competency appears to have an indirect impact, through workforce involvement and relationship management, and a direct impact on safety performance. Workforce involvement and relationship management leadership behaviours, along with other behaviours, have been concluded to be effective on safety performance (Martínez-Córcoles et al. 2012).

In this paper, the influence of safety leadership appears to increase by combining the safety leadership behaviour (workforce involvement and relationship management) with the cognitive competency. Cognitive competency helps leaders in optimising the delegation of responsibility toward their followers, influencing followers in identifying safety problems, and involving followers in decision making creating a more effective workforce involvement. It also assists them in establishing a high level relationship with their followers, which is characterised by being open, honest, and trusting.

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An Examination of Lean Construction Techniques to Promote Health and Safety Practices

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Abstract

The aim of this research was to examine the effectiveness of implementing lean construction techniques to promote health and safety practices in the construction industry in the Kingdom of Saudi Arabia. Mixed method was adopted in this study, where both qualitative and quantitative data was collected. Literature review was conducted to provide an in-depth understanding of the research that was carried out in the past, which was useful in giving insight into the current study. Quantitative data was collected from 46 respondents using a structured questionnaire. Simple random sampling was used to select participants for the questionnaire survey while purposive sampling was used to select the firms to be included in this study. Qualitative data was collected using direct observation method and face to face in-depth interviews with five safety managers from the five firms included in the study. Data from the questionnaires was analysed using Microsoft Excel software to provide descriptive information on the study results. Qualitative data provided additional information to supplement the findings drawn from the survey. The results show that Last Planner System and visualization were the most commonly used lean construction techniques in the Kingdom of Saudi Arabia. This study established that the use of lean construction methods was instrumental in promoting health and safety practices in the construction industry in Saudi Arabia. Limited knowledge was established as the most important challenge in implementing lean techniques. This study, additionally, provides recommendations for practice and future research on lean construction and safety in Saudi Arabia.

Keywords: Lean Construction Techniques, Health and Safety Practices, Kingdom of Saudi Arabia.

1. Introduction

The importance of the construction industry in a given country is on the economic and social well-being of its population. The industry, nevertheless, has been acknowledged to present the highest risk on the well-being of its workers and the general population (Farooqui, 2008; Fewings 2013; Ruddock & Ruddock 2011). Despite the recent investment in strategies for improving the practices in the industry, the level of safety still remains to rank lowest (Godwin et al., 2013). In the United States and Malaysia, for example, the construction industries are considered to be the sectors contributing significantly to the economy as well as being the most hazardous industries (Waehrer et al., 2007; Mosly, 2015). Studies have also found that rate of injuries and their associated costs in the construction industry worldwide are the highest when compared to the averages across the other industries (Waehrer et al., 2007; Mosly, 2015).

According to the National Safety Council estimates, 6 percent of the industry workforce is constituted by workers in the construction industry (GOSI, 2010). However, it accounts for approximately 21 percent of all industrial fatalities. The construction industry has, therefore, been found to be the industry with the highest rate of accidents in comparison to the other industries. Furthermore, the incidence of fatalities and disabling injuries are highest in this industry. In reference to 2010 regional statistics, Japan, Ireland, and the United Kingdom had 40 percent, 50 percent, and 25 percent of the accidents occurring in the construction industry (GOSI, 2010). Saudi Arabia, however, had 51 percent of the total workplace injuries in the construction sector (GOSI, 2010; Mosly, 2015). Therefore, Al Shaikh (2010) postulates that the construction industry in Saudi Arabia is responsible for the highest incidence of accidents

annually, particularly the occurrence of accidents that are life-threatening in comparison with the remaining industries in the country. Reported work accidents, in 2014, in Saudi Arabia's industry amounted to 69,241 accidents. Of these accidents, 51.35 percent were associated with the construction industry (GOSI, 2015; Mosly, 2015).

The greatest concern of the lean construction concept is to implement lean philosophy in the construction industry (Sarhan and Fox, 2013; Sharma et al., 2016). The major purpose therefore, in the execution of lean thinking in the construction industry in Saudi Arabia is to improve efficiency and quality (Banawi and Bilec, 2014). Lean Construction is, therefore, a management philosophy that is production-based and can be applied for the elimination of waste from a construction project using Lean principles (Fewings 2013; Forbes and Ahmed 2011). It can, therefore, be acknowledged as an on-going practice of eradicating wastage of effort, resources, and time to meet or surpass the requirements of the customer, while concentrating on the value stream for the duration of the construction project (Dickson et al., 2007; Koskela 2004; Womack & Jones 1996). As a result Lean Construction techniques can be applied to accidents viewing them as causes of wastage of labour, money and time, which can be a hindrance to consistent flow of work (Bashir et al., 2013).

Despite lean construction techniques causing a revolution in the manufacturing and construction industry worldwide, the theory of lean has played a significant role in challenging the traditional norms and rules that guided planning and work management in a manner that has seen a significant improvement in performance (Ogunbiyi, 2014). It is for these reasons accidents need to be eliminated by utilizing practices of safety and health on construction sites in the Kingdom of Saudi Arabia. As a result, the purpose of this study was to investigate in what ways lean construction techniques can be utilised to encourage health and safety practices in the Saudi Arabian construction industry. The objectives of this study were to (1) to study the concept of lean construction techniques through a literature review; (2) to study health and safety practices in the Saudi Arabian construction industry through a literature review; (3) to identify current lean construction techniques along with health and safety communication practices, used in the construction industry of Saudi Arabia by means of a case study; (4) to conduct a questionnaire survey in order to gain professional opinions on the awareness of lean construction techniques and health and safety as well as the challenges and benefits in the construction industry of Saudi Arabia; and (5) to provide recommendations and suggestions based upon the research findings to improve the safety performance in the Saudi Arabian construction industry.

2. Literature Review

The concepts, tool and principles of lean construction have attracted great attention in the literature for the last two decades (Jorgensen & Emmitt, 2008; Pettersen, 2009). The concept of lean construction was first introduced in 1992 by Koskela. However, the adoption of the concept in the industry has been slow. Nevertheless, lean construction has been shown to have a positive impact on the construction practices (Abdullah et al., 2009; Suresh, Bashir & Olomolaiye, 2011). Particularly, lean construction has been shown to have a positive impact on health and safety in construction activities (Koskela, 1992; Abdullah et al., 2009; Suresh, Bashir & Olomolaiye, 2011). Lean construction involves the adoption of lean manufacturing techniques and principles in the building industry (Lukowski, 2010). The main objective of lean construction is to optimize the use of resources, materials and people in order to eliminate waste, reduce costs and deliver the project in a timely manner (Lean Construction Institute, 2012).

There are various lean construction tools and concepts that can be applied in the project implementation process. Fundamentally, there are five principles of lean construction including specification of the value, identification of the value stream, flow, pull and perfection (Aziz & Hafez, 2013). On the other hand, Koskela (1992) suggested three principles that could be used in production including management philosophy (such as total quality control and just-in-time), tools (quality circles and Kanban) and manufacturing methods. The other key concepts of lean construction include total production maintenance (TPM), continuous improvement, employee improvement, value based strategy, visual management, concurrency engineering and re-engineering (Koskela, 1992). Alinaitwe (2009) utilized the principles suggested by Koskela (1992) to develop the techniques of lean construction. These techniques include Last Planner System (LPS), 5Ss, concurrent engineering, Business Process Re-

engineering, Total Quality Management, Just-In-Time, Value Based Management and Teamwork (Alinaitwe, 2009; Aziz & Hafez, 2013; Salem, Solomon, Genaidy and Luegring, 2005; Salem, Solomon, Genaidy and Minkarah, 2006).

The hazards that are present at the construction work sites are most of the time obvious to the workers and the employers. The occurrence of injuries, death and illnesses at the construction sites affect the workers, their families and even passers-by (Mosly, 2015). Practices aimed at preventing such accidents need to be adhered to from the planning phase to the end of the project. Competent site supervision and effective management of work activities are crucial in maintaining safety and health conditions in the construction sites. The degree of supervision and control required on the site is, therefore, dependent on the risk levels (Health and Safety Executive, 2006). The Saudi Arabian construction industry emphasizes on providing employees, visitors, and other contractors with important information about the site hazards, site rules, and welfare facilities. The need to obtain employees views regarding health and safety is also not overlooked by the management of the construction sites (Haadir & Panuwatwanich, 2011; Zeng et al., 2004).

The construction industry in the Kingdom of Saudi Arabia is experiencing rapid growth (Mazher et al., 2015). Construction techniques that increase productivity while reducing expenses and time are necessary. The presence of numerable health and safety hazards in construction sites necessitates the development and implementation of oversight laws and guidelines. Construction in the country is growing and the government has put in place measures to protect workers from injuries, health and safety risks. The Royal Decree of 6 Ramadan 1389 (15 /11/1969) number M/21 governs the labour industry of the country. It outlines the employment regulations and the responsibilities of the state, employers and employees (Medallah, 2015).

Lean construction has been proposed as a solution to increasing productivity, while implementing health and safety standards is seen as an important tool in reducing injuries and death (Ikuma et al., 2010). A research by Cheng et al. (2012) established a relationship between processes for management of safety in construction sites to the productivity of the project. The use of lean construction in improving health and safety together with increases in productivity has been studied by Pasquire and Gibb (2009). The study established a reduction of exposure of workers to health and safety hazards as a result of implementing lean construction techniques. Furthermore, ensuring the safety and health of people at a construction site requires the provision of prevention measures that reduce the hazards in the environment and exposure of workers to the risks (Mitropoulos et al., 2005). On the other hand, Love et al. (2015) state that quality of performance and safety at construction affect each other. They investigated the relationship between reworks and safety performance and found that they were significantly associated. These studies illustrate that the construction technique, methods and principles affect the health and well-being of the people at the site.

Several studies have been conducted on the use of lean construction techniques in the construction industry (Alinaitwe, 2009; Locatelli et al., 2013; Salem et al., 2006). Some of these studies have been carried out in the Middle East and Saudi Arabia (AlSehaimi et al., 2009; Banawi & Bilec, 2014). Health and safety in the construction industry have also been widely studied (King et al., 2012; Mosly, 2015; Verma et al., 2014). However, it is worthwhile to note that studies that have investigated the relationship between lean construction and health and safety in the construction industry are limited. More conspicuous is the limited number of studies that have examined the association of lean construction and occupational health and safety in Saudi Arabia. Furthermore, research is limited on the individual effect that lean techniques in construction have on health practices in the industry. The current study is, therefore, relevant as it seeks to investigate lean construction and health and safety practices in the Saudi Arabian construction industry.

3. Methodology

The research strategy which was selected for the present study is the mixed methods research, combining qualitative and quantitative approach. Therefore, taking into consideration the research goals and objectives, and the constraints provided by the timeframe and location of the research, the mixed method research strategies selected to investigate the research problem include a questionnaires, a case study and a site visit.

Multiple research designs were utilised in the proposed study including a survey questionnaire, a case study, a review of the literature and observations (through site visits). Multiple designs are utilised to enhance the validity and reliability of the outcomes through triangulation. The review of the literature provided information regarding research that has been conducted and this information was utilised in the design of the case study, the survey and observations. Simple random sampling was used to select 50 participants for the survey. On the other hand, purposeful sampling was used to identify the five construction sites that were visited.

Participation in the study was voluntary and the participants were free to exit the study at any time. The participants who agreed to participate in the study provided informed consent. Second, the researcher ensured that confidentiality was maintained throughout the study. Finally, personal information was not gathered to ensure the anonymity of the participants.

Data analysis comprised of investigating, evaluating, classifying, tabulating, and re-combining both the qualitative and quantitative data to concentrate upon the original proposition of the study. The raw data collected from the case study and site visit was analysed using the Cross-case analysis. Data from the questionnaire survey was then tabulated and analysed with the use of Microsoft Excel. The final result is presented in chart and graphic form, to allow visual comparison of the data.

4. Findings

4.1 Response rate and characteristics of the respondents

From the survey 46 questionnaires were returned and found to valid, giving a response rate of 92%. Of the firms involved in the study, three had 50-100 employees, two had between 0 and 50 employees and one had more than 250 employees Figure 1 and 2 below illustrates the demographic and work experience of the respondents.

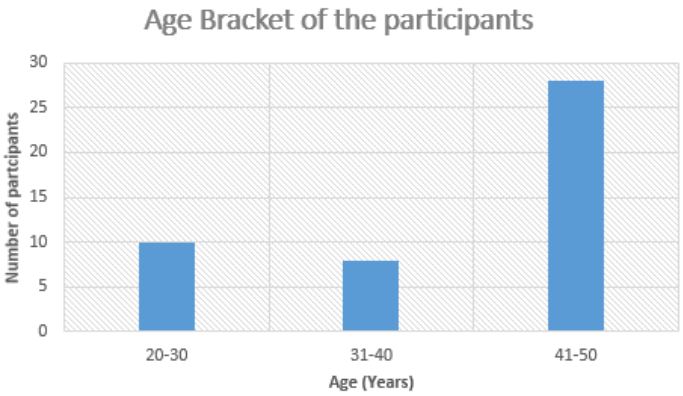

Figure 1 Age distribution.

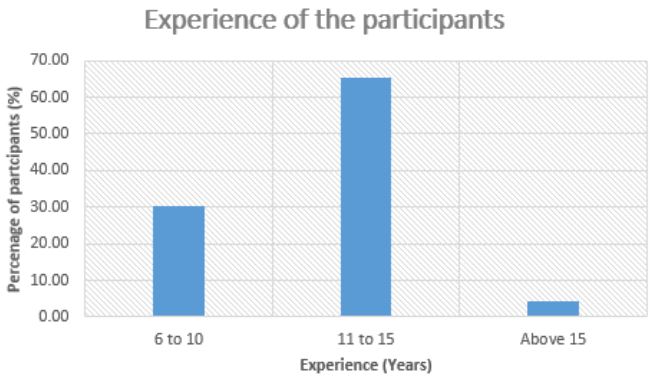

Figure 2 Number of years in the construction industry.

The measure of effectiveness was applied on the following study variables: eliminating errors and waste, communication, direct intervention, elimination of non-value adding activities, continuous improvement, improving work planning and forward scheduling, specifying value from the perspective of the customer, identifying the processes that deliver customer value, and ensuring the working environment is clean, safe and efficient. Continuous improvement was indicated to be an effective strategy (42% indicated very effective while 58% indicated effective) for enhancing health and safety at the construction sites. The results of the remaining variables are provided in the figures below.

Figure 3 Effectiveness of eliminating errors and waste.

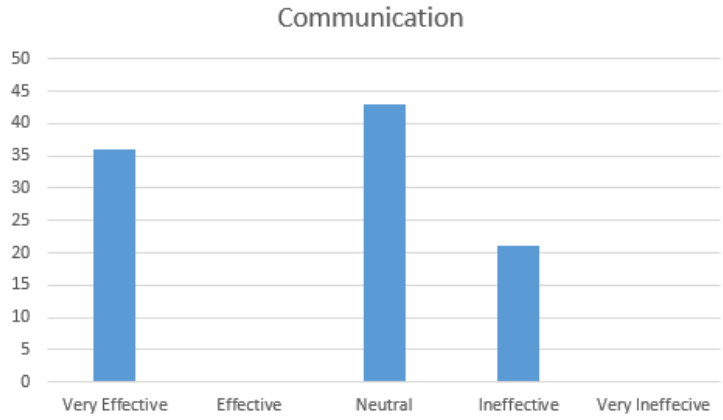

Figure 4 Effectiveness of communication.

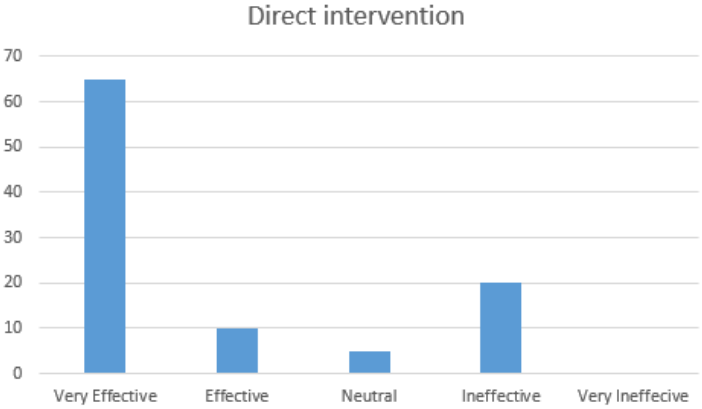

Figure 5 Effectiveness of direct intervention to drive immediate and apparent change.

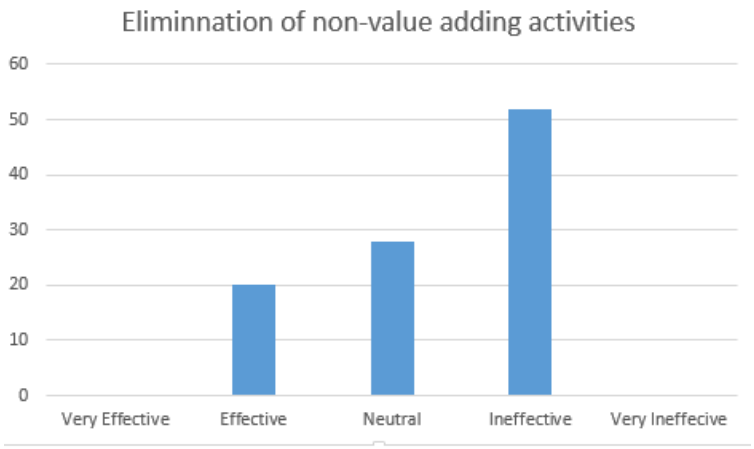

Figure 6 Effectiveness of Elimination of non-value adding activities

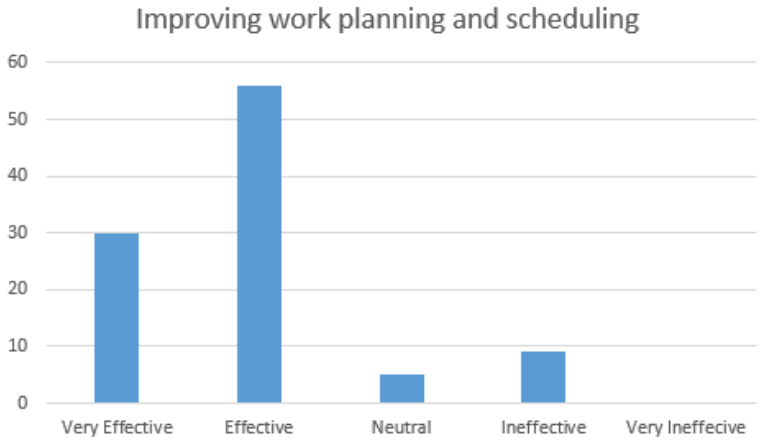

Figure 7 Effectiveness of improving work planning and forward scheduling

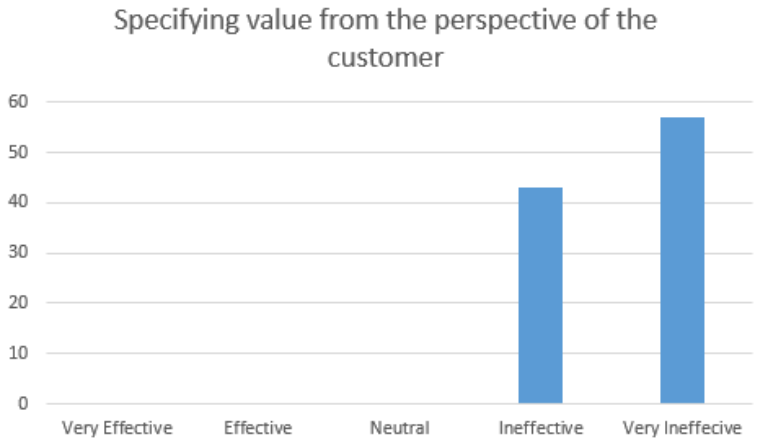

Figure 8 Effectiveness of specifying value from the perspective of the customer.

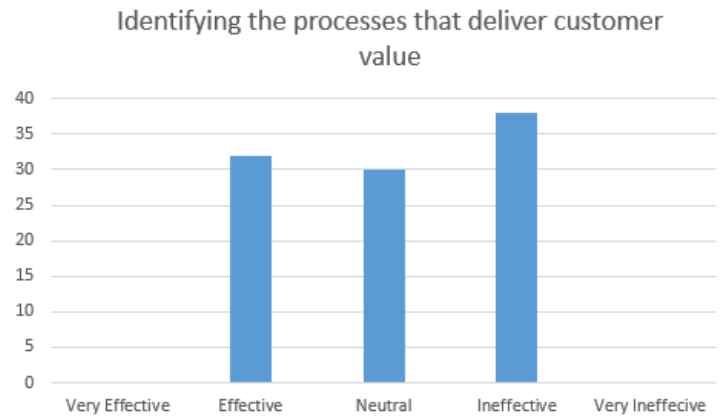

Figure 9 Effectiveness of identifying the processes that deliver customer value.

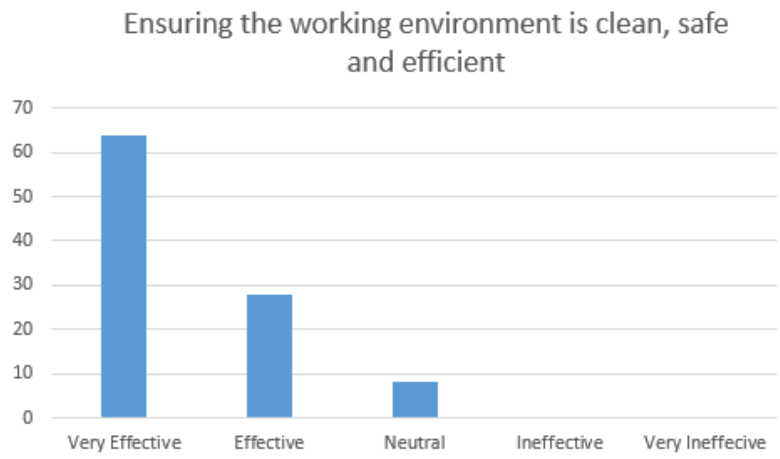

Figure 10 Effectiveness of ensuring the working environment is clean, safe and efficient.

The Table 1 below illustrates the ranking of practices in lean construction associated with health and safety.

Table 1 Health and safety practices.

Practice	Median	Mode	Rank
Have a health and safety manual	5	5	1
Provision of personal protection equipment	5	5	2
Have a person(s) responsible for safety and health	5	5	3
Make daily or routine inspection of site	4	3	4
Provision of wash and sanitation facilities	4	3	5
Site access and boundaries	3	3	6
Emergency procedures	3	2	7
Height protection strategies	2	2	8

The respondents rated their perceptions regarding the importance of given factors on a Likert scale (Little importance (1), some importance (2), quite important (3), important (4) and very important (5) and the results are presented below.

Table 2 Benefits of lean construction techniques.

Benefits	Median	Mode	Rank
Improving safety	5	5	1
Reduce project cost	5	5	2
Reduce accidents and injuries	5	4	3
Improve productivity	4	4	4
Eliminate wasteful activities	4	4	5
Smooth Project delivery	3	4	6
Reduce project duration	3	3	7
Client satisfaction	2	3	8

67% of the participants indicated that limited knowledge of lean techniques was a key challenge. Employee non-compliance was identified as another key challenge by 57%, inadequate incentives (43% of the respondents), lack of government support (12% of the respondents) and inadequacies of the lean construction methods (4% of the respondents).

Figure 11 Challenges faced in implementing lean construction techniques.

5. Discussion of Findings

The construction industry has been seen to provide increased risk to injuries and accidents for both the workers in the construction site and other people who may be passing by. This has led to the need of stringent measures to promote the health and safety of all the people concerned. In addition, the construction industry has also moved towards the use of technology that increases productivity and minimizes wastages. The use of lean technology has the potential of increasing productivity in the construction industry while at the same time promoting the health and safety of workers at the construction sites. The findings of this study were in agreement with several findings drawn from the review of literature regarding the use of lean construction and health and safety at the construction site (Alinaitwe, 2009; King et al., 2012; Pasquire& Gibb, 2009; Teizer et al., 2013; Zhang et al., 2013).

This study was carried out among firms in the construction industry in Saudi Arabia. The participants in the study worked in firms that had between one to two hundred and fifty workers. The most commonly used lean construction techniques, as indicated by 100% of the respondents in the interviews, in the Saudi Arabian construction industry were visualization and Last Planner System (LPS). However, not all the components of these techniques were implemented in the construction process. The use of lean construction techniques in the industry was reported to provide several benefits to the projects and the firms. The factors that influenced the use of lean methods were reduction of project costs and duration, elimination of non-value adding activities, reduction of injuries and accidents, increasing

productivity, and promoting safety at the construction sites. Out of these factors, the promotion of safety was ranked as the first and most important benefit achieved form the use of lean construction methods. This finding is supported by Leino and Elfving (2011) and Ikuma et al. (2010) who found a relationship between lean construction and health & safety through prevention policies, respecting people and waste minimization. Client satisfaction was rated as the least beneficial outcome of using lean construction techniques. Several authors, however, argue that shift in customer preferences as well as dynamism of the construction industry has prompted the adoption of lean construction techniques (Ashworth and Perera, 2010; Kelly, Male and Graham, 2014).

The research identified that the most commonly used health and safety practice in the industry was having a health and safety manual at the construction site. Other practices included the provision of personal protection equipment, having a designated safety personnel, routine safety inspection, and provision of sanitation facilities. The least used practices include having height protection strategies, emergency procedures, and site access and boundaries protocols. This finding supports the findings of Mosly (2015) who established that emergency procedures, safety signage, and protection from heights were the least used methods in promoting safety in the Saudi Arabian construction industry. On the other hand, several challenges faced in the implementation of lean construction methods were established. The most vital challenge faced in Saudi Arabia was lack of adequate knowledge on lean construction techniques followed by non-compliance to lean principles. This finding is supported by the study conducted by Ogunbiyi et al. (2013) who also found lack of knowledge as a key challenge among the UK firms. Lack of incentives was also found to be a major challenge faced in the implementation of lean techniques in construction to promote health and safety. An in-depth analysis of existing literature conducted by Bashir et al. (2015) examining UK firms and professionals support this finding. The four new challenges revealed by Bashir et al. (2015) included low effort to learn from employees, non-compliance with instructions, lack of incentives and high expectations from the management.

Several lean construction practices were established to be effective in promoting health and safety practices in the Saudi Arabian construction industry. The most effective strategies were the elimination of waste and errors, direct health and safety interventions, continuous improvement, communication, maintaining a clean, safe and efficient workplace, and improving work planning and forward scheduling. Several authors in literature provide support for this findings (Abdelhamid et al., 2013; Fernandez et al., 2012; Lim YenWui, Abdul Rahman & Abdul, 2009; Ogunbiyi & Goulding, 2013; Rodrigues et al., 2013). Specifying value form the client's perspective and elimination of non-value adding activities from the construction processes were found to be the most ineffective strategies in promoting safety and health using lean construction techniques.

Figure 12 Challenges faced in implementing lean construction techniques.

In this study, 67% of the respondents noted that limited knowledge of lean construction techniques as a major challenge in the Saudi construction industry. This therefore meant that limited knowledge of lean construction techniques among top managers in Saudi hindered the application of the same techniques in construction. This finding is supported by the study conducted by Ogunbiyi et al. (2013) who also found lack of knowledge as a key challenge

among the UK firms. The study found out that only 14.5% of the surveyed firms had above 70% of lean construction techniques and practices on their project. Ogunbiyi et al. (2013) further maintained that the reason for the low percentage was due to the fact that lean construction concept was still new to the UK construction industry. In support, a study by Bashir (2013) in the UK found that limitations in lean knowledge were the third highest reason that was encountered in the implementation of lean construction methods. This finding of the current research is also supported by the findings reported by Lindhard and Wandahl (2014). The latter study revealed a general deficiency of knowledge of lean construction techniques among the surveyed firms. According to Lindhard and Wandahl (2014) 18.8%, 28.1%, and 78.1% did not perceive flow, value creation, and transformation as part of lean construction practices. The study also found that lack of knowledge of lean construction techniques played a significant role in facilitating the partial application of lean construction techniques as opposed to application as a complete system.

In line with compliance, this research found that 57% of the respondents supported employee non-compliance as a key challenge in Saudi construction industry. This means that the lean construction techniques, according to the 57% of the respondents, were largely ignored by the construction firms. The non-compliance, according to the findings, may have been caused by the culture of resistance to change, lack of awareness, and adequate knowledge of the lean construction techniques. An in-depth analysis of existing literature conducted by Bashir et al. (2015) examining UK firms and professionals support this finding. The four new challenges revealed by Bashir et al. (2015) included low effort to learn from employees, non-compliance with instructions, lack of incentives and high expectations from the management. This is further highlighted by the study conducted by Bashir (2013) among construction firms in the UK. This therefore means that human and management related challenges are significant in reducing the application of lean construction practices in construction industry. Bashir et al. (2015) therefore maintained that resistance to cultural change, misconception about lean techniques, and lack of cooperation from employees played an important role in impeding the application of lean techniques. Barbosa et al. (2013) also supports this finding in the Saudi context by maintaining that the difficulty in the implementation of lean construction techniques was largely due to employee non-compliance. Employees, according to Barbosa et al. (2013), had difficulty in understanding the new philosophy of planning that further led to non-compliance.

This research also found out that 43% of the respondents supported the inadequacy of incentives as a major challenge to the implementation of lean construction techniques among Saudi construction firms. According to this section of respondents, the implementation of lean construction techniques was greatly hindered by the lack of adequate incentives. The lack of adequate incentives according to this research may have been propagated by the lack of support and commitment from the top management which in some cases is viewed as an additional expense. Sarhan and Fox (2013) support this finding through a survey conducted in the UK on the lean construction techniques and practices among firms. The study also identified the lack of adequate incentives and motivation as a key barrier to the implementation of lean construction. Sarhan and Fox (2013) further maintained that the implementation of lean construction should be accompanied by adequate funding to facilitate the acquisition of relevant equipment, reward systems and incentives. Bashir (2013) and Bashir et al. (2015) also supports the current study's findings by identifying lack of incentives as a major challenge to the implementation of lean construction techniques. The major reasons brought forward by Sarhan and Fox (2013) and Bashir et al. (2015) for propagating the lack of incentives is lack of top management support and commitment, which is in agreement with the current study's position. Sarhan and Fox (2013) further maintain that, due to lack of management support, lack of motivation and incentives to professionals is experienced. Unwillingness to invest more funds in training workers on lean construction is also experienced from the management. In as much as the reasons brought forward by Sarhan and Fox (2013) and the current study for the non-commitment of managements to facilitate lean construction differ, the point of convergence is the fact that the lack of adequate incentives results from non-commitment of managements.

The findings of this study also indicate that lack of government support and inadequacies of lean construction did not receive much support from the respondents as a key challenge to the implementation of lean construction techniques. This study found out that only 12% and 4% of the respondents respectively supported the fact that two latter factors were great

barriers to the implementation of lean construction. The study conducted by Bashir et al. (2015) however, presents a contrary view by indicating that the role of government is important to the implementation of lean construction techniques. In light of the governments' intervention in the construction industry, Bashir et al. (2015) identified government policy as a key challenge to the implementation of lean construction. According to Bashir et al. (2015) problems related to government policies such as policy inconsistencies and unsteady commodity pricing significantly impedes the implementation of Lean construction in various countries. The current study's position as opposed to Bashir et al. (2015), in relation to government's policy, is not supported by Jalil et al. (2015). Jalil et al. (2015) found that the lack of specific regulations to control the stakeholders in the construction industry also contributed significantly to the slow implementation of lean construction. In this case, therefore, Jalil et al. (2015) and Bashir et al. (2015) differ with the current study's finding on the role of the government in facilitating or impeding the implementation of lean construction. According to the two latter studies, therefore, comprehensive and consistent government policies are instrumental in facilitating lean construction among firms.

The findings of this study do not bring forward the inadequacies or weaknesses of lean construction as a major challenge to the implementation of lean construction techniques because only 4% of the respondents support it. This therefore means that, in the Saudi context, inadequacies of lean construction do not pose a challenge to the construction industry. This position is however, not supported by the study conducted by Locatelli et al. (2013) which sought to examine the performance of projects with lean construction. Locatelli et al. (2013) found out three weaknesses associated with lean construction that impeded the implementation of lean construction and they included associated training costs, challenge to spread the culture, and the need to overcome the initial resistance. In addition, Nesensohn et al. (2013) also found out sustainability of employees, new partners, understanding of lean thinking, increase of planning effort, and willingness to change were the instrumental weaknesses associated with lean construction hence facilitating its inadequacy. According to Nesensohn et al. (2013), planning efforts would be higher and a higher employee fluctuation would also weaken the implementation of lean construction. The introduction of new partners would also bring forward inconsistencies especially considering the existing number of partners required in construction such as architects, contractors and sub-contractors, engineers, and project managers. Workers are also inclined to falling back to the original daily routine which does not poses any lean approaches and techniques (Nesensohn et al. 2013). In order to reduce the impact of the weaknesses of lean construction, a good communication maturity, willingness to change, existence of a process vision, and top managements' commitment are needed in firms for the establishment of the frameworks that would effectiveness of lean techniques. In this case, therefore, Locatelli et al. (2013) and Nesensohn (2013) differ with the current study's finding that seeks not to support the inadequacies of lean construction as a major challenge to the implementation of the lean techniques.

6. Conclusions

Lean construction can be useful in reducing- if not eliminating- injuries, death and accidents at the construction site. This study has established the benefits of using lean techniques to promote safety and health in the construction industry in Saudi Arabia. However, it is important for practitioners in the industry to invest their attention and resources in training and increasing the knowledge of all the concerned workers on how to effectively implement lean techniques with the aim of eliminating injuries and accidents. In addition, it is important for construction stakeholders to invest in direct safety strategies including having a clear emergency procedure at the site. Practitioners in the construction industry may also benefit by implementing lean construction techniques comprehensively as opposed to using specific components of this methodology.

The use of qualitative and quantitative research approaches provided an in-depth understanding of how lean construction and health and safety practices interact to reduce fatalities and injuries in the industry. However, future studies can further investigate the causal-effect association between lean construction and safety. It is also interesting to explore how introduction and use of other lean technologies, apart from LPS and visualization, can impact on safety and health practices in the construction industry. Finally, this study did not find adequate support for customer dimensions of lean construction methods in promoting

safety and health. It is, therefore, significant for further investigation to specifically ascertain whether this customer satisfaction and value strategies of lean methods is not effective in promoting safety.

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The Key Challenges for Managing Knowledge in the Kingdom of Saudi Arabia Construction Industry: An Empirical Study

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Abstract

The Kingdom of Saudi Arabia (KSA) construction sector is an important industry and contributes approximately 20% of the GDP. It has been the most significant economic activity outside the oil sector. However, uncertainty, complexity, sustainability, climate change, and Saudi Arabia National Policy Plan 2030 are among the most important features of the current construction business environment in the KSA. Therefore, for the KSA construction organisations, the creation of economic value by addressing the above issues now increasingly poses real profound strategic challenges. As organisations try to meet these complex challenges, they need to be innovative. It is widely recognized that knowledge is an essential strategic resource for a firm to retain a sustainable competitive advantage. Therefore, managing knowledge has become significant for today's organisation to meet changes and challenges. Although Knowledge Management (KM) has been widely practiced in the western countries, there is a little evidence in the KSA especially in the construction industry. This paper primarily reports on the empirical findings of an on-going research study, which is focused on managing knowledge in the KSA construction industry for competitive advantage. This paper focuses on the key challenges construction organisations face in managing knowledge en-route to organisational competitiveness. The findings are in the main, based on semi-structured interviews with 46 professionals from 30 construction organisations. The data analysis revealed that, the key challenges organisations facing in managing knowledge are: capturing tacit knowledge, managing stakeholders' knowledge, cultural issues, leadership support, and organisational infrastructure issues. The paper concludes that managing knowledge is an integrated and complex process. More effective knowledge-sharing within and across construction organisations is required. Therefore, the KSA professional institutions and construction industry should support and participate in the work of knowledge-sharing groups to address perceived risks and opportunities from new technologies (e.g. BIM, mobile applications) and processes (e.g. sustainability issues).

Keywords: construction industry, knowledge management, Kingdom of Saudi Arabia, and tacit knowledge.

1. Introduction

The Kingdom of Saudi Arabian (KSA) construction is worth USD 25.3 billion and contributes approximately 20% of the Saudi Arabia GDP and continues to be, the most significant economic activity outside the oil sector (Timetric, 2014). This is particularly important in the Saudi Arabian construction sector as the Saudi Government is making huge investments in its attempt to move towards a knowledge-based society as highlighted in the vision 2030 of the Saudi Arabian National Policy Plan (Al Hussain et al., 2012). Alotaibi et al. (2013) state that large number of mega construction projects being carried out in the Saudi private and public sectors due to rapid economic growth of the KSA. However, uncertainty, complexity, sustainability, climate change, and Saudi Vision 2030 are among the most important features of the current construction business environment in the KSA. There is also a shortage of skilled, experienced local engineers in Saudi Arabia, which is hampering the growth and development of the local construction sector. The strict Suadization measures imposed across the industry resulted in large scale and acute shortage of skilled labour to meet the needs of the growing construction, causing delays in projects for which contracts had been awarded (Ventures, 2015). Therefore, for the KSA construction organisations, the creation of economic value by addressing the above issues now increasingly poses real profound strategic challenges. As organisations try to meet these complex challenges, they need to be innovative.

It is widely recognised that knowledge is an essential strategic resource for an organisation to retain a sustainable competitive advantage. Therefore, managing knowledge has become significant for today's organisations to meet changes and challenges. Specifically with respect to the construction industry, Yu et al., (2013) highlighted the complexity associated with the knowledge-intensive environments of the construction industry where cumulative identity of experiences and knowledge daily differ across engineers, projects and companies.

Khuzaimah and Hassan (2012) pointed out that knowledge must be deliberately and consciously managed in a systematic manner to enable organisations to avoid repetition of costly mistakes, to achieve improved performance and reinvention of wheels. However, the process of managing knowledge in the construction industry is not a simple task and requires thorough planning and preparation. Due to the intrinsic characteristics of the construction industry that is highly fragmented and transient in nature, the success rate of managing project knowledge has been somewhat minimal (Egbu and Robinson, 2005).

Knowledge is a vital resource for construction oriented organisations. In construction projects knowledge is scattered and the pool of knowledge could be lost if there is no proper channel for the knowledge created during the construction phase, for re-use on other projects (Kasimu et al., 2013). The organisation can expand their knowledge base through the application of existing knowledge in the company, along with the new one (Szulanski, 2003), allowing the organisation absorbs the internal and external knowledge and mix them with the pre-acquired knowledge, and creates new one (Cohen and Levinthal, 1990). Even the explicit knowledge can be involved. This can be combined with the internal knowledge which may result in new and exclusive knowledge (Zack, 2002). Therefore, KM can be seen as a tool in order to enhance organisational performance with many academic and practitioners advocating the construction organisational benefits of KM including delivery of projects with quality, shorter design and production times, customer and staff satisfaction and market leadership (Carrillo and Chinowsky, 2006; Suresh et al., 2017). In addition, Teerajetgul *et al*., (2009) emphasised that KM is in fact the formalisation of the admittance in the direction of experience, knowledge and expertise with the aim of creating new capacities, facilitate better quality performance, promote innovation, as well as improve customer worth. Kasimu (2013) acknowledges when experiences, in other words knowledge and skills are properly shared at the right time then the same problems in the construction project do not necessarily need to be solved constantly.

Considering the prevailing and emerging political and economic conditions in the KSA, the Vision 2030 presents several upcoming opportunities for the growth and development of the country. Such opportunities also highlight the need for inculcating effective KM practices within the KSA construction organisations to enhance the skills, ability and knowledge among the employees to be able to take advantage of the growth opportunities increase their profitability and sustainability (Fakeeh, 2016). In this respect, the Vision 2030 emphasises three pillars, firstly, the position of KSA to be central to the Arabian and the Islamic countries; secondly, determination of the country to emerge as a global investment powerhouse and transform the unique strategic location of the country into an international centre that connects the three continents of Europe, Asia and Africa. The focus in these areas opens numerous opportunities of growth and expansion for the organisations, which can capitalise on such opportunities by harnessing knowledge among the employees (Fakeeh, 2016). Thus, KM is proved to be highly essential for the growth of construction organisations of the KSA (Whittom and Roy, 2009). Although KM has been widely practiced in the western countries, there is a little evidence in the KSA especially in the construction industry.

A key challenge for construction managers in the turbulent KSA business environment is cultivating commitment of knowledge workers to the organisational vision. Therefore, managers would need to facilitate the confidence of knowledge workers in acting on incomplete information, trusting their own judgments, and taking decisive actions for capturing increasingly shorter windows of opportunity. Therefore, aim of this research is to investigate the key challenges KSA construction organisations face in managing knowledge en-route to competitiveness.

For the purpose of this research, KM is defined as "a systematic and integrative process of coordinating the organisation-wide activities of mapping, capturing, and sharing knowledge by individuals and groups in pursuit of the major organisational sustainability goals and objectives". Various construction organisations in KSA are engaged in the KM strategies for leveraging knowledge within the organisation and across the value chain. For successful KM

implementation, it is essential for the KSA construction organisations to establish knowledge networks and develop an effective mechanism for knowledge mapping, capturing, and sharing.

2. Research Methodology

The aim of this research is to investigate the key challenges KSA construction organisations face in managing knowledge en-route to competitiveness. In order to achieve this aim, a robust methodology was considered essential. Tutt et al (2012) noted that research methodology in social enquiry refers to far more than the methods adopted and encompasses the rationale and philosophical assumptions that underlie a particular study. These, in turn, influence the actual research methods that are used to investigate a problem and to collect, analyse and interpret data. Therefore, the choice of research methodology is a crucial and difficult step in the research process. Given the complexity of KM issues and the paucity of comparable research in the KSA, qualitative research methodology was adopted.

According to Bryman and Bell (2015), the qualitative method tends to be concerned with words rather than numbers. The findings of qualitative research are focused acknowledging the qualities of phenomena rather than their mathematical measurement. The qualitative method covers the subject of study holistically. Bernard (2006) noted that data gathering is crucial in research, as the data is meant to contribute to a better understanding of a theoretical framework. Primary data was collected through semi-structured interviews. Indeed, semi-structured interviews were selected, due to flexibility they afford whilst still allowing detailed responses between the interviewer and the interviewee (Smart et al., 2014). To ensure greater dependability and transferability (Creswell, 2014), a total of 46 professionals from 30 KSA construction organisations were interviewed. A purposive sampling technique was used in order to achieve representativeness. The purposive sampling technique, also called judgment sampling, is the deliberate choice of a participant due to the qualities the participant possesses. The study sample included directors, advisers and managers responsible for KM strategies implementation in their respective organisations.

The interviews took place between the months of July 2016 and February 2017 and were recorded with prior authorisation of respondents in an iPhone handset and supplemented with field notes as appropriate. The format of these interviews was face-to-face. The interviews lasted between 30 and 90 minutes, with later transcription of the entire content of the interviews. The analysis of the interviews was undertaken using Content Analysis. Fraenkel and Wallen (2003) noted that content analysis is a study of textual messages of human behaviour in an indirect way. This helps researchers generalise findings, predict the future, understand attitudes, values and cultural patterns of an organisation or an industry or a country.

In the study, coding of the transcribed documents involved open coding of meaning units, that is, words, phrases, sentences, paragraphs, which essentially involved labelling concepts. The emerging concepts were mapped into themes. Threats to validity were minimised through triangulation of data collection methods (interviews, internal and external documents) and verification of the initial thematic codes by participants, where they judged the accuracy of data collected, though not its conclusions. The unit of analysis adopted for this study was the KSA construction industry, and the embedded unit of assessment was the 'individual employee'.

3. The key challenges KSA construction organisations face in managing knowledge

Table 1 presents five key challenges the KSA construction organisations face in managing knowledge as revealed by those interviewed in the current study. From the data in Table 1 it is evident that the single most important challenge is capturing tacit knowledge. This is followed by managing stakeholders' knowledge, cultural issues, leadership support, and organisational infrastructure issues. Each of these challenges is discussed in detail below.

Table 1 The key challenges KSA construction organisations face in managing knowledge.

Challenges face in managing knowledge	Total number of interviewees cited (N=46)

Capturing tacit knowledge	91%
Managing stakeholders' knowledge	87%
Cultural issues	83%
Leadership support	80%
Organisational infrastructure issues	76%

3.1 Capturing tacit knowledge

In this study, overwhelmingly 91% (42 of the 46) of the interviewees cited that capturing tacit knowledge is one of the key challenges for the KSA construction organisations. The construction industry is one of the critical industries that operate in an information-rich environment, which relies heavily on tacit knowledge as one of the strategic resources to ensure the tasks associated with the domain can be performed effectively and efficiently by the project team members (Egbu and Robinson, 2005). The tacit knowledge is normally defined as the personal knowledge which is difficult to be: formalised, written down, explained and described. In contrast of the tacit is the explicit knowledge which can be easily to formalised and described, which means it is easily transmitted between people (Nonaka, 1994). In the same vein Hariharan (2015) supported this view defining the tacit knowledge is normally managed by experts due to is difficult nature to document and share with others. In broader perspective Gerami (2010) also shared the same opinion, pointing out that, this type of knowledge is normally in peoples mind, obtained through their experiences. For practitioners, tacit knowledge remains largely problematic in terms of methods of mapping and capturing. The view has emerged that the challenge of KM is to understand how to create practical solutions to support individuals, groups and organisations as they generate and capture multi-faceted knowledge so as to suit the particular requirements of their application context. Because tacit knowledge is difficult to write down or formalise, it is personal knowledge, it is practical, and it is context-specific. Lack of time, lack of knowledge capture techniques, lack of culture, and lack of rewards are highlighted as some of the main concerns. For instance, one of the interviewees stated that:

"Certainly we cannot do the business without knowing specific knowledge related to BIM initiatives. Knowledge related to BIM initiatives resides in our stakeholder's and employee's heads. However, we have not yet found a magic way of managing that knowledge".

Aforementioned view of the interviewee clearly suggests that managing tacit knowledge-related to BIM initiatives is a daunting task for any organisation. It is apparent from the above results that managing tacit knowledge is more difficult to formalise, impart, exchange, or purchase because it resides in peoples' beliefs, experiences, values, organisational routines, and institutions. For example, in construction site safety, safety hazard recognisation is an important actualisation of tacit knowledge. Safety hazard knowledge is considered as a tacit knowledge because it relies on the safety engineer's experience. Therefore, tacitness of knowledge is a natural barrier to the successful sharing of knowledge between individuals in organisations.

3.2 Managing stakeholders' knowledge

In this study, 87% (40 of the 46) of the interviewees stated that managing stakeholders' knowledge, in particular capturing and sharing stakeholder's knowledge is most important challenge their organisations face. This may be due to an organisations limited control over behaviours of stakeholders and certain stakeholders could simply have irreconcilable differences with one another based on ethical, religious, cultural, social or other issues. When the unique knowledge of various stakeholders is pooled and used to solve corporate problems, however, new practices and strategies emerge that benefit all constituencies – just as entrepreneurship is recognised as the source of economic progress. It is evident from the above result that managing stakeholders' knowledge is one of the most important challenges

for the KSA construction organisations. For instance, implementing BIM, social network, or sustainability issues requires the recognition of a wide range of stakeholders, including secondary ones that are not directly involved in a market relationship but can still greatly affect a company's business. Stakeholder ambiguity is caused when key stakeholders often have disparate goals, demands and opinions, they can easily interpret the same situation differently, especially when the information and knowledge necessary to make informed decisions is limited. Hence, managing stakeholder's knowledge is important challenges for KSA construction organisations.

3.3 Cultural issues

In this study, 83% (38 of the 46) of the interviewees noted that national and organisational cultural issue is another key challenge their organisations are facing in managing knowledge. Organisation culture and leadership forms the foundation for successful KM implementation (Kim*, et al.*, 2003). For instance, a culture of knowledge sharing has to be formed to transform the behaviours and attitudes of individuals working in the organisation as well as to cut down barriers (Bolisani and Handzic, 2014). Therefore, it is necessary to increase awareness of the advantages of KM. Staff and managers are supposed to be well informed about the changes and benefits that KM can offer them as well as their organisation. Although they feel and acknowledge the power of knowledge, they have to believe in the power of sharing knowledge (Bolisani and Handzic, 2014).

Arif et al. (2015) argued national culture as one of the major barriers to effective KM practices. However, Magnier-Watanabe and Senoo (2008) found organisational characteristics to be a stronger prescriptive factor in KM compared to national culture. De Long and Fahey (2000) suggested four ways in which culture affects the behaviours central to knowledge creation, sharing and use. First, culture shapes assumptions about what knowledge is and which knowledge is worth managing. Second, culture identifies the relationships between individual and organisational knowledge, determining who is expected to control specific knowledge, who must share it and who can store it. Third, culture shapes the processes by which new knowledge is created, legitimised and distributed in firms. Fourth, culture creates the context for social interaction that determines how knowledge will be used in particular situations.

Serna (2015) suggested that knowledge should be managed along with the human experience of knowledge itself and that proper management of such knowledge is required. Hofstede (2001) suggests that there would be a significant impact of culture on management practices and processes. Therefore, it is important to incorporate the cultural aspects in the future training programmes related to KM in the KSA construction industry.

The absence of active management involvement is likely to mean that the KM process will be handicapped by insufficient time, finance and human resources. Many interviewees in this study noted that their organisations do not have any monetary or non-monetary incentives as rewards for KM initiatives. The lack of rewards combined with the low level of assessment as part of annual performance reviews could perhaps hinder KM practices. It is generally believed that management support and organisational culture are critical factors for successful deployment of KM initiatives. Therefore, organisations must create new job roles, reward systems, and specific training programmes to promote KM initiatives in the KSA construction industry.

3.4 Leadership support

In this study, 80% (37 of the 46) of the interviewees stated that leadership is a key success factor for effective implementation of KM initiatives in their organisations. Many interviewees noted that leadership in the KSA construction organisations is of great importance because it deals with knowledge workers, with specialised expertise. Leading them can be done only through intellectual power, conviction, persuasion, and interactive dialog. It requires skills that build confidence and engagement.

From a strategic perspective, management and leadership skills include the capacity to demonstrate a purpose-driven leadership and the ability to provide strategic leadership through the development of knowledge based models. Moreover, there is a need to implement KM strategies and plans across various levels. In this study, interviewees noted that the ability

to set direction, create alignment, and maintain commitment toward the idea of knowledge based organisation is a key leadership skill gap in their organisations. The ability to align business goals with knowledge based targets and objectives are a desired capability, as is the capacity to develop return on investment for all stakeholders. Most often cited leadership skill gaps identified by the interviewees include: development of the KM vision and mission; active promotion of a knowledge agenda including the creation and diffusion of KM models, frameworks and language; the design, implementation, and oversight of the creation and development of organisation's knowledge architecture and infrastructure; prioritising funding for KM programmes; the establishment of knowledge culture; and creating reward systems.

3.5 Organisational infrastructure issues

In this study, 76% (35 of the 46) of the interviewees noted that the implementation of information and communication technology (ICT) tools to facilitate KM is an issue for their organisations. In today's knowledge economy, rapid access to knowledge is critical to the success of many organisations. Therefore, appropriate technology is likely to be the single most important factor in leveraging knowledge in organisations. Massingham (2014) asserts that KM tools are able to collect data from various sources and classify, integrate and codify these data. Davenport and Prusak (1998) assert that KM tools are more than information technology it is about the people who add value by transforming static data into meaningful information and knowledge by mixing it with their own experience and interpretations. Therefore, Davenport and Prusak (1998) acknowledge that KM techniques and technologies are mutually dependent.

Massingham (2014) suggests that KM tools make it possible to retrieve and reveal knowledge and can also be employed in order to disseminate knowledge among staff. Pfeffer et al. (2013) state that KM tools are technologies that facilitate KM sub-processes such as codification and knowledge transfer. Alternatively, Massingham (2014) suggests that the terms 'KM tools' and 'KM techniques' are interchangeable and believe that KM techniques are simply the means through which knowledge is managed using tools.

4. Conclusions

Knowledge in organisations is dynamic in nature and is dependent on social relationships between individuals for its creation, sharing, and use. Managers would continue to strive for productivity, innovation, profitability, and other competitive goals, but they would do so more effectively by harnessing the key knowledge assets. This paper has highlighted some of the key challenges KSA construction organisations face in managing knowledge. The key challenges KSA construction organisations face in managing knowledge, as revealed from the study, are: capturing tacit knowledge, managing stakeholders' knowledge, cultural issues, leadership support, and organisational infrastructure issues. The paper concludes that managing knowledge is an integrated and complex process. This involves social, cultural, financial, and technological considerations. Furthermore, the KSA construction industry needs to work more collaboratively with its stakeholders. There is a need for developing a new co-value creation business models and use of collaborative knowledge sharing platforms, but also by a need to overcome shared risks and realise long-term outcomes. More effective knowledge-sharing within and across construction organisations is also required. Business memory is lost as project teams break up toward the end of a project, or when people move on from short term contracts. Opportunities to reflect on lessons which could benefit future projects are missed in the KSA construction industry. Therefore, the KSA professional institutions and construction industry should support and participate in the work of knowledge-sharing groups to address perceived risks from new technologies (e.g. BIM, mobile applications) and processes (e.g. sustainability issues).

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Construction Claims, Avoidance and Management

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Abstract

Construction activity continues to play its role as one of the principal economic indicators and regulators, more so in a sustainable environment, and therefore the need arises to investigate the principal issues that may affect its efficiency, deliverability and improve its performance. This paper intends to review and identify the main causes of construction disputes and the best ways to avoid claims and/or minimize their implications. The paper will highlight the typical risk areas that may give rise to potential claims, whether of time and/or cost, in addition to other claim issues resulting from insufficient knowledge, misunderstanding and non-adherence to the relevant contractual clauses; and Laws of the land or the contract. The paper will include references to a number of relevant issues related to the preparation and management of claims, in addition to a brief review of the alternative dispute resolution procedures which was implemented in this region several years ago.

Keywords: Construction claims, Sustainability, Disputes, Risks, FIDIC.

1. Introduction

This study intends to review the concepts of claims avoidance and claims management and to describe relevant factors that relate to it, with particular emphasis on experience in the Gulf region. The concept of 'claims avoidance' is to identify the principal causes of claims and to implement strategies in attempt to avoid the cause of claims. The concept of 'claims management', on the other hand, relates to a number of issues and actions, including;

- The receipt and acknowledgment of claims;
- Tracking of claims;
- The achievement of compliancy with the Contract;
- The assessment of claims and entitlement; and
- Determination following consultation and disputes.

2. Principal Timing and Causes of Claims

The main causes of claims predominantly relate to insufficient knowledge, understanding and adherence to the Contract, including key provisions relating to notification, time and cost management and changes/variations to the Contract.
Generally, the timing of claims may fall into three different categories dependent on the stage of the work, as follows:

- Pre-Tender stage;
- Tender stage; and
- Post-Tender stage.

During Pre-Tender stage, issues relating to the Contract Conditions and the misinterpretation of certain provisions can result in potential claims. Documents such as the Invitation to Tender (ITT), and the like, should correctly be incorporated into the Contract Documents. If this is not achievable, then all of the appropriate tender queries/responses/clarifications and addendum which amend the ITT documents must be incorporated into the Contract Documents. Claims during this stage may also arise due to:

- Insufficient pre-qualification methodology to select the best design and suitable tenderers.
- Unsuitable procurement and contract strategy;
- Use of inappropriate or heavily amended standard set of Contract Conditions;

- Lack of specific and measurable targets with reasonable timescales listing specific and achievable targets or scope of work;
- Lack of firm decision on activities of works, which are to be awarded separately to other contractors; and
- Use of poorly defined Provisional Sums.

During Tender stage, claims may arise from the following:

- Poor communication between all parties throughout the pre-tender stage; and
- Incomplete Contract documentation, including:
  - Inconsistencies between the Conditions of Contract and the Particular Conditions of Contract, BoQs and the Specifications;
  - Incomplete design and design drawings;
  - Incomplete or missing price adjustment formulae in the Appendix to Tender;
  - The absence of relevant provisions dealing with exceptional price escalation – this may present an opportunity for contractors to claim under the Civil Code of the relevant country in the region.

At Post-Tender stage, claims avoidance can be achieved through implementation of the following:

- Clearly identified roles, responsibilities and goals within the Project Management Team;
- Maintenance/updating of a key role/responsibility register, tracking the actions achieved or any failures to achieve objectives for the avoidance of claims;
- The establishment of tools, protocols, guidelines and training in attempt to avoid other claims that may arise.

The key causes of claims can include:

- The Conditions of Contract generally, including:
  - Insufficient knowledge and understanding of the Contract;
  - Delays caused by late handover of the site;
  - Delays caused by time taken to obtain approvals or NOCs from local authorities;
  - Late issuance of construction drawings;
  - Late release of bank guarantees;
  - Late payment (advance, interim and final) which may trigger claims for payment of interest;
  - Failure to apply the contractual requirements to reduce the value of the guarantees in accordance with the progress of the works;
  - Changes by the Employer in the scope of work or the design.
  - Delay caused by others (Employer or Nominated Vendors and Sub-Contractors);
  - Awarding part(s) of the original scope to others without following the correct contractual procedure; and
  - Failure to notify the Contractor of the Employer's intention to apply Delay Penalties.
- Time and cost management, including:
  - Failure to agree on a realistic completion date and Baseline Programme;
  - Failure to ensure the timely submission of updated programmes;
  - Failure to assess the effects of delay events as they occur;
  - Failure to maintain proper record of events causing delay to the Works and failure to identify the causes thereof;
  - Failure to keep proper daily records of resources (manpower and equipment) utilized on site;
  - Failure to ensure that time and cost schedules provide the scope of all other vendors/subcontractors, nominated by the Employer;
  - Failure to assess the impact of events causing delay to the Works using a reliable delay analysis methodology; and
  - Failure to assess prolongation costs following the award of an extension of time for completion.
- Variations and change management:
  - Failure to provide instructions and information in relation to design and construction issues in a timely manner;

- Failure to formalize verbal instructions with written instructions, as required by the Conditions of Contract;
- Failure to promptly confirm Variation Orders, as required by the Conditions of Contract; and
- Failure to formalize a standard format for Site Instructions and Variation Orders, to avoid uncertainty.

3. Identification of the Primary Composition of Claims

In order to identify the primary composition of claims submitted by contractors on major government contracts in this region, the writer carried out an extensive study covering considering three hundred claims submissions over the last thirty years. The study concluded the following list of common heads of claim in descending order, by value:

- Prolongation
- Material price Escalation
- Finance charges
- Delay in payment of certified sums
- Loss of opportunity costs
- Variations and Change Orders
- Delay damages
- Deductions/ set-off
- Disruption
- Delay in releasing guarantees
- Claim preparation costs
- Miscellaneous

The figure below shows the proportions of each of the main claim heads covered in this study, including the head "Miscellaneous" which covers minor and rarely used heads of claim:

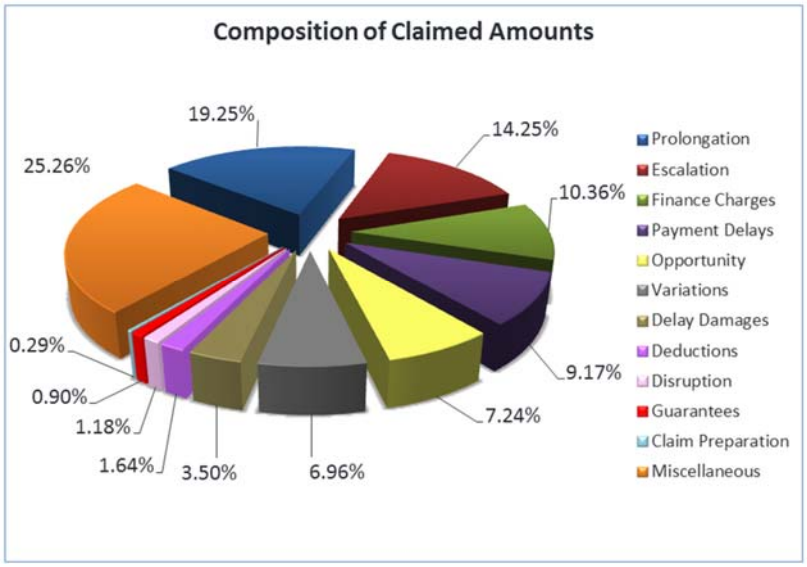

Figure 1 The proportion of claim heads covered in this study.

4. Claims Management

4.1 Introduction to the claims management process

The claims management process is reliant upon the 'principal documents' detailed below, that bind all parties to a construction contact together (i.e. the Employer, Engineer and Contractor) by setting out rights, obligations and actions. These are required to be complied with fully, timeously and with the intent expressed in the documents.

For the Employer and the Engineer, the 'principal documents' are the Employer/Engineer Consultancy Agreement and the Conditions of the Construction Contract. For the Contractor, the principal documents are the Conditions of the Construction Contract.

Careful drafting of both documents is crucial for effective claims management, so that contradictions, inconsistencies and the like are avoided. Unfortunately, it is often the case that contradictions and inconsistencies arises, and this can detract from the efficient management of claims and at time the progress of the Works. It is not unusual for the Engineer's authority and power under the Consultancy Agreement to be different to the express power provided to him under the Main Contract leading to confusion as to the Engineer's power to bind the Employer.

4.2 The Contract as the main tool of the project manager and its team

4.2.1 The Receipt and Acknowledgement of Claims

Under normal circumstances, claims for additional time and/or money are received from the Contractor via the project document control system and the receipt of claim documentation may fall into two categories:

- Receipt of a Notice of Claim; and
- Receipt of detailed particulars of the Claim on an interim or final basis.

Most forms of Contract require the Contractor to submit notice of the intention to submit a detailed and particularized claim within a specified time period from the recognition that an 'event' has occurred which has or is likely to result in delays to completion date or the incurrence of additional costs to the Contractor.

Upon submission of the notice by the Contractor, the Engineer should acknowledge receipt, but within the obligation to accept any liability of the Employer, and confirm whether he wants the Contractor to keep particular contemporaneous records of ongoing claims.

4.2.2 Tracking of Claims

This is best achieved by the creation of a 'Claims Register', a typical example is provided in table No. 1 below, where;

- Column 1 records the claim reference number;
- Column 2 records the title/description of the claim notice/submission;
- Column 3 records the 'event' date; (*It is important to check this 'event' date. In some cases a Contractor may claim a later date than actual, to avoid the risk of being 'time – barred')*;
- Column 4 records the receipt date by the Engineer of the Contractor's claim notice; (*It is important to check that the time between the 'event' date and the Notice receipt date does not exceed any specified time limit within the Contract)*;
- Column 5 records the Contractor's mail reference/transmittal reference no.;
- Column 6 records the Engineer's required response date to the notice submission; (*This may be a specified requirement of the Contract or in the absence of this, a self-imposed requirement by the Engineer e.g. 7 days).*
- Column 7 records comments as appropriate;
- Column 8 records the Engineer's letter of acknowledgement of receipt of the Contractor's notice of claim. (*This letter of acknowledgment should either:-*
    - *confirm receipt of a compliant and thus acceptable Notice of Claim OR*
    - *Confirm the Notice is non- compliant, unacceptable and thus rejected - dependent upon the Conditions of Contract.)*
- Column 9 records the due date of the Engineer's response to a Contractor's submission of detailed particulars of Claim. In Exhibit 3, this is shown as 42 days, but this may vary dependent on the Contract;
- Column 10 records the date of the Engineer's letter requesting further and better particulars - this may vary dependent on Contract; and
- Additional Columns can be added to cover such matters, as subsequent submissions and responses. (Not shown in the table below).

- The use of a Claims Register is an essential tool in the management of claims in that timely notices can serve as early warning to the Engineer and the Employer. It can also assist in the 'red- flagging' of any non-compliance by the Contractor.

Table 1 Claims Register.

HKA Global limited

Notices & Claims Tracker

1	2	3	4	5	6	7	8	9	10
			CLAIMS NOTICE - (CONTRACTS DEPT)					CONTRATORS	
C No	DESCRIPTION	Date of the Event	Rec'd	Ref	RESPONSE REQ BY	Resp *	ENGINEER-LETTER Acknowledgement of receipt	Due	Engs Letter of requesting Detailed Particulars
	Project Title	a	b		c = b + 7			d = a + 42	
7879	Second Interim Claim for Extension of Time for Events up to 28 May 2012	24-Dec-12	CCCTAVJV-TRANSMIT-0033699	Contractors' claim submission does not reference a specific notice of claim letter but relies upon 50+ events described in the particulars. As such this claim cannot be referenced against any one notice of claim.					
	Second Interim Claim for Additonal Payment Arising From Extension of Time for Events up to 28 May 2012	24-Dec-12	CCCTAVJV-Transmit-047641	Contractors's claim submission does not reference a specific notice of claim letter but relies upon the events in its 'Second Interim Claim for Extension of Time for Events up to 28 May 2012'. As such this claim cannot be referrenced against any notice of claim.					
382	Re-Location of Batching Plant (Letter Ref: DMIA/MC1/HI/CW/10250)	03-Mar-14	10-Mar-14	CCCTAVJV-TRANSMIT-060901	17-Mar-14		8589	14-Apr-14	
381	Notice of Claim: Surge Vessels for Potable Water System in NDA (Letter Ref: DMIA/MC1/HI/QS/10226)	24-Feb-14	02-Mar-14	CCCTAVJV-TRANSMIT-060543	09-Mar-14		8321	07-Apr-14	
380	Notice of Claim – Engineer's Instruction 706 (Improved Sub-Grade around Antenna + Localizer) (Letter Ref: DMIA/MC1/HI/QS/10194)	03-Feb-14	24-Feb-14	CCCTAVJV-TRANSMIT-060255	03-Mar-14		8282	17-Mar-14	
379	Notice of Claim – Engineer's Instruction 715 (Concrete Repairs to Soffit of Bridge 186) (Letter Ref: DMIA/MC1/HI/QS/10195)	03-Feb-14	24-Feb-14	CCCTAVJV-TRANSMIT-060257	03-Mar-14		8281	17-Mar-14	
360	Notice of Claim: Relocation of Rotunda Bases and Setting Out of Anchor Bolts (Letter Ref: DMIA/MC1/HI/QS/10095)	22-Dec-13	09-Feb-14			TB			
359	Additional Works to Engineer's Instruction 587 (Letter Ref: DMIA/MC1/HI/EL/10073)	28-Jan-14	05-Feb-14	CCCTAVJV-TRANSMIT-059690	12-Feb-14		7736	11-Mar-14	DRAFT-029906
358	Notice of Claim: Revision to Levels Between Buildings 411 and 413 (Letter Ref: DMIA/MC1/HI/QS/08974)	30-Jun-13	04-Jul-13	CCCTAVJV-TRANSMIT-053263	11-Jul-13		7734	11-Aug-13	7735
357	PAPI Units - Northern Runway (Letter Ref: DMIA/MC1/HI/AP/10093)	29-Jan-14	04-Feb-14	CCCTAVJV-TRANSMIT-059662	11-Feb-14		7660	12-Mar-14	
356	Notice of Claim: Approach Lights at Sta. 4+680 and Sta. 4+710 (Grid 510) (Letter Ref: DMIA/MC1/HI/QS/10088)	30-Jan-14	05-Feb-14	CCCTAVJV-TRANSMIT-059672	12-Feb-14		7659	13-Mar-14	
355	Notice of Claim: Employer's Use of SPS-4 and its Associated Works (Letter Ref: DMIA/MC1/HI/QS/10063)	26-Jan-14	05-Feb-14	CCCTAVJV-TRANSMIT-059697	12-Feb-14		7657	09-Mar-14	8519
354	Notice of Claim: Adjustment to Threshold Markings (Letter Ref: DMIA/MC1/HI/QS/10076)	23-Jan-14	04-Feb-14	CCCTAVJV-TRANSMIT-059626	11-Feb-14		7546	06-Mar-14	8516
353	Notice of Claim: Location of Aiming Point at Runway 08L and 26R (Letter Ref: DMIA/MC1/HI/QS/10041)	20-Jan-14	28-Jan-14	CCCTAVJV-TRANSMIT-059437	04-Feb-14		7434	03-Mar-14	8319
352	Notice of Claim: Firefighting and Potable Water Chambers at Grids 508, 609 and 708 (Letter Ref: DMIA/MC1/HI/QS/10045)	20-Jan-14	28-Jan-14	CCCTAVJV-TRANSMIT-059439	04-Feb-14		7435	03-Mar-14	8320
351	Notice of Claim: Loop Out of Cables at Air Side Ring 2; 11kV Substations SS-CB and SS-19 (Letter Ref: DMIA/MC1/HI/QS/10044)	23-Jan-14	28-Jan-14	CCCTAVJV-TRANSMIT-059441	04-Feb-14		7433	06-Mar-14	8514

4.2.3 The Assessment of Claims – Entitlement

A Contractor's entitlement to an extension of the Time for Completion and/or payment of additional costs is solely reliant upon the proper and timely compliance with the terms of the Contract. Most of the widely used Contract forms clearly set out the conditions, which must be met by the Contractor for it to qualify for entitlement to a claim. The following represents the most commonly used examples:

For additional TIME:

- a Variation or other substantial change in the quantity or quality of an item of work included in the Contract;
- a cause of delay giving an entitlement to an extension of time under a Sub-Clause of the Conditions of Contract;
- exceptionally adverse climatic conditions;
- unforeseeable shortages in the availability of personnel or goods caused by epidemic or governmental actions; and
- any delay, act of impediment or prevention caused by or attributable to the Employer, Employer's personnel, or the Employer's other Contractors.

For additional TIME & MONEY:

The following is a typical requirement (this being an extract from Clause 20.1 (Contractor's Claims) of the FIDIC 1999, First Edition ("Red Book") :

"If the Contractor considers himself to be entitled to any extension of the Time for Completion and/ or additional payment, under any Clause of these Conditions or otherwise in connection with the Contract, the Contractor shall give notice to the Engineer, describing the event or circumstance giving rise to the claim. The notice shall be given as soon as practicable, and ***not later than*** *28*

days after the Contractor became aware, or ***should have become*** *aware, of the event or circumstance".* (**Emphasis added**)

The foregoing can be described as a 'condition precedent' clause. Should the Contractor fail to comply with the notice requirements of the Contract, it may have 'waived its rights' to any entitlement(s) for an extension of Time for Completion and/or additional payment. In which case the Employer can use this a complete defence to the Contractor's claims and the Engineer may consider rejecting the Claim on this basis. This is, of course, dependent upon the specific Conditions of Contract applicable to each individual case.

5. Award of extension of time

On the assumption that the Contractor has clearly established a contractual entitlement to an award of extension of Time to Completion (EOT) and that the Engineer is satisfied with this, the next step is to determine the extent of the EOT.

Whilst the conditions for determining the extent of an award of EOT may vary from one Contract to another, the following criteria are generally used:

- the existence of an actual and contractually compliant Claim for EOT from the Contractor;
- agreement of a Baseline/Contract Programme and any/all agreed contractual revisions thereto;
- clearly identified primary delay events and establishment of cause & effect;
- clearly established and identified concurrent and non-concurrent periods of culpable delay; and
- clearly established and identified Contractor culpable delay periods, if applicable.

A forensic delay analysis can then be undertaken to determine the effect of the cause(s) of the delay incurred by the Contractor to the Completion Date and the extent to which these delays are compensable to the Contractor (in terms of payment of prolongation costs).

6. Payment of associated additional costs

Payment of additional costs (with or without profit, overhead, etc.) are usually determined from the following substantiated and audited data:

- Salaries & wages payroll and site attendance records;
- Petty cash ledger;
- Purchase ledger – materials & consumables;
- Internal & external plant hire ledger;
- Sub–contract, Consultants & External Bodies (Laboratory etc.) Ledger; and
- Purchase acquisition sheets, Purchase Orders, Payment Advice & Sub-Contract Orders/Agreements.

Payment may fall into the following different categories**,** dependent upon the form of Contract applicable:

- Extended Contract 'Preliminaries' during the net period of EOT;
- Increases in the levels of overhead staff mobilized;
- Acceleration costs (weekend and extended day time working hours);
- Disruption;
- Increased costs of labour, plant & material in the extended period {if a Fixed Price Contract};
- Increased Sub-contractor costs;
- Under recovery of off-site and on-site overheads;
- Claim preparation costs; *(not generally recoverable)*
- Lost opportunity costs; and
- Profit.

7. Determination following Consultation and Disputes

Most of the Contracts in use provide for the Employer, Engineer and Contractor to consult in an endeavor to agree the Engineer's proposed determinations in respect to time and cost, an example being the following extract from FIDIC Red Book, First Edition 1999:

Clause 3.5 – Determinations:

". . . the Engineer shall consult with each Party in an endeavour to reach agreement. If agreement is not reached, the Engineer shall make a fair determination in accordance with the Contract, taking due regard of all relevant circumstances."

It is prudent to ensure that the consultation meetings, which can be bipartite or tripartite, are minuted, 'signed–off' by all parties and then distributed. In the event that either Party disagrees with the Engineer's determination, then either Party may, dependent upon the Contract, elect to dispute the Engineer's determination. In such cases, the resolution of a dispute can progresses in accordance with the Contract, and will likely involve resolution through some or all of the following:

- Request for an Engineer's Decision;
- Issuance of Notice of Dispute or Dissatisfaction;
- Appointment of Dispute Adjudication Board;
- Issuance of further Notice of Dissatisfaction;
- Amicable Settlement; and
- Arbitration or Litigation.

It is noted that some Contracts allow for the commencement of Arbitration proceedings prior to the completion of the Works whereas others require completion of the Works prior to commencement of Arbitration.

8. Alternative Dispute Resolution

In the Emirate of Abu Dhabi, UAE, an alternative route to resolve construction disputes has been in place for the last thirty years, whereby an independent professional body, appointed by the Executive Council of the Emirate, (the "Claims Committee"), was appointed and commissioned to carry out the necessary assessment and evaluation of all claims referred to it by the Executive Council. The process covered all claims raised by any of the Contractors or Consultants, against government entities, thereby avoiding the Litigation or Arbitration. Following detailed assessments, the Claims Committee would submit its study and recommendation to the Executive Council who had authority to settle the dispute and bind the Employer. During this period and through this procedure, hundreds of claims were reviewed, assessed and ultimately settled, saving time and cost to all parties.

9. Recommendations and Lessons Learned

The following recommendations and 'lessons learned' are listed herein for further consideration:

- Perform and establish a pre-qualification process and register competent contractors and consultant in different domains;
- Standardization of the form of contract and minimize amendments thereto;
- Establish a comprehensive contract review process to ensure that the Contract documents are thoroughly completed and compatible, before the Contract is signed;
- Avoid signing a Contract until the design and construction drawings are complete;
- Ensure that Project's site teams are appropriately resourced (in term of number and level of experience) in relation to the size and nature of the project;
- Develop and implement a standard document control system to all projects, for record keeping of time and cost for all resources throughout the construction process;
- Coordinate the works of all working groups on the same site location, to avoid claims and counter claims by different parties; and
- The Governments in the region may consider setting up their own arrangement for an alternative Dispute Resolution procedure, to save time and cost inevitably incurred by following the existing dispute resolution procedures.

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Regeneration of Natural Pasture in the Rangelands of Jig-Jiga District, Somali Regional State

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Abstract

A study was conducted in Jig-jiga district of the Jig-jiga Zone, Somali Regional State, with the objectives of investigating species composition and diversity of the vegetation cover, the composition and density of plant species in the soil seed bank and assesses the regeneration capacity of the vegetation. A single visit survey was conducted in the study area to document the pastoralists & agro-pastoralists' perceptions on overall livestock and rangeland management practices through visual observations, group discussions and structured questionnaire. A total of 45 quadrats each measuring 20m×20m (400m2) were laid out randomly in 9 sample sites from three corresponding land use types (i.e. twenty years enclosure, five years enclosure and communal grazing land).

There was significant ($P<0.05$) difference for soil erosion and compaction between the land use types & high degree of soil erosion and compaction exhibited in the open gazing land use. The study also revealed that significant ($P<0.05$) variation occurred between land use types in grass species composition, basal cover, age category, and herbaceous species richness.

The present study revealed that, the two enclosures land use type in the Jig-jiga rangeland have shown relatively higher level of soil and vegetation cover, woody species regeneration potential and soil seed bank flora. Therefore, expansions of enclosure with proper grazing management and planting of native flora seedling are recommended for improvement of the Jig-jiga rangeland.

1. Introduction

Rangeland is the largest land use system on earth. It constitutes some 35 million km^2 of the earth's surface, with the majority in developing countries and some 65% (almost 22 million km^2) of this in tropical Africa. Over 180 million people in the developing world depend for their livelihood on this system, with just over half of them living on less than two dollars per day and a quarter on less than one dollar per day (Thornton *et al*., 2002).

Rangelands occupy many arid and semi-arid parts of the world where precipitation is insufficient to support growth of forage and also insufficient to regularly produce cultivated crops. Because production is strongly driven by precipitation, which is often erratic and variable, production of forage is also highly variable between years and these may be far from equilibrium for much of the time (David, 2003). Generally, large year-to-year variability of precipitation makes rangelands unsuitable for crop production, and livestock grazing presents a sustainable means of food and fiber production.

Despite the large size of the Somali regional livestock population, its economic contribution to the regional and national economy is not significant, mostly due to natural and human limitation (Amaha, 2006). The latter include the impacts of environmental and rangeland degradation (Gemedo-Dalle*et al.,* 2006), increasing aridity and the occurrence of recurrent droughts at shorter intervals of every third year, causing feed and water shortages. As a result, there are high livestock mortalities in most pastoral areas (Amaha, 2003).

The specific objectives of the study were to:

- Assess the pastoralist and agro-pastoralist perceptions towards range-livestock management practices;
- Investigate the species composition and diversity of the natural pasture, and
- Evaluate the relationship between the regeneration of natural pasture and the soil seed bank flora.

2. Materials and Methods

2.1 Description of the Study Area

2.1.1 Location and area coverage

Jig-jigadistrict is one of the seven Districts of Jig-jiga Zone and it is located at the North-eastern part of Somali Region. It is a part of Wabisheble river basin. The district is situated in the northern part of Somali Regional State and borders in the east with Kebribeyah district, in the west with Oromia regional state and Bombas district of SRS, and in the south with Fik Zone of SRS. The total land cover is 40,861 km^2 of whichthe rangeland extends over 36, 629 km^2 (World Bank, 2001).

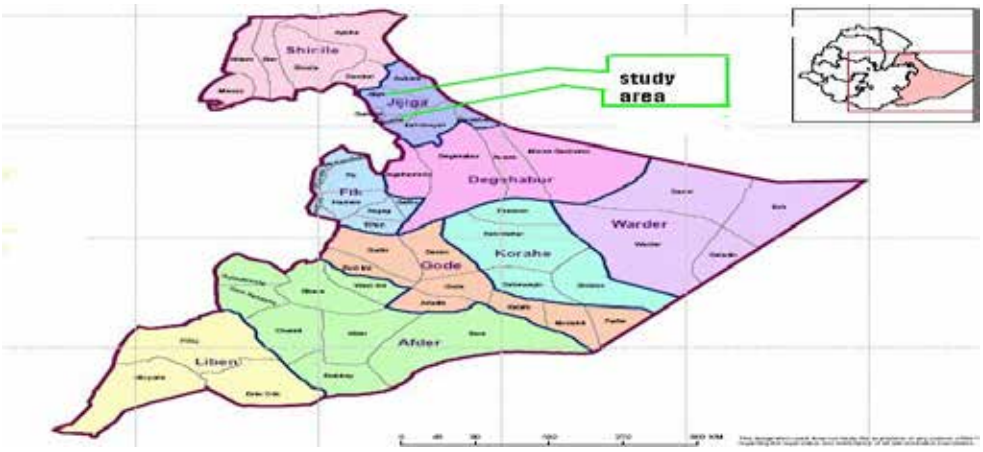

Figure 1 Map of the study area.

2.2 Data collection and survey procedures

Primary and Secondary information on range-livestock management practices of the two community groups that follow different livelihood (pastoral and agro-pastoral) was collected from all possible sources and further studied through group discussions and personal observations during the field work. Group discussions were held with elders, community leaders, and district officials to extract information on management practices of range - livestock and to get insights from community members who are directly or indirectly involved in the production system. Stratified random sampling procedure was followed to identify the pastoral and agro-pastoral households. A total of 60 households were randomly selected (each 30 from pastoral and agro pastoral). A single-visit formal survey method (ILCA, 1990) was followed for data collection.

Figure 2 Data collection from respondents during Survey in study area.

2.3 Vegetation and soil sampling

The field study for the species composition, diversity of the enclosure & communal grazing lands vegetation and the associated change in vegetation cover was undertaken from June to September, 2011.Transect survey method (Moore and Chapman, 1986) was used in three land use i.e, five years enclosure (*Jigjiga Airport &Harre)*, twenty years enclosure (*Gerabase Military Camp)* and corresponding open grazing land (called *Dhul-daaqsimeed*) located in the study area.

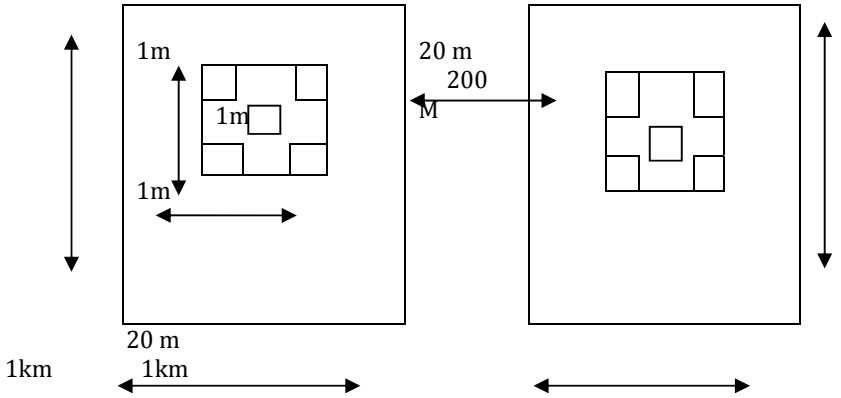

Figure 3 Experimental plot for vegetation and soil sampling.

Some of the species collected from each quadrat were identified in the field. For those species that were difficult to identify in the field, their local names were recorded, herbarium specimens were collected, pressed and dried properly using plant presses and transported to the Haramaya University Herbarium for identification.

Figure 4 Plant species sampling and identification during the field study and discussion with local elders

2.3.1 Herbaceous Species composition and dry matter biomass production

The herbaceous vegetation layer was investigated for species composition, diversity, basal cover, seedling number and age categories in each sub-quadrat of $1m^2$ area. Classification of herbaceous species into decreasers, increasers and pioneers, according to the succession theory of Dyksterhuis (1949), was employed as documented in Baars*et al.* (1997) and as adapted to the local condition

2.3.2 Woody vegetation layer

In each sample quadrat, the identity, number, and height of individual stems of woody plant species (i.e. trees and/or shrubs) were recorded. Height was measured by hypsometer (Type

65, Swedish made), while diameter of small and big trees were measured with the use of a diameter tape. Individuals with more than one stem (frocked below breast height in to two or more stems) were treated as individuals of the same tree and the largest stem was measured for diameter only. The density of woody plants (trees/shrubs) was enumerated in each quadrat and an area with no tress/shrubs was given 0 point and that with more than 20 trees/shrubs scores 10 points.

2.3.3 Soil condition assessment

The extent of soil erosion and compaction in each quadrat of the study area was evaluated subjectively by visual observations and a corresponding score ranging 1-5 was assigned in each case. Soil erosion was based up on the amount of pedestals (higher parts of the soils, held together by plant roots, with eroded soil around the tuft), the presence of pavements (terraces of flat soil, normally without basal cover, with a line of tufts between pavements). The maximum score (5 point) was given for no sign of erosion, while the following points 4 for slight sand mulch, 3 for weak pedestals, 2 for steep sided pedestal, 1 for pavements and 0 for gullies, respectively were designated. Following the suggestions of Baars*et al.* (1997), soil compaction was assessed based on the amount of capping (crust forming).

2.4 Soil Seed Bank

2.4.1. Soil sampling

To investigate the soil seed banks (SSB) in the rangeland of the study area, five randomly located 1m^2 area each, was selected and marked, within each 400m^2 sample quadrat of sample sites located along the main transect. At the center of each plot, three sub plots, 15cmX15cm, were marked in a triangular shape. Soil samples were removed from three separate soil layers, each three centimeters thick (0-3cm, 3-6cm and 6-9cm) using a knife and a spoon (Belaynesh, 2006; Shashie, 2007).

Figure 5 Soil sampling from depth layers inside enclosures after the seed shattering.

Figure 6 The researcher discussed about the soil seed bank experiment trial in green house of Haramaya University with his senior advisor.

2.5 Statistical Analysis of the Data

The household survey data were summarized and analyzed using the SPSS Statistical Package for the Social Sciences (SPSS version 16) taking each household as a unit of analysis. Descriptive statistics such as means, percentages, frequency, standard deviation and standard errors were calculated to present the result.

The grazing land assessment and soil seed bank (SSB) study data that were gathered from the field samplings and greenhouse experiment were summarized and analyzed in SAS-General Linear Model (GLM). A total of 9 sample sites each having five quadrats (400m^2) were used for vegetation, soil and SSB data analysis. One-way analysis of variance (ANOVA) was used for variables of the vegetation and soil characterizing in the study area. Duncan multiple range tests (DMRT) with $P< 0.05$ was employed to investigate if significant differences occurred for each of the vegetation and soil variables under consideration.

3. Results and Discussions

3.1. Rangeland degradation

The respondents indicated that rangeland degradation in this study area is becoming severe. They indicated that drought, Soil erosion and overgrazing were one of the critical factors that resulted rangeland degradation.

3.1.1 Causes of rangeland degradation

The pastoralists and agro-pastoralists indicated that recurrent drought was the main cause of rangeland degradation followed by overgrazing; soil erosion and population pressure (Table 1). Prolonged drought has been the most important natural threat to the livelihood of the pastoralists and agro-pastoralists, similar to many other studies (Ndikumana*et al.* 2001). Overgrazing by domestic livestock has been considered as a major cause of degradation because it changed vegetation structure and composition as a result of which some species increase in abundance and others decrease (Yates *et al*., 2000).

Table 1 Causes of rangeland degradation.

Rangeland Degradation	Pastoralist		Agro-pastoralist		Rank
	Frequency	Percentage	Frequency	Percentage	
Drought	19	6.3	16	53.3	1st
Heavy grazing	7	23.3	8	26.7	2nd
Soil erosion	3	10	4	13.3	3rd
Population pressure	1	3.3	2	6.3	4th
Total	**30**	**100**	**30**	**100**	

3.2 Pastoralists and agro-pastoralists Perception towards rangeland enclosures

3.2.1 Description of types of enclosures in different parts of the region

According to respondents of pastoralists (80%) and agro pastoralists (60%) were oppose and supporters of rangeland enclosures, respectively (Table 2). Group discussion made with the elders of pastoralist and agro-pastoralists indicated that enclosures cause risks such as inter-clan conflict, no accommodation of a large number of livestock and limits access to roads, footpaths for humans and livestock. But agro-pastoralists indicated that it cause benefits. The main benefits pointed out by agro-pastoralists were including land recovery, pasture reserve, and protect livestock (feed conservation) during the drought time. The researcher seen/observed in the enclosure of Jig-jiga Airport which supported the surrounding communities near the enclosure during the drought of 2011 in the study area.This study was supported by the findings from different pastoral areas of Ethiopia (Beruk and Tafesse, 2000).

Table 2 Perception of respondents towards rangeland enclosures in the study area.

Perception	Pastoralist		Agro-pastoralist	
	Frequency	Percentage	Frequency	Percentage
Detest	24	80	8	26.7
Support	4	13.3	18	60
Indifferent	2	6.7	4	13.4
Total	**30**	**100**	**30**	**100**

Similarly, it was reported that the inter clan conflicts have often been resolved using traditional social organization (Oba, 1998; Beruk and Tafesse, 2000). The same authors further suggested that traditional social institutions could have a key role to play in resolving conflicts, management of natural resources and to bring sustainable development in the pastoral areas. Hence, in the pastoral areas, taking due considerations in strengthening the traditional institutions and formulating conflict management policy would be crucial for successful development programs.

3.3 Coping mechanisms of pastoral and agro-pastoral community

At present, more than 50% of the chronically drought affected population in the country is from the pastoral areas (Beruk, 2003). Drought has been a common phenomenon in the study district and according to the majority of the respondents, its frequency and recurrence is greater than before. The major coping-up strategies of drought according to the sampled households were migration, sale of animals, and herd splitting, herd diversification and keeping of large herd size (Table 3).

According to pastoralists 56.7% out of the sampled were using migration as coping mechanism while agro-pastoralists preferred for feeding (crop residues) (33.3%) followed by sale of animals, herd splitting and migration, respectively (Table 3). Agro-pastoralists preferred other coping mechanism (feeding, sale of animals and herd splitting) rather than migration. This might be due to the settlements, cultivation of crops and their restriction of land. The pastoralist coping strategies is more or less similar to those reported by other pastoralists elsewhere in Horn of Africa (Oba, 1998;; Beruk, 2003; Teshome, 2007).

Table 3 Coping mechanisms to drought of the pastoralists and agro-pastoralists in the study area.

Coping mechanisms	Pastoralist		Agro-pastoralist	
	Frequency	Percentage	Frequency	Percentage
Migration	17	56.7	6	20
Sale of animals	4	13.3	8	26.7
Herd splitting	9	30	6	20
Feeding (crop residues)	0	0	10	33.3
Total	**30**	**100**	**30**	**100**

3.4 Soil and Vegetation Condition Assessment

3.4.1 Soil condition assessment of the study area

The mean values of soil erosion and compaction have shown significant difference between the three land use types (Table 4). Open grazing land exhibited a high degree of erosion in the study area. The high degree of erosion in the open gazing might be due to reduction of vegetation cover by overgrazing, removal of wood for fuel and for construction purpose in the open grazing land.

Table 4 LSM ±SE of soil erosion and compaction score assessed on the land use types.

Land use type	Soil erosion	Soil compaction
Five year enclosure	2.86±.19[a]	2.73±.18[a]
Twenty year enclosure	2.53±.18[a]	1.73±.16[b]
Open grazing land	1.71±.20[c]	1.60±.19[c]
P in ANOVA	**0.000**	**0.000**

[abcd]Means within a column with different superscript are significantly different at P ≤ 0.05

3.5 Herbaceous vegetation

3.5.1 Herbaceous species composition and diversity

The five years enclosure showed higher significant (P<0.05) mean score for the grass species composition compared to the twenty years enclosed land use type and showed that, long year protection of enclosure in this area had showed a non-significant effect on the increment of grass species composition and diversity. The present result is in agreement with Dereje (2003) who reported that after long year's enclosures herbaceous species composition in enclosure might decline as was observed in eastern Horn of Africa.

Herbaceous species richness was determined based on the number of species present in specified area and evenness (the abundance of individuals of a species per sampled site) showed significant difference (P<0.05) between land use types. The highest mean value of species richness was recorded in the five year enclosed land use; twenty year enclosure land use type scored intermediate value whereas the least mean species richness was recorded on the open grazing land use type (Table 5). This result is in agreement with Green and Boone (1995) who reported that 8 year enclosure had significantly lower (P<0.01) species richness and diversity compared to grazed counter parts.

Table 2 LSM ± SE of herbaceous (grass) score species composition, species richness, basal cover, age distribution, biomass and seedling number of the land use types.

Land use Type	Species composition	Basal cover (m^{-2})	Age distribution (m^{-2})	Species richness	Seedling number/ A4	Biomass (gm^{-2})
Five-year enclosure	6.73±0.17[a]	72.33± 3.15 [a]	2.13±0.19[a]	6.66±0.38 [a]	4.60±0.13 [a]	395.4±49.9 [a]
Twenty-year enclosure	5.06±0.26[b]	64.53±5.37[b]	4.46±0.13 [b]	5.46±0.44 [b]	4.60±0. 13 [a]	295.40±28.2[b]
Open grazing land	3.73±0.13[c]	26.33±1.98 [c]	1.60±0.21[c]	4.66±0.37 [c]	4.46 ±0.13[a]	121.7±8.08 [c]
P in ANOVA	**0.00**	**0.00**	**0.00**	**0.00**	**NS**	**0.00**

[abcd]Means within a column with different superscript are significantly different at P ≤ 0.05 NS= none significant

3.5.2 Basal cover, age distribution, seedling number and dry matter biomass

The basal cover data demonstrated that there was significant variation (P< 0.05) between the land use types (Table 5). The result showed that the basal cover difference was in relation to variation in species composition between the land use types (Table 5). The five year enclosure land use type scored the highest mean basal cover; twenty year enclosure scored intermediate value, while the open grazing scored least mean basal cover.

The oven dry weight biomass of the grass species composition showed that, there was a significant variation (P< 0.05) between the sample sites (Table 5). The mean total herbaceous dry matter biomass value recorded in this study was much less than those reported (878 gm^{-2} and 839 $gm^{-2})^{yr-1}$ Ahmed (2003) . This finding of this study is in line with the studies of Amsalu and Baars (2002); Abule (2003); Ahmed (2006) who reported the effects of high grazing pressure to have caused a loss of high yielding forage species ground cover.

Figure 7 Determination of fresh Weight of Herbaceous Biomass in the Sampled Plots.

3.6 Woody species richness, diversity, and evenness

The woody species richness calculated based on Shannon diversity index (Magurran, 1996) showed that there was significant difference between land use types (P<0.05). The highest woody species richness was scored in sites from the twenty year enclosure and five year enclosure land use types. Whereas, the least woody species richness was scored in the open grazing land use type (Table 6).

The study showed that a moderately successful restoration of woody species richness is more apparent in area enclosures land use type compared to the open grazing landscape. The present result was in agreement with other study in Horn of Africa (Negussie , 2008 and Mulbrhan*et al.,* 2006). Elsewhere in East Africa long-term enclosure periods resulted in a decline of herbaceous species and an increase in woody plant species (Oba *et al.*, 2001).

Table 6 LSM ± SE Woody species diversity, evenness and species richness of land use type.

Land use type	Shannon diversity Index	Evenness	Species Richness
Twenty years enclosure	2.88±0.043[a]	0.87±.016[a]	3.60±.25[a]
Five years enclosure	2.38±0.054[b]	0.62±.024[b]	3.06±.26[a]
Open grazing land	1.94±0.08[c]	0.48±.030[c]	2.46±.19[b]
P in ANOVA	**0.00**	**0.00**	**0.00**

[abcd]Means within a column with different superscript are significantly different at P ≤ 0.05

Species diversity calculated based on Shannon diversity index (Magurran, 1996) revealed that there was significant variation (P<0.05) between land use types (Table 6). The high woody species diversity index were scored for both enclosure land use types of varying years and the least woody species diversity index were scored for the open grazing land use type. This result showed that individuals with variability in the type of species and heterogeneity with community were regenerating in the enclosures. This is might be due to the restriction of human and livestock movement inside the enclosures which reduce the vegetation species and cover.

3.7 Soil Seed Bank Study

3.7.1 Species composition of the soil seed bank

This result, confirmed that the soil seed bank of Jgjiga rangeland was dominated by invasive weeds like *Partheniumhysterophours*rather than desirable seeds.The study result was in harmony with the investigation made by (ShashieAyele, 2007) who suggesting the extent of degradation of the land reported thatthe increasing trend of parthenium weed invasion might lead to a decline in the other species diversity and abundance in the Jgjiga rangeland. Moreover, drought together with human activities may adversely affect the seedling recruitment of the seed in the soil seed bank causing in the reduction of the species richness and evenness (Skglund, 2003).

Table 7 Mean±SE for the species seedling density of layers among the three land use types.

Land use type	Layer 1 (0-3 cm)	Layer 2 (3-6 cm)	Layer 3 (6-9cm)
Five year enclosure	16.06±1.28[a]	6.53±.79[a]	4.00±.55[a]
twenty year enclosure	15.8±1.99[b]	5.00±.72[b]	3.93±.45 [b]
open grazing land	7.80±.726[c]	4.26±.67[c]	2.7±.26[c]
P in ANOVA	**0.00**	**0.00**	**0.00**

[abcde]Means within a row with different superscript are significantly different at P < 0.05

One-way ANOVA revealed that, there was significant difference (P<0.05) between land use types and along layers (Table 7). The highest seedling number of the layers was recorded in five year enclosure, followed twenty years enclosure and least was on the open grazing (Table7). Depletion of soil seed bank of Jig-jiga open grazing land might be attributed to the overgrazing which did not allow the pasture species to flower and set seeds. The study result was in line with the investigation made (Snyman, 2004) by Seed banks are depleted through germination, predation, senescence, pathogens, drought and compaction that would determine the turnover of the seed bank in arid and semi-arid rangeland conditions.

Figure 8 Counting & discarding the identified species in the green house during the experiment study.

3.8 Similarity between the soil seed bank flora and the standing vegetation

Knowledge of the similarity between the soil seed bank and above ground vegetation is significant for predicting the potential contribution of seeds to the future. It is therefore, important to know, if the desirable species are present in local seed bank, and what are the conditions for their successful germination and seedling establishment (Luciana, 1995).

This study confirmed that there was low similarity between soil seed bank and above ground vegetation. The study revealed that there were 27 species common between the soil seed bank and above ground vegetation. These represented 71. 05% of the soil seed bank and 40.29 % of standing vegetation cover. The variation could be attributed mainly due to the difference in the number of woody species in the above ground vegetation (i.e. 24) and there were not accounted the germination seeds from the soil seed bank (i.e. 0). The observed poor similarity was much due to few shared species and due to too many woody species presence in the above ground communities. The poor correspondence between seed bank and standing vegetation might hold true for woody species especially that of trees and/or shrubs (Thompson and grime, 1979).

4. Conclusion and Recommendation

This study revealed that the current status of the rangeland was highly affected by the prolong drought, shortage of rainfall, overgrazing, invasive weeds, population pressure, and soil erosion. Moreover, the status of Jig-jiga rangeland enclosure land use type sample sites were in a better condition than the corresponding open gazing land use type. The enclosure land use

types had significantly higher grass species composition, living plant basal cover and woody plant species richness. As a result soil erosion and compaction has been low in the enclosures land use types.

The regeneration of herbaceous and woody species was also expanding in the enclosure land use types. In the present study, the occurrence of climax invader species of the soil seed bank experiment could suggest a lower potential seed for restoration and/or rehabilitation of the vegetation composition in the rangeland of the study area. Moreover, the relatively lower herbaceous seedling densities observed in the present investigation from sampled sites (For example open grazing) might indicate the needful interventions for future rehabilitation of the vegetation from soil seed banks and protection of the soil from agents of soil erosion. Open grazing sites with relatively low vegetation and soil erosion have been the lowest grass seedling densities and might demonstrate lower potential for species regeneration and restoration of the vegetation cover compared to enclosures in the study area of Jig-jiga district. Therefore based on the present result the author recommends the following points.

- There is relative higher woody species richness, higher herbaceous abundance in enclosures than open grazing land use type. Therefore protection of the open grazing land from human and animal could intensify regeneration in woody and herbaceous vegetation. Hence, admirable attention should be given for the expansion of enclosures in both pastoralists and agro-pastoralists of the study area.
- Rangeland restoration interventions also have to provide adequate resting periods by excluding human and livestock interference. Appropriate techniques should be employed for restoration of degraded land through conservation of native seed sources including rangeland improvement measures (such as proper grazing management (rotational grazing), invasive weed control mechanisms, reducing stock numbers etc). Therefore, the necessary intervention should be introduced in order to increase the diversity and regeneration of desirable grasses and woody species, since natural regeneration alone could not help for quick regeneration of enclosures. Enrichment planting of the required species, gene bank, feed resources, wildlife conservation and eco-tourism and reseeding could be among the possible alternatives for the success of enclosure.
- The study evidenced that; the enclosures could enhance regeneration of significant amount of natural pastures when given consideration to their term of years. Therefore, proper resource utilization of the enclosures should be given consideration by emphasizing with sustainable rehabilitations of the Jig-jiga rangeland.
- Awareness creation among pastoralists and agro-pastoralists about the benefits of enclosures should be facilitated and implemented.

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Section 9

Sustainable Education

A Comparative Investigation of Industry, Academics' and Students' Perceptions on Essential Sustainability Knowledge, Competencies and Skills

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Abstract

Design and construction educational programmes offered throughout the world play a vital role in sustainability education by producing professionals knowledgeable and competent in sustainable practices. It is extremely important to align the sustainability knowledge of the graduates to the industry expectations. This paper compares industry expectations about essential sustainability knowledge with both academics' and students' perceptions of requisite knowledge about sustainability. A three stage mixed research approach was adopted for the study. Essential sustainability knowledge expected from recent graduates was identified through literature review and surveys of design and construction firms. Students enrolled in design and construction programs were surveyed to measure their perceptions about requisite knowledge about sustainability. The position and perception of academics was analysed from survey data. Subsequently, the three sets of data were analysed using Simple Relative Index and Spearman Rank Correlation Coefficient techniques to identify the level of importance and degree of agreement between the responses of the industry and the students. Upon comparison of the students versus industry and academia responses about essential sustainability knowledge for recent graduates, it was evident that the perceptions of the students were almost diagrammatically opposite to that of the industry on multiple occasions. The position of academics also revealed some interesting directions. Overall the results of this study clearly indicate the need to embed sustainability focused on Architecture, Engineering and Construction (AEC) curricula for both undergraduate and postgraduate education.

Keywords: Sustainability, Sustainability Education, Green Building Rating System, LEED, BREEAM

1. Introduction

In the next 40 years, the world's population is likely to double. In theory this is good news for the AEC sector because all those extra people will need homes, schools, workplaces and infrastructure. However, the world is of finite resources and within 40 years, many of the natural resources that are taken for granted today, such as oil, water, some base metals and minerals, will be in very short supply. Also, climate change caused by greenhouse gas emissions will fundamentally change the way that people live and do business. The ethics of doing business on a global scale is under increasing scrutiny, particularly the exploitation of workforces. This is not just a developing world issue, for example a major construction company suffered huge damage to its reputation for using a road surfacing team from Latvia working under forced labour conditions.

The long-term winners will be those who take responsibility for their effects on society and the environment, and address those issues in a positive manner. Sustainability as expressed by the Brundtland Commission Report (1987) is the desired goal of development with proper control on environmental management. It is one of the most important challenges faced in the society today. Although different societies conceptualize the concept of sustainability differently, yet, indefinite human survival on a global scale can only be maintained or sustained through a healthy and environmentally stable society. Along with the escalating human growth the need built facilities is also increasing. Though built facilities enhance living standards, it also accounts for a large portion of nonrenewable energy depletion, greenhouse gas emission, raw material use, waste generation and freshwater consumption (Randolph & Masters, 2008). Thus, sustainable design and construction practices can substantially reduce or eliminate negative

environmental impacts through high-performance design, construction and operations practices. The design and construction industry is integrating ideas of sustainability in their planning and operations. With most of the top design firms and contractors utilizing sustainable construction, there is a huge demand of skilled designed and construction professionals with profound knowledge on sustainable design and construction ideas.

Although several HE institutions across the world have started incorporating sustainability education in their curriculum, there is no consensus on what constitutes the body of knowledge on sustainability and how to deliver it (Bhattacharjee, Ghosh & Jones, 2012). Design and construction educational programmmes offered throughout the world play a vital role in sustainability education by producing professionals knowledgeable in sustainable practices. This paper compares industry expectations about essential sustainability knowledge with students' perceptions of requisite knowledge about sustainability.

2. Sustainability

Sustainability, first developed in the field of forestry ensured not to harvest more than what the forest can yield through current growth (Wiersum, 1995). Since then sustainability is being used in various context among different disciplines. The use of the term sustainability ranges from the context of sustainable yield in forestry and fisheries management to the vision of a sustainable society with a steady-state economy (Brown, Hanson, Liverman & Merideth, Jr., 1987). The original meaning of the term is strongly dependent on the context it is applied to and on whether its use is based on the social, economic or ecological perspective. With time, this simple concept of sustainability gained much prominence across the globe at various levels. As referred to earlier, the widespread acceptance of sustainability was initiated by the report published by the Brundtland Commission in 1987 titled "Our Common Future". A plethora of attempts have been made to define sustainability since then emphasizing its importance. Today, sustainability is most popularly defined in terms of the three associated dimensions: social, economic, and environmental (EC, 2005; Helming, Perez-Soba & Tabbush, 2008; Robert, Parris & Leiserowitz, 2005: Tracey& Anne, 2005). This concept of the three dimensions of sustainability is embodied in the definition of sustainability adopted under United Nation's "Agenda for Development" which states "Development is a multidimensional undertaking to achieve a higher quality of life for all people. Economic development, social development, and environmental protection are interdependent and mutually reinforcing components of sustainable development" (UN, 2007). The popular means of conceptualizing sustainability in terms of social, economic, and environmental dimensions originated from Elkington's (Elkington, 1994) Triple Bottom Line concept. Opoku and Ahmed have advance the concept of sustainability, particularly in the context of AEC and offer the following definition "the adjustment of human behaviour to address the needs of the present, without compromising the ability of future generations to meet their own needs" (2013:141).

3. Sustainable Design and Construction

The AEC sector is responsible for high pollution rate due to energy consumption during the process of extraction, processing, and transportation of raw materials and construction of the structure using the raw materials, large-scale use of land. It is important to improve the building design and construction practices to reduce its harmful effect on the environment. This harmful effect on the environment can be reduced through the process of technology innovation (Spence & Mulligan, 1995), adoption of low carbon fuels (Hendriks, Worrell, De Jager, Blok & Reimer, 1998), identification of alternative low-carbon raw materials (Herzog, 2001). The concepts of sustainable design, sustainable construction, green building, product recycling, and eco-labelling have gained prominence in the design and construction industry across the globe (Cole1999; Crawley & Aho, 1999; Johnson & Carter, 1993; Rees, 1999).

Sustainable design and construction practices have been accepted across the globe due to their potential benefits to the environment, economy, and the larger society. While the benefits to the environment and society can be easy to measure, adoption of sustainable practices in design and construction can result in tangible and intangible benefits to the stakeholders. As a result, several design and construction firms are implementing sustainable design and construction methods. This has created a demand of skilled design and construction professionals knowledgeable in sustainability concepts and practices. Design and construction

programs in the US have a vital role in preparing professionals with formal knowledge in sustainable construction. To keep up with the growing demand, design and construction programs have incorporated course on sustainability in their curricula.

4. Sustainability Education in AEC programmes

Several researchers in the past have identified the benefit of sustainable education in AEC programmmes, how sustainable should be taught in the construction program and to what level should it be introduced in the course curriculum. In a review of the sustainability related courses offered by the construction programmes in the US, Tinker and Burt (2004) analysed the content of those courses and suggested how they could be integrated into the existing construction curriculum. Mead (2001) agreed that sustainability education could easily be integrated into construction programs. He suggested two ways to do so:

(i) incorporating sustainability ideas into existing courses such as materials and methods, mechanical/electrical courses, or

(ii) creating new courses that focus primarily on sustainable construction.

In their research paper, Cotgrave and Alkhaddar (2004) developed sustainable curricula within construction programmes in the UK where the course was delivered as a stand-alone course. The challenge for programme teams is whether to embed sustainability education across the programme or include it as a stand-alone course.

Using a systematic course development approach Ahn, et al. (2008) proposed a sustainable course for construction programs, whose learning objectives were in accordance to the industry expectations. The authors further suggested that courses when designed based on industry expectation is more effective as the actual knowledge gained by the students would then be more applicable in actual construction projects. Ahn and Pearce (2007) surveyed industry professionals along with construction students to create a bench mark against which the future changes in the industry could be measure over time.

Bhattacharjee et. al (2011) identified that more than 50% of the courses are offered at the senior level, followed by 30% offered at the junior level of bachelorette degree. The authors further analyzed the course content of the different sustainability courses and grouped them under eight categories of summarized under eight of, (i) environment/ eco-system, (ii) health, (iii) sustainable construction, (iv) sustainable rating systems, (v) role of stakeholders, (vi) lifecycle cost, (vii) ethics, and (viii) community.

The architecture community historically is known to have embraced the idea of introducing sustainability into architecture education as early as in 1987 when, for example five national architectural organizations that play varying roles in architectural education in the USA approached The Carnegie Foundation for the Advancement of Teaching to provide an independent study of professional education and practice. The results of the study published in a special report, *Building Community: A New Future for Architecture Education and Practice* contained several recommendations on sustainability, the most important of which is:

> *"Architects and architecture educators assume a leadership role in preserving the environment and the planet's resources. It is this priority, we are convinced, that could have the most far- reaching implications about the way schools, and the profession itself, conduct themselves in the next century" (Boyer & Mitgang, 2002).*

Based on the effort initiated by the five national architectural organizations Wright (2003) conducted a study to identify different ways to introduce sustainability into architecture curriculum in US. Performing a thorough literature review the author identified various approaches to introducing sustainability into the architecture curriculum, followed by the identification of criteria to be used to integrate sustainability into architecture curriculum, educational programmes, and practice.

5. Research Goal and Objectives

The goal of the study was to compare industry expectations about essential sustainability knowledge with academics' and students' perceptions of requisite knowledge about sustainability to work efficiently in the construction industry. The specific objectives were as follows:

1. To determine the expectations of the design and construction firms regarding essential knowledge on sustainability of recent graduates entering the workforce

2. To determine the perceptions of the students in design and construction programmes regarding the required sustainability knowledge necessary to work efficiently in the industry
3. To determine the perceptions of the academics teaching on architecture and construction programmes regarding the required sustainability knowledge necessary to work efficiently in the industry
4. To compare the industry's expectations with the academics' and students' perceptions.

6. Methodology

This research gains high motivation from the approach to study and gain a better understanding of industry expectations about essential sustainability knowledge with academics' and students' perceptions of requisite knowledge about sustainability to work effectively and efficiently in the construction industry. The methodology applied was determined on the basis of relevance to the focus of this research enquiry but also on the basis of pragmatic positioning. This was the case as a different methodological stance would not have allowed the research to be completed within the constraints applicable. Creswell (2009) stated that research methodology is the systemic approach that a research adopts to accomplish the research's aim and with that in mind an explorative interpretivist position has been adopted.

The objectives were achieved by conducting surveys among the design and construction firms as well as students enrolled in design and construction programmes. The survey questionnaire for the construction firms was divided into three sub-sections to accomplish the main objectives, which included: (1) capturing the background information of each firm; (2) understanding the sustainability practices adopted by the firms and their perceptions; and (3) examining the essential sustainability knowledge expected from recent graduates. Similarly, the survey questionnaire for the students was divided into three sub-sections including: (1) understanding the background of individual respondents; (2) examining the importance of sustainability practices as perceived by the respondents; and (3) examining the essential sustainability knowledge required to work efficiently in the industry as perceived by the respondent.

The overall research process of the study involved the following steps: (1) selecting sample firms working in the design and construction industry and students enrolled in the design and construction programs; (2) developing the survey instruments; (3) performing cognitive interviews for instrument validation; (4) distributing the survey questionnaire to selected samples; (5) collecting data to examine the industry's expectations and students' perceptions; and (6) analyzing the collected data.

6.1 Scope of the Study

The survey questionnaires were restricted in distribution to AEC firms located in the US and Europe. The design and construction firms listed in the Engineering News Record's (ENR) top 100 list and Construction Index in Europe were included in the sample for the study. It was assumed in the study that the respondents' answers reflected the corporate policy and philosophy of the respective organizations. The authors assumed that the knowledge of an individual delegating the organization is representative of the organization's philosophy and goals, and the delegates' responses to the survey questionnaires accurately represent the organizations by which they are employed.

The academics and students included in the study were enrolled in the undergraduate and graduate programs in member institutions of Association of Collegiate Schools of Architecture, UK universities and Associated Schools of Construction. While the surveys were sent to students at all levels, responses from students who were within one to two years of their graduation were included in the data analyses. This was done to ensure the respondents had well-developed perceptions about the necessary skills required to be successful in the industry.

6.2 Sample Selection

The population for the study was firms doing business in the design and construction industry and listed in the ENR's list of top 100 design firms and top 100 contractors, and in the Construction Index in Europe published in 2015. These firms were diverse in their geographic

locations and can be considered leaders of the industry. All the firms on the previously mentioned list were contacted through general e-mails and phone calls for the purpose of acquiring the contact information of the personnel who will be best suited to respond to the survey questionnaire. 118 email addresses and phone numbers of concerned personnel were collected (35% of the sample of 250). The questionnaires were sent via email with multiple reminders. 72 out of the 118 firms provided their responses, but nine out of them were not included in the analyses due to their incompleteness. 63 complete responses with a response rate of 53% were included in the data analyses.

The sampled student population included those enrolled in member institutions of Association of Collegiate Schools of Architecture and Associated Schools of Construction. As mentioned previously, responses from students with junior and senior standing (as per their standing during spring semester of 2016) of the four-year undergraduate construction degree programs were included in the data analyses. Emails with link to the survey questionnaires were sent to the member institutes using the list serve of the organizations, which were in turn forwarded to the students.

6.3 Survey Instrument Development

The author identified the survey items based on the study's key constructs of interest. Once the first drafts of the survey instruments were developed, a research measurement expert and two academic experts reviewed those in order to ascertain the content validity of the items in terms of relevance, representativeness and technical quality. Feedback from the subject matter experts was incorporated into the second draft, the pretest version of the survey instruments. The pretest versions of the instruments were next evaluated by two experts from the construction industry. Information obtained from the cognitive interview sessions were incorporated into final version of the survey instruments.

6.4 Distribution of Survey Questionnaires and Collection of Data

The developed and validated survey instruments were encoded using a web survey tool (Qualtrics) to facilitate the distribution and collection of the survey questionnaires via internet. After successfully developing the web survey questionnaire, the invitation email along with the survey questionnaire was sent to the study sample. The survey link was open for two months to limit the collection period. After two weeks of the first invitation to participate in the survey, two wave of reminder emails were sent to motivate the study sample for participating in the survey.

6.5 Analyses of the Data

As mentioned previously, both the survey questionnaires were divided into three sub-sections. The first section in both the questionnaires were meant to understand the profiles of the responding firms and the background of individual students respectively. The second section contained items to determine the perceptions about sustainable design practices. The third section contained items to determine the expected and perceived essential sustainability knowledge to work effectively in the construction industry.

Survey data were analyzed using Simple Relative Index (RI) and Spearman Rank Correlation Coefficient (SRCC) techniques to identify the level of importance and degree of association between the responses of the firms and the students. The RI ranking technique is used extensively in construction research for measuring perceived level of importance (Holt,1997; Wong, Holt & Cooper, 2000). An ordinal scale was used for the measurement of each survey item, each respondent being asked to assign a level of importance from 1 to 5, where 1 = least important and 5 = most important. From this, the magnitude of the RI for each item was calculated. To evaluate the overall rank orders, the mean and standard deviation of each individual item was considered inappropriate, as they fail to demonstrate any relationship between the items. Thus, all the numerical scores of each item on the questionnaire were transformed to relative indices to decide the rank orders.

7. Findings

Upon collection and verification of all the data, the data was analyzed. The following sections present the findings of the analysis.

7.1 Profile of Responding Students

66.4% of the responding students were male and 52.2% of the students were in the age group of 21-30 years old. Out of all the respondents, 27.3% are at the graduate level followed by 19.9% who are at the senior level. Overall, 58.8% of the responding students are majoring in Construction or related field. Only 9% of the students has more than twenty years of design/construction related experience. The vast majority (51.8%) has no design/construction related work experience. Based on their responses, it was found they have worked for a variety of companies in the Architecture, Interior Design, Construction, and Engineering fields.

Table 1 Background Information of the Student Respondents.

Background Information		**Student Respondents (%)**
Gender	Male	66.4
	Female	33.6
Age (years)	18-20 years	23.6
	21-30 years	52.2
	31-40 years	11.3
	41 -50 years	8.6
	51 -60 years	4.3
School Year	Freshman	13.8
	Sophomore	18.9
	Junior	18.5
	Senior	19.9
	Graduate	27.3
	Other	1.7
Major	Design	23.6
	Construction	58.8
	Engineering	3.7
	Other	14
Work Experience (Years)	0	51.8
	< 1	3.7
	1-5	30.6
	6-10	5.0
	>10	9.0

7.2 Student Awareness about Sustainability Design and Construction

Approximately 90% of the students agreed about the increasing concern of climate change as important. Student demonstrated an overall awareness about sustainability. More than 95% of the student respondents indicated that built facilities have significant impact on the environment, which can be altered by the way buildings are designed and constructed through technological innovations. Only 38.75% of the above mentioned 95% student respondents have participated in courses or school projects related to sustainability. 33.9% of the above mentioned 95% of the student respondents has worked on sustainable design or construction projects of which 18.7% has taken courses related to sustainability and also worked on projects related to sustainable design or construction.

7.3 Industry Awareness about Sustainable Design and Construction

Approximately 84.75% of the responding firms indicated their firm's familiarity with

sustainable design and construction practices. Additionally, 66.1% of the responding firms indicated that their firm has implemented sustainable design or construction practices in the past of which 2% of the firms have sustainable components integrated with all their design or construction projects. 42.4% of the responding firms either encourage or require their employees to attend trainings or workshops on sustainable design and construction practices.

8. Analyses and Discussion

In order to compare the industry expectations about essential sustainability knowledge matches with students' perceptions of requisite knowledge about sustainability to work efficiently in the industry, students were asked to indicate their perception about the required level of knowledge for the nine items related to sustainable design and construction identified from literature. The firms were also asked to indicate their expectations about essential sustainability knowledge based on the same nine items. The internal consistency reliability coefficients (Cronbach's alpha = α) were calculated for both the questionnaires. It was found that $\alpha = 0.85$ for the students' questionnaire and $\alpha = 0.88$ for the industry questionnaire. According to Morgan et al. (2007) Cronbach's alpha greater than 0.70 provide good support for internal consistency reliability.

Based on the three sets of response from the academics, students and industry, the RIs for each of the items were calculated followed by rank ordering of the survey items. A summary of the derived RIs and ranks for all the items are given in Table 2. In the next step, SRCC test was performed on the pair of ranks. No significant positive correlation between the ranks of the various sustainability knowledge items was found amongst the students and the industry ($r = 0.2$, $p>0.05$ [two tailed], $df = 7$). In other words, there was minimal agreement between the perception of both the academics and students with the expectation of the industry about the required sustainability knowledge to work efficiently in the industry.

Table 2 Summary of Derived RIs of Essential Sustainability Knowledge for Recent Graduates.

Essential Sustainability Knowledge	**Industry Expectations**		**Students Perception**		**Academic Perception**	
	RI	**Rank**	**RI**	**Rank**	**RI**	**Rank**
Green building design process	0.671	1*	0.571	3	0.651	1
Building codes related to green technology	0.671	2	0.570	4	0.639	5
Green building rating systems	0.667	3	0.578	2	0.645	4
Principles of green building construction	0.651	4	0.555	8	0.650	2
Life cycle cost analysis of green buildings	0.647	5	0.565	6	0.635	6
Green buildings products and materials	0.635	6*	0.556	7	0.630	7
Climate change	0.635	7	0.568	5	0.649	3
Green building construction means and methods	0.624	8	0.553	9	0.624	8
Biomimicry	0.569	9	0.583	1	0.580	9
* Equal RI; ranked in accordance with the percentage of respondents assigning 5 to the item						
Spearman's Rank Correlation Coefficient, $r = 0.2$ $p>0.05$ (two tailed), $df = 7$						

Table 3 Comparison of Knowledge Requirement about Rating System and Assessment Tools.

Rating Systems	Industry Feedback		Student Feedback		Academic Feedback	
	Freq.	Rank	Freq.	Rank	Freq.	Rank
LEED	70%	1	78%	1	75%	1
BREEAM	31%	2	36%	3	36%	3
Green Globes	2%	3	27%	5	25%	4
Living Building Challenge	2%	3	29%	4	3%	6
Energy Star	<1%	4	56%	2	3%	6
NAHB Green Rating System	<1%	4	<1%	7	<1%	7
CASBEE	<1%	4	9%	6	<1%	7
Impact Assessment Tools						
Other Assessment Tools	65%	1	12%	5	11%	4
Ecotect	14%	2	47%	2	45%	1
Equest	14%	2	30%	4	15%	3
Green Building Studio	14%	2	54%	1	17%	2
Athena	8%	3	35%	3	8%	5
Spearman's Rank Correlation Coefficient, r = 0.846 p<0.05 (two tailed), df = 10						

9. Discussions

Upon comparison of the students/academics versus industry responses about essential sustainability knowledge for recent graduates, it was evident that the perceptions of the students and academics were almost diagrammatically opposite to that of the industry on multiple occasions. One such instance was observed when respondents were asked about the required knowledge about 'Biomimicry.' Biomimicry, which is a relatively innovative approach to sustainable solutions imitating nature's strategies has not been adopted and implemented heavily in the design and construction industry. As a result, the industry practitioners and academics do not expect the students/recent graduates to have the operational knowledge about biomimicry. On the contrary, the students believed they should be aware of the novel concepts related to sustainability as that might put them in an advantageous position to gain professional success. While this study did not provide a means to further explore this apparent contradiction, the results suggest a need for further investigation to better understand the reasoning behind this potential discrepancy. The author believes this was a classic instance of disconnect between theory and practical knowledge. For some of the essential knowledge items, the students' perceptions were closely aligned with the expectation of the industry and academics.

The knowledge about the different rating systems were almost equally valued by the students, academics and the industry. On a similar note it is evident from Table 3 that there is statistically significant agreement between the industry and the students on the value of the knowledge about LEED among other rating systems currently in use. This could be due to the significant importance given to the rating systems in the text books as well as in literature coming out of professional organizations. Another observation was the heavy usage of LEED and BREEAM in the industry in comparison to the students' perception about the importance of other rating systems such as Green Globes, Living Building Challenge and Energy Star.

The respondents also expressed similar views on the importance of sustainable design processes and understanding of building codes/ regulations related to green technology. Knowledge related to climate change found place further down the list for both set of respondents. While concerns related to climate change seems to appear in a plethora of literature lately and receive global attention, the respondents of this survey did not rate that as one of their top priorities. Regarding the impact assessment tools the author found that large proportion of the responding firms utilize their in-house impact assessment tools. The students were not exposed to these in house tools and thus they differed in their opinions about the usage of the individual assessment tools.

10. Conclusion

This study developed an understanding of the current status of sustainable design and construction knowledge/perception and requirement among students, academia and industry practitioners. The study taped a random pool of respondents and reflected on the perception of the broad diverse population sample of design and construction industry practitioner and students around the globe. From the findings it can be concluded that though there has been a lack of agreement between the students, academics and industry practitioners about their perception on the essential sustainability knowledge, there is significant agreement between them about the importance of LEED and BREEAM as the most predominantly used rating system.

There is a depth of agreement in the need for the graduate professionals of the future to have a sound and well developed understanding of the current knowledge and best practices that are required within the AEC to embed sustainability as a matter of routine practice. The students perceive that they must embrace them and include sustainable approaches in the daily protocols of built environment processes. The industry practitioners believe and have confirmed that graduates need be fully equipped with the knowledge and competences of sustainable strategies so that their futures employers can be informed by and benefit from their knowledge. Academics are of the view that the most up to date sustainability knowledge is required by their students. Langford (2008) refers to embracing and encouraging the new construction professional on graduation as, while they lack experience, they will bring the innovation and creativity that those who are more established will lack. Looking to this research the construction professionals survey indicated that sentiment and the importance of the AEC industry being open to the supporting those new recruits.

As the AEC industry strives forward in the modern technological world it is the current student AEC body that will be the leaders in the next 10 to 15 years and their current educators have a responsibility to challenge and equip them to take on this role. Being sustainable will be part of that as recognized by those who have researched in the area but also those who have had an input into this research enquiry. Their message is clear, create significant learning opportunities that embed the necessary competences, understanding, skills and knowledge of sustainability so that society will be enhanced and sustainable.

The potential to explore further research in this important area are boundless and this research group propose to achieve a deeper understanding through more interpretive qualitative methods of the participants.

It is clear from the paper that there is still much to do to improve the embedding of sustainability focused AEC curricula for the undergraduate. Key to the success of this process is taking students [and academics] deliberately out of the institutionalized frameworks that bind them - frameworks that often, ironically, restrict innovation. To succeed in this inter-professional, intercultural collaboration requires improvisation, both in mind-set and in design technique, and requires a willingness to operate with uncertainty whilst embracing risk, and risking failure.

Sustainability and knowledge of our evolving technological driven society, are key skills in a world of rapid change and unpredictable unknowns. The professional roles in the BE sector are rapidly evolving, and new formats of processes and transactions developing at an unprecedented rate. Successfully navigating this environment requires graduates with essential inter - professional skills, effectively acquired through collaborative inter-disciplinary projects that embed the principles of sustainability. Going forward this study propose that sustainability be embedded in as many forms of collaborative professional education as possible. How this might be done should be a decision for programme teams.

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Assessment of Maintenance Strategies Used For Hostel Accommodations and Operational State of Hostel Facilities in Tertiary Institutions of Lagos and Ogun State, Nigeria

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Abstract

One of the buildings in tertiary institutions that require adequate and up-to-date maintenance is the students' halls of residence where a great deal of students' time is spent. The aim of this study is to investigate the maintenance strategy adopted for hostel accommodations in tertiary institutions, the effectiveness of the strategy and the operational state of the elements of the hostel accommodations. The survey research design (questionnaire) was adopted for the study and the population of the study is the tertiary institutions in Lagos and Ogun state that have hostel accommodations within their campuses. Hence, 38 hostel accommodations were used for the study. The respondents of the study were the hall managers, hall wardens and facility managers of the halls of residences. The frequency, percentages and mean scores were the statistical tools used for the analysis of the study. The results of the study show that the corrective maintenance strategy is the most commonly used method for hostel accommodations. The result also indicates that the current maintenance strategy is not effective on the elements of hostel accommodations considered in this study. Also, the important facilities in hostels (bunks/mattresses/wardrobe, electricity, plumbing etc.) ranked least in terms of operational conditions. Based on the findings, it was concluded that the current method of maintenance is the most probable cause of the current uproar among students of higher learning and if changes are not made to the method, students' unrests may get worse and get irredeemable. Therefore, the study recommended that the preventive and scheduled maintenance strategies should henceforth be embraced above the current corrective maintenance strategy. Also, government intervention by way of policy drive towards ensuring that higher institutions of learning embrace the preventive and scheduled maintenance strategy over the corrective method is recommended to improve the operational states of hostel facilities.

Keywords: Hostel accommodation, Maintenance strategy, Preventive maintenance, Scheduled maintenance, Tertiary institution**.**

1. Introduction

Buildings in tertiary institutions are required to create suitable space that support and stimulate learning, teaching, innovation and researches (Olanrewaju, 2012). One of such buildings in the college environment is the students' halls of residence where students spend a great deal of their time and interact with other students. As a result of the importance of hostel accommodation buildings, it is imperative to keep them in optimum condition throughout their lifetime.

Adejimi (2005) noted that, no thought is given to maintenance at the point of design and construction of any building in Nigeria, hence the neglect of buildings leading to dilapidation and dysfunctional states as in the case of residential facilities in many tertiary institutions in Nigeria. It is on this backdrop that students' protests and unrests have been reported in the years over the total neglect of student residential facilities by government and school authorities. The complaints centre majorly around the effects of hostel buildings on students' health and academic performance.

According to Daily Post (2012), students of Ondo State School of Nursing (OSSN) stampeded lectures to protest their poor hostel facilities and its effects on their health and academic performance. Also, severe damages, including deaths were recorded when students of

University of Uyo set a hostel and some offices in the school ablaze to express grievances against the government for its zero-maintenance policy leading to the degradation of the halls of residence in the school (Premium Times, 2013). The is the situation in many institutional buildings in Nigeria. Therefore, the focus of this study is to investigate the types of maintenance practices that is carried out by government and their effect on students' halls of residences in tertiary institutions in Lagos and Ogun States. The study also ascertains the operational state of hostel accommodations in Nigeria's higher institutions with a view to identifying areas that need upgrade in students' hostels.

2. Literature Review

Housing is an important aspect of human life because it enhances productivity, health and well-being of occupants. For a house to continue to serve the purpose for which it is built, it must be maintained on a regular basis. According to Olanrewaju (2010) maintenance is the required processes and services undertaken to preserve, protect and enhance buildings' fabrics and services after completion, in accordance with prevailing standards to enable building and services to serve their intended functions throughout their entire life span without drastically upsetting their basic features and uses. Siyanbola, Ogunmakinde and Akinola (2013) described it as an activity whose primary objective is to preserve buildings in their initial functional, structural and aesthetic states. Ismail (2014) opines that maintenance is a continuous operation to keep building in the best form for normal use. These descriptions suggest that maintenance revolves around building care.

The maintenance of buildings becomes more important when it comes to education buildings because of the unique purpose it serves in the welfare and academic performance of students. Lingnan University Students' Support Centre (2015) noted that the out-of-class experience from living in halls of residence provides an environment that is favourable for self-learning, social, cultural, extra-curricular involvement and the personal development of students. Wahab and Basari (2013) noted that it is of utmost importance to maintain the existing students' residential buildings to meet acceptable quality standards that are capable of facilitating transfer of knowledge and carrying out other academic activities effectively and efficiently.

However, in Nigeria, it appears the maintenance culture in educational buildings is poor and the buildings are beginning to fall short of their intended purpose. For instance, in April 2016, the students of a leading university in Lagos and Nigeria as whole took to the street with complaints that the general condition of their hostel accommodations is poor and they could no longer inhabit the buildings for reasons related to poor health and reduced academic performance. The management of the University in an interview with the media organizations responded that the students' hostel accommodations were in good condition and that the students were only tactically trying push examination dates forward. Not long after this incident, students of another university in a neighboring state came up with the same complaint of poor hostel accommodations.

Maintenance objective is primarily to preserve buildings in their initial functional, structural and aesthetic states. According to Okuntade (2014), the success of a building project depends on its performance. Adejimi (2005) opined that poor functioning of facilities in most of our buildings is a consequence of inadequate maintenance management. As reviewed by Simpeh (2013), buildings are very important assets that are procured to perform specific functions required by the building users. However, several factors can affect how buildings perform during their service life. Buildings begin to lose their value and performance and become obsolete as soon as the activities of building users are threatened by discomfort, ill-health or excessive cost (Leaman & Bordass, 1993).

Buildings may lose their performance due to functional obsolescence, unfavourable cost balance, physical degradation or a combination of these factors. Arazi *et al*. (2009) reported that decay, defect or their combination could cause a building to fail to perform its intended function. Both nature and human activities can cause buildings to lose their performance. However, maintenance can help to reduce or possibly even stop the impact of decay or deterioration (Douglas, 2006). Lavy and Shohet (2004) noted that there is a strong connection between building maintenance and building performance. Optimum building performance is what any maintenance process aims to achieve (Olanrewaju *et al*., 2012).

The importance of building maintenance has been reviewed by many researchers (Alner & Fellows, 1990; Arazi *et al*., 2009; Department of Treasury and Finance, 2005; Lee, 2001;

Olanrewaju *et al.*, 2012; Seeley, 1987). Olanrewaju *et al*. (2012) stated that the performance of buildings decreases unless maintenance is carried out. Buildings need maintenance to ensure best performance over their life cycle (Arazi *et al.*, 2009). Olanrewaju et al. (2010) also stated that the value of buildings as asset fluctuates in accordance with the quality and quantity of maintenance invested in them. The same point was made by Drouin *et al*. (2000) that the performance of a building is affected by the way maintenance and repairs are carried out. Certainly therefore, building maintenance has a substantial effect on building performance.

Maintenance combines both technical and administrative actions which contribute to the protection and satisfactory operation of asset maintenance. These activities range from regular cleaning to repairs and replacements (Wahab, 2013). However, the conventional methods of practicing maintenance have faced many issues and irregularities which include poor service delivery, inadequate finance and maintenance backlogs. Maintenance activities on most facilities hit a deadlock owing to lack of provision for tracking and effective monitoring. According to Ismail and Kasim (2013), these problems are largely dependent on poor or lack of maintenance plans which informs the need for maintenance management.

Choka (2012) explained that maintenance management is the systematic approach of planning, organizing, monitoring and evaluating maintenance activities and their costs. It involves the effective planning and execution of tasks performed to maintain the operation of equipment and facilities (Adnan, Fauzi, Rahmat & Supardi, 2012). In Odediran *et al.* (2012), it was noted that maintenance management is concerned with the planning and control of construction resources to ensure that necessary repairs and renewal are carried out with maximum efficiency and economy. The importance of maintenance management cannot be overemphasized, with many authors stressing its role in preserving a building in its effective state in order to serve its purpose effectively (Farida, 2013).

According to BS3811 (1964), all maintenance methods fall into planned and unplanned category. However, for the purpose of this study, the following maintenance methods will be discussed: (1) **Planned maintenance** is the maintenance work that is organized and executed with fore-thought, control and the use of records to a predetermined plan or schedule; (2) **Preventive maintenance** is carried out on routine-basis and at predetermined intervals to lower the probability of failure as well as performance degradation of an item and (3) **Corrective Maintenance** takes place after failure has occurred and efforts are being made to rectify or restore items to a state in which its required function can be performed.

According to Usman, Gambo and Chen (2012), corrective maintenance is the simplest type of maintenance strategy, where an element in a building is used until it breaks down. It covers all activities, including replacement or repair of an element that has failed to a point at which it cannot perform its required function. Corrective maintenance is sometimes referred to as failure-based maintenance. Its tasks often take place in an ad hoc manner, in response to breakdowns or user requests.

Other alternative names used to explain maintenance strategies are:

Predictable Maintenance which is a regular periodic work that may be necessary to retain the performance characteristics of a building and replace or repair the building or its elements after it has achieved a useful life span. It is a type of preventive maintenance. Predictable maintenance strategy was introduced to overcome the disadvantages of corrective maintenance, by reducing the probability of occurrence of failure and avoiding sudden failure. The strategy is also referred to as time–based, planned, or cyclic maintenance. Preventive maintenance tasks are performed in accordance with a predetermined plan at regular fixed intervals, which may be based on operating time.

Schedule Maintenance is also type of preventive maintenance that takes place at predetermined interval of time, number of operation or mileage. **Unplanned Maintenance** is the maintenance that takes place at no predetermined plan. It is referred to as semi-emergency maintenance. **Unpredictable Maintenance** is the work resulting from unforeseen breakdowns or damage due to external causes. **Avoidable Maintenance** is the work required to rectify failures caused by incorrect design, incorrect installation or the use of faulty materials. **Emergency Maintenance** is the work that is carried out in order to avoid serious problems. It is otherwise referred to as day-to-day maintenance (Olanrewaju, 2012; Simpeh, 2013). For the purpose of this study, maintenance strategies will be classified as corrective, preventive and scheduled.

3. Research Method

A survey research design was used for this study. The study was conducted on hostel accommodations of tertiary institutions (Universities, polytechnic and colleges of education) in Lagos and Ogun states, Nigeria. Lagos and Ogun States share boundaries in the Southwestern geopolitical zone of Nigeria. The two states have the highest number of tertiary institutions in the country and also the most rated Universities, polytechnics and colleges of education by the Nigerian University Commission (NUC) and National Board for Technical Education (NBTE). Therefore, a study of Institutions in Lagos and Ogun state will give good idea of what obtains in less rated institutions in the country. Hence, the result of the study can be generalized as representative of the all tertiary institutions in Nigeria.

The research instrument (questionnaire) is prepared and administered on hostel representatives (porters, hall wardens, facility managers and hall masters) to elicit useful information. The population of the study are the hostel accommodations in Lagos and Ogun State tertiary institutions as shown in Table 1. The questionnaire targeted only public tertiary institutions in those states. The same questionnaires were designed and distributed in the institutions. It was known at the conception of the study that it is the same government that finance the halls of residence in those states but to increase the number of responses, it was necessary to combined two prominent states in the Southwest of Nigeria where many tertiary institutions are mostly concentrated in Nigeria.

Table 1 Population of the study.

State	Name of Institution	Name of Halls
Lagos	University of Lagos	King Jaja Hall Moremi Hall Mariere Hall Sodeinde Hall Eni Njoku Hall Makama Hall Madam Tinubu Hall Fagunwa Hall Kofo Hall Biobaku Hall Elkanemi Hall Honors Hall Queen Amina Hall Erastus Hall Henry Carr Hall
	Federal College of Education (Technical) Akoka	ETF Hall Independent Hall Hall Five Hall Four Newest Hall
	Yaba College of Technology	Bakassy Hall Moshood Abiola Hall Complex Hall New Hall PGD Hall Akata Hall
Ogun	Federal University of Agriculture, Abeokuta	Umar Kabir Hall Iyalode Tinubu Hall PG Hall
	Federal College of Education, Osiele, Abeokuta	Hall 1 Hall 2 Hall 3 Hall 4 WICE Hall
	Federal Polytechnic, Ilaro	Queens Palace Aluta Hostel Annex Hall Kings Palace

It is important to note that there more tertiary institutions in the two states than the ones identified in Table 1. However, since the study is about hostel accommodation, only the institutions with hostel accommodations are tabulated and considered for the study. The questionnaires for the study was distributed by hand and via email to the respondents. Data measured on nominal scale was analyzed with frequency distribution and percentages. Mean scores and standard deviations were used to analyze data measured on ordinal scales.

4. Data Analysis

A total of 38 questionnaires were distributed and returned accordingly by the halls' representatives. Table 2 indicates that 20 questionnaires (53%) were distributed and collected in Lagos State while 18 (47%) were distributed and collected in Ogun State. Out of the 38 respondents, 79% were Porters, 13% were hall wardens, 5% were Facility Managers and 3% were Hall masters. The questionnaire is meant to cover just the halls of residence; however, responses from facility manager and hall masters were few. The norm is that, in Nigeria, a facility manager may be required to be responsible for many hostels. In fact, the same facility managers may be responsible for all the halls in a particular campus. The same trend is applicable to hall masters who are not really professionals but professors overseeing the jobs of the facility managers among others. Therefore, one could say that the response is bias as it is skewed towards the porters. However, the responses of the facility managers and hall masters were desired as leaders and overseers of the entire halls of residences.

Additionally, 71% had OND/HND as their highest academic qualification, 13% had B.Sc/B.Tech, 11% had M.Sc/MBA while 5% had other undisclosed qualifications. Also, 76% have 1-10 years' experience, 13% have 11-20 years' experience, 5% have 21-30 and 5% had 31-40 years' experience respectively. The results in Table 2 shows that the respondents have sufficient experience and knowledge overtime on the halls of residences they answered for. They also had adequate education to respond to the issues raised in the study.

Table 2 General information of respondents.

	Frequency	**Percentage**
State		
Lagos	20	53
Ogun	18	47
Total	**53**	**100**
Designation of the Respondents		
Porter	30	79
Hall master	1	3
Hall warden	5	13
Facility Manager	2	5
Total	**38**	**100**
Highest Academic qualification		
OND/HND	27	71
B.Sc/B.Tech	5	13
Msc/MBA	4	11
Others	2	5
Total	**38**	**100**
Years of Experience in hostel residency		
1-10 years	29	77
11-20 years	5	13
21-30 years	2	5
31-40 years	2	5
Total	**38**	**100**

Table 3 reveals that 5% of the hostels were built before 1960 (year of independence), 3% were built in 1960-1970, 8% were built in 1971-1980, 29% were built between 1981-1990, 21% were built in 1991-2000 and 34% were built in 2001-2015. Furthermore, 95% of the respondents indicated that school management is responsible for deciding the maintenance

strategy to be used in the halls while 5% indicated that the halls management had autonomy to decide the maintenance management strategy to be used. 89% revealed that funds for maintenance of halls were provided by subvention from school management and 11% indicated they get funds for maintenance from government intervention. Furthermore, 84% of the halls were provided with maintenance staff by the school management (in-house) and 16% were outsourced maintenance staff. Also, 18% of the halls keep records of maintenance activities manually (logbook) while 82% made use of computerized database for record keeping. Additionally, 55% of the institutions do not provide training for their staff on latest maintenance trends while 45% provided training for hostels staff.

Table 3 Information about the Hall of Residences.

	Frequency	**Percentage**
Year hall was constructed		
Before 1960	2	5
1960-1970	1	3
1971-1980	3	8
1981-1990	11	29
1991-2000	8	21
2001-2015	13	34
Total	**38**	**100**
Decision maker on maintenance strategy		
Hall management	2	5
School management	36	95
Total	**38**	**100**
Method of raising funds for maintenance		
Subventions from school management	34	89
Government intervention	4	11
Total	**38**	**100**
Human resources for maintenance activities		
Contract/Outsource	6	16
In-house staff	32	84
Total	**38**	**100**
Method of record keeping for maintenance need		
Computerized database	7	18
Manual (logbook)	31	82
Total	**38**	**100**
Training for maintenance management staff		
No	21	55
Yes	17	45
Total	**38**	**100**

Table 4 depicts the maintenance strategies adopted on elements of hostel accommodations. It is important to note that more than one or more of these strategies can be adopted on a building element but the respondents were asked to indicate the most commonly used among the strategies. Hence, it is evident that for all the elements of hostel buildings, the corrective strategy is the most employed among the tertiary institutions. In the case of wall finishes, scheduled maintenance is the most used strategy for maintenance.

The implication of this revelation is that, the preventive and scheduled maintenance strategies are rarely used on hostel accommodations and this explains the reason for the deplorable state of hostel accommodations in tertiary institutions in Nigeria. What is quite possible with the corrective method of maintenance is that, maintenance officers will not even know when the elements get spoilt and until reports are made, no correction will be done. It is also possible that, at the time the elements get damaged, there may not be replacement materials on ground. Sometimes, when it is evident that elements of a hostel accommodation are in bad shape, the maintenance officers will still be thinking they can be managed for some time before replacement.

Table 4 Maintenance Strategies adopted on elements of hostel accommodations.

Building Element	Corrective		Preventive		Scheduled	
	F	%	F	%	F	%
Wall finishes (paints inclusive)	15	39	7	19	16	42
Floor finishes	25	66	9	24	4	10
Ceiling/roofs	26	68	7	19	5	13
Doors/windows	28	74	6	16	4	10
Plumbing works	26	68	9	24	3	8
Electrical fittings	26	68	6	16	6	16
Staircase/Handrails	22	58	11	29	5	13
Bunks/Mattresses/Wardrobe	27	71	7	19	4	10
Safety systems	20	53	10	26	8	21
External works	28	74	6	16	4	10

Table 5 indicates the effectiveness of the maintenance strategies used for hostel accommodations in tertiary institutions in Nigeria. The results of the study show that the corrective method of maintenance that is commonly used for maintenance is only working to an average scale and this is not good enough for buildings that are meant to be in top shape to enhance study and improve academic performance of students. Apart from plumbing works, external works and safety systems, other elements are in bad shape because the maintenance strategy that is adopted on them is not effective. It is worrisome that bunks/mattresses is the worst of all the elements when it is actually supposed to be the best because that is where students lay their head at the end of every daily activities. There have been eye witnesses' reports stating that bedbugs are seen on students' mattresses and this is evidently due to poor maintenance.

Table 5 Effectiveness of maintenance strategies used on elements of hostel accommodations.

Building Element	Mean	Rank
Plumbing works	3.59	1
External works (Drainage, landscape)	3.55	2
Safety systems (surveillance, fire)	3.52	3
Staircase/Handrails	3.49	4
Electrical fittings	3.48	5
Doors/windows	3.42	6
Ceiling/roofs	3.40	7
Wall finishes (paints inclusive)	3.40	7
Floor finishes	3.40	7
Bunks/Mattresses/Wardrobe	3.35	10

5 = VE (Very effective), 4 = E (Effective), 3 = A (Average), 2 = SE (Slightly effective), 1 = NE (Not effective)

The results in Table 6 show that building elements are not in their optimum condition. Safety systems with a mean of 3.96 ranked highest of all the elements, followed by the ceiling/roofs (3.91), wall finishes (3.87), floor finishes (3.85), external works (3.75), staircases/handrail (3.75), plumbing works (3.54), electrical fittings (3.40) and bunks/mattresses/wardrobe ranked poorest of all with mean 3.64, 3.60 and 2.57 respectively. The result of this table is quite revealing as it shows that the condition of students' hostel accommodations is not befitting for learning purposes. The beds and mattresses are used by the students daily and it is rated last with less than an average score. This shows that the students are going through difficult times in the halls and cannot perform in their studies. None of the elements attained the good (4.0) state and this means that all the elements and facilities in the students' halls of residence require maintenance before they can habitable and conducive for learning

Table 6 Operational state of hostel facilities in Lagos and Ogun State.

Operational state of institutional Hostel facilities	Lagos state mean	Ogun state mean	Mean	Rank
Safety systems (surveillance, fire)	3.70	4.19	3.96	1
Ceiling/roofs	3.92	3.90	3.91	2
Wall finishes (paints inclusive)	3.86	3.87	3.87	3
Floor finishes	3.96	3.72	3.85	4
External works (drainages, landscape)	3.50	3.80	3.75	5
Staircase/Handrails	3.73	3.75	3.75	5
Doors/windows	3.67	3.75	3.72	7
Plumbing works	3.79	3.29	3.54	8
Electrical fittings	3.81	2.96	3.40	9
Bunks/Mattresses/Wardrobe	2.79	2.31	2.57	10

5 = VG (Very Good), 4 = G (Good), 3 = F (Fair), 2 = B (Bad), 1 = VB (Very Bad)

5. Conclusion

This study investigated the maintenance strategies used for hostel accommodations in tertiary institutions in Nigeria. It also examined the effectiveness of the maintenance strategies on the elements of hostel accommodations. Based on the result of the study, it was concluded that the corrective maintenance strategy is the most commonly used maintenance strategy for hostel accommodations in tertiary institutions in Nigeria. It was also concluded that the corrective maintenance strategy is not effective for buildings in educational institutions especially hostel residences. The study further concludes that the current method of maintenance is the reason for uproar among students of higher learning and if changes are not made to the method, students' unrests may get worse and irredeemable. Therefore, the study recommends that the preventive and scheduled maintenance should henceforth be embraced above the current corrective maintenance strategy. Also, it is not out of place to have government intervention by way of policy drive towards ensuring that higher institutions of learning embrace the preventive and scheduled maintenance strategy over the corrective method.

Furthermore, the study investigated the operational conditions of elements in students' halls of residence based on the complaints of students and management defense to debunk students' claims. Based on the results of the study, it was concluded that the operational condition of students' halls of residences are not good enough for habitation. Good sleep is key to learning; yet the beds are not good and electricity are consistently unstable. Apart from poor bed and electricity, other facilities investigated in the study do not support learning as well. With poor electricity and plumbing works, hostel accommodation will be unbearable for students to live in.

The students that protested the conditions of their accommodations noted that electricity supply was very bad to the extent that they slept and studied without electricity most of the time. Some of them complained that water supply (plumbing) seized for like three days sometimes and they may have to endure up to two days without taking their bath. All these conditions are indicators of poor academic performance and ill-health for students. Therefore, based on the conclusion, it was recommended that management of higher institutions should look into the problems of students' hostel accommodations and fix all the problems associated with them. The poor accommodation is a major reason for students' poor academic performance.

Also, government need to support the institutions with the required funds to undertake the rehabilitation process and monitor the disbursement of the funds accordingly. Other recommendations are that halls of residence should be managed by built environment professionals who can easily detect defects in hostel accommodations and maintenance departments are advised to adopt sound quality control policies with respect to building elements/services replacement. This will provide an appropriate basis for preparing budgets and scheduling/planning of maintenance activities that meet the actual maintenance needs of the students' halls of residence.

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Core Competencies of Academics from Students' Perspective

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Abstract

Academics in Higher Education Institutions play a vital role in the educational process and shape the future of countries based on what they represent to their students and the different attributes they possess and apply in their teaching approaches. Usually, such academics are required to be equipped with specific attributes and competencies that are determined by their educational institutions that believe they have an upper hand and a full understanding of their students' demands. How about having the concept upside down in listening to the voice of our students?

This paper aims at probing to what extent the academic members in Applied Science University possess the professional competencies required, as per the students' demands, whether such competencies are associated with teaching, technological, humane, or evaluation. A designed survey shall be developed and distributed among a representative sample of students. The analysis of which will show the availability level of such competencies, and any missing ones, from the students' perspective. Qualitative data will also be gathered through structured interviews with the Deanship of Student Affairs and the Students Council members.

In the light of the paper's findings, a conceptual framework will be developed and a set of recommendations will be submitted to the top management of the university in order to be considered in the future academic hiring process, and the development programs of the current academic staff.

Keywords: Higher Education, Professional Attributes, Students' Perspective, Teaching.

1. Introduction

"Higher education is a dynamic enterprise facing unprecedented change" (ACPA, NASPA, 2015). Just like most of the concepts in modern world, it encounters both, opportunities and challenges. Of the opportunities, we have the higher demand for access to higher education with the mounting number of applicants each year, the increasing demographic and non-demographic diversity, especially in modern time Arab world with the tendency to educate more women, and the special care directed towards individuals with special needs, the technological innovations with its impact on the teaching/ learning strategies and pedagogies and the process delivery systems, and the shift that occurred to the students' learning experience moving from the traditional spoon feeding approach, to the modern ones that enabled more interactions from students and their increasing role in the learning process.

Among the significant challenges higher education encounters in our area are its increasing costs compared to the average income, the higher expectations of employers, the mismatch that happens sometimes between the graduate attributes and the labor market demands, and the quality of faculty preparation and core competencies that sometimes are not the right ones for message delivery.

Hiring of higher education faculties in the middle -east in general is subject to various conditions. In some countries the process is a routine one getting the graduates' top of class students, in some others, it is subject to certain criteria established by the governmental body responsible for the higher education, and in some countries, educational institutes management get to establish their own criteria and competencies for which the newly hired faculties should possess in order to pursue their career with such institutes.

Faculty core competencies is one of the main reasons for the difficulties we encounter with higher education in the middle- east in general, and in the Arab world in particular. In most of the above mentioned procedures adopted by higher education institutions in selecting their faculties, we rarely hear about the perspective of those who are most concerned with faculty competencies and attributes, namely students.

Even though we find in some higher education institutions some surveys asking their opinions about their learning experience within such institutions, most of students in fact deal with such surveys as a routine thing they have to take in order to get to the following step in this procedure.

There are some questions about how convinced the top management and faculties of such institutions about the ability of students to realize and evaluate their teachers' strengths and weaknesses and how to separate them from each other, and how efficient students' perspective is in developing and enhancing the professional core competencies of faculty members,

This document is intended to set out the scope and content of professional competencies required, from the students' perspective, in their faculty members at ASU, as one of the higher education institutions in the Kingdom of Bahrain, to outline the strengths and weakness of faculty members in four of the teaching process key areas of professional competencies, namely professional, technological, humane, and assessment/ evaluation competencies. The main aim of this process is to set a conceptual framework and a set of recommendations to be submitted to the top management of the university in order to be considered in the future academic hiring process, and the development programs of the current academic staff.

2. Theoretical Review

Higher education is a source of pride in the western civilization for anyone concerned with it (Jamil Salmi, 2015). Leaders of higher education in these countries claim that their countries were the cradle of the most ancient universities in the modern time. Oxford was established in 1167 and the French Sorbonne in 1160. In spite of these claims, it was proven by historians that the most ancient, and still operative, university in the whole world is the University of Al Quaraouiyine in Fez, Morocco that was established in 859. Contributions of the Arab universities should be a source of pride for the Arab world represented by its ancient universities such as Zitouna in Tunisia, Al Nezamia in Iraq, and Al Azhar in Cairo, in addition to role played by the Cairo university that was established in 1908 under the name of the Egyptian University, that was the minaret for many Arab intellectuals during the 20th century (Jamil Salmi, 2015).

In spite if this, higher education in the Arab world nowadays encounters several challenges. In the meantime our countries witness a substantial increase in number of educational institutions and students, quality and content of education are still sources of concern (Jamil Salmi, 2015). In many cases, weak selection and insufficient resources led to excessive congestion in the educational facilities that made it unsuitable for the delivery of its main mission. Most universities in our countries depend on traditional syllabi and outdated educational practices. This led to a high rate of drop out that sometimes reach 50% of students. In addition, the mismatch between the graduate attributes and the requirements of the labor market in most of our countries led to a high rate. According the Economist, "In 2010, on the eve of the Arab uprisings, total and youth unemployment rates in the Arab world were already the highest of any region, at 10% and 27% respectively. Since then these figures have risen further, to nearly 12% and 30%. Amazingly, in some Arab countries, the more time you spend in school, the less chance you have of finding a job. In Egypt 34% of university graduates were unemployed in 2014, compared with 2% of those with less than a primary education" (The Economist, 2016).

It is apparent then that the role of higher education institutions needs to be modified in order to suit current international developments, with its various political, economic and social dimensions (Al-rashdan, 2010). Most of the Arab universities adopt traditional education based on rote memorization of material without enabling students to be innovative and mix scientific knowledge with practical application. Students are not encouraged to take a critical, analytical approach towards numerous problems in society, creating a spirit of student submissiveness and fear to voice their opinion (Al-rashdan, 2010).

Engaging students and staff effectively as partners in learning and teaching is arguably one of the most important issues facing higher education in the 21st century. Students as partners is a concept which interweaves through many other debates, including assessment and feedback, employability, flexible pedagogies, internationalization, linking teaching and research, and retention and success (Healey et al., 2014).

Students need not be silent in the improvement of reaching in higher education. In actively seeking students' response to instruction, college, and universities are sending the important

message that they honor and support the teaching- learning process (Gordon,). According to North Carolina State University Handbook for Advising and Teaching (1994), student evaluation of teacher effectiveness serves two purposes, providing instructor with important feedback from the consumer's point of view, and providing administrators and department chairs in assessing perceived effectiveness of instruction (NC State University, 1994).

Faculties remain the effective human means for transferring and facilitating of all kinds of expertise to students (Radouan, 2014). Passion for knowledge cannot be implanted effectively in students without the human medium and the personal rapport represented in the teacher (Radouan, 2014).

It also became evident that for those that participated in a partnership approach it can lead to more motivated learners and enthused academic staff. Students talked about the breaking down of barriers and how they experienced a better classroom experience (Curran, 2015).

There are plentiful literature on the importance of measuring and developing faculty core competencies in the Arab world universities. Ben Bateel (2010), Al Hakami (2004), Al Khateeb (2006), Momany (2010), Bani Domi (2010), Al Omary (2009) and a lot of other researchers, examined the different required competencies of faculties in different educational institutions in the Arab world from different perspectives.

Having the perspective of students is a very important addition to the different perspectives adopted by other researchers in measuring and developing such competencies. Murray (2005) stated that student rating forms try to do the next best thing by assessing teacher or course characteristics that are 1) believed to contribute to student learning, 2) observable by students, 3) widely applicable, and 4) under the control of the instructor, and thus justifiable for use in faculty personnel decision on salary, promotion, and tenure. (Murray, 2005).

But how well do student ratings do in providing a reliable and valid assessment of quality of faculty competencies? Research indicates that student ratings are adequate in terms of reliability, in that ratings of a given instructor are reasonably stable or consistent across courses, years, rating forms, and group of raters (Murray, 2005). Educators often have mixed feelings about having their students evaluate them. After all, it's inevitable that some students might use the evaluation to "vent" on a more personal level. However, most student feedback can be genuinely helpful, offering teachers a chance for self-awareness and insight that can help then become better at their jobs (Concordia University, 2012).

Feedback is good for students, too, because it helps them feel more fully engaged in their education. Students who feel their opinion matters are far more likely to have a personal stake in the educational process. Feedback also gives teachers concrete advice on making the education process more enjoyable and effective. Educators who are more responsive to their students stand a better chance of providing a quality educational experience (Concordia University, 2012).

3. Methodology

To examine to what extent the academic members in Applied Science University possess the professional competencies required, as per the students' demands, whether such competencies are associated with teaching, technological, humane, or evaluation/ assessment, a practical study was conducted on the university students, with all of its three colleges, Admin. Sciences, Arts and Science, and Law, to come up with findings that would shed the light on this area and help in providing a set of recommendations will be submitted to the top management of the university in order to be considered in the future academic hiring process, and the development programs of the current academic staff.

To develop this questionnaire, the researchers reviewed available literature to expose common ground related to the different areas of competencies that are most convenient with the teaching environment within the university, namely competencies that are associated with teaching, technological, humane, and evaluation/ assessment. A designed survey was developed and distributed, online and manually, among a representative sample of students. Then, a structured interviews was developed and conducted with Deanship of Student Affairs and Student Council to gain qualitative data to support the quantitative data gathered from the questionnaire.

3.1 Sample size

Due to the vast study population, represented in all students within the university, a convenient sample of 250 students was chosen to test to what extent the academic members in Applied Science University possess the professional competencies required. The valid questionnaires analyzed was 184, with the response rate of 72%. Sample size should have been more than this, but due to the short time of the summer semester, and the necessity to gather the required information after the mid-semester exams, researchers were working under a tight timeframe that should be considered in future studies.

Apart from demographic variables, all others statements were measured using Likert type five point scale, where "strongly agree" was given the highest response "5" and "strongly disagree" was given the lowest response "1".

3.2 Data analysis Technique

Data was analyzed via the Statistical Package for Social Science (SPSS), to get such statistical tools such as means, simple regression, Pearson correlation, and standard deviation.

3.3 Tested Hypotheses

H1: ASU academic members practice the Professional Competencies from the students' perspective.

To empirically test it, a set of indicators were chosen, to include:

- Mastering the Specialty Subject.
- Illustration and analyzing lesson contents.
- Employment of expertise and student support.
- Awareness of the proper teaching strategies and methodologies.
- Motivating of students.

H2: ASU academic members practice the Technological Competencies from the students' perspective.

To empirically test it, a set of indicators were chosen, to include:

- Employment of electronic teaching means.
- Urging students to use online sources and references.
- Employment of technological software and applications.

H3: ASU academic members practice the Humane Competencies from the students' perspective.

To empirically test it, a set of indicators were chosen, to include:

- Encouraging an atmosphere of democracy within class.
- Adoption of respect and fairness with students.
- Avoiding sarcasm and underestimation with students.
- Providing a proper teaching/ learning environment to students.

H4: ASU academic members practice the Evaluation/ Assessment Competencies from the students' perspective.

To empirically test it, a set of indicators were chosen, to include:

- Consideration of individual differences in assessment.
- Seeking of justice in assessment.
- Employment of various evaluation/ assessment means.
- Equipping students with sufficient knowledge and psychologically preparing them for exams.

4. Statistics and Discussion

This part of the paper represents the statistical data of the survey conducted at the designated case study; the Applied Science University, in the Kingdom of Bahrain with the main aim is to study the core competencies of a 'Good Lecturer' from the perspective of students. The primary data collection was based on quantitative research method where survey questionnaires were randomly distributed amongst students at the University of about 3000 total Number of students, from three existing colleges (i.e. the college of administrative sciences, the college law and the college of arts and science).

The selected descriptive variables were as follows; (i) student gender, (ii) student employment status, (iii) student age that varies between 17 -20 years, 21-24 years, 25-29 years, above 30 years and, (iv) student study period at the University that varies between 0-1 year, 1- 2 years, 2-3 years, 3-4 yeas, above 4 years. A set of dependent variables were selected from the undertaken literature review as listed in table 1, and clustered into four themes that describe the core competencies of a good lecturer as follows; (1) professional competencies, (2) the use of technology competencies, (3) the humane competencies, (4) assessment and evaluation Competencies.

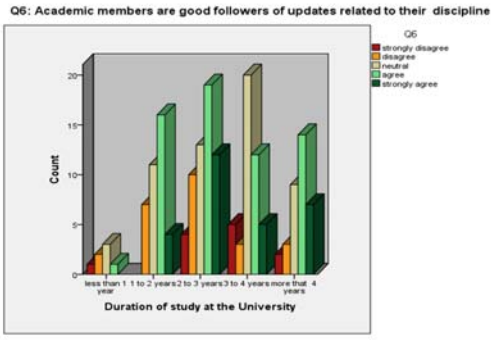
The number of participants that completed the questionnaires was 184 out of 250 distributed, reaching 72% response rate. The participants who are mostly students were offered the choice of 5 pre-coded responses using Likert scale, giving them the choice to select one option, and express their opinions in how much they agree or disagree with the variable statements, with the option to neutral point where students neither agree nor disagree. The survey was carried out in summer of the academic year 2016-2017. The results of the averages as presented in the table 2 and in the schematic representations from graphs Q6 to Q33 show that most students either agreed or neither agreed nor disagreed on the listed statements presented in the questionnaire survey of this study, furthermore most of the trends are inclined towards significant agreements. In other words and in general, the results of the study show no significant conflicts of opinions from the core competencies of a good lecture as selected by the authors in the presented questionnaire survey and the students' opinions.

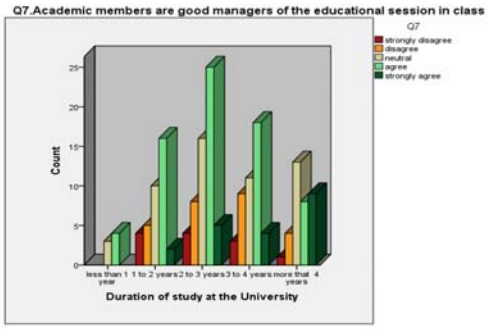
A correlation between the variables was also carried out and the results show that; (a) there is no correlation between the number of years the students spent at the University and his/or her change of view on the core competencies of a good lecturer (refer to graphs Q6-Q33). (b) There was a negative significant correlation between the age of the student and statements Q13, Q14, Q15 at the levels 0.01, 0.05 and 0.01 respectively which fall within the core technology competencies. This indicates that older students believe that technology and eLearning are not the competencies used by the lecturers. (c) There was a negative significant correlation between the gender of the student and the statements Q9 and Q10, where male and female students disagree on the lecturer enthusiasm and motivation expertise in keeping them focus and increasing their knowledge. (d) There was a positive significant correlation between the colleges and the statements Q12, Q25 and Q30, where students from the same college agree that the core competencies for a good lecturer are in encouraging students to use more critical thinking, research, in creating a sense of humor in class, and in providing formative and summative assessment and feedback.

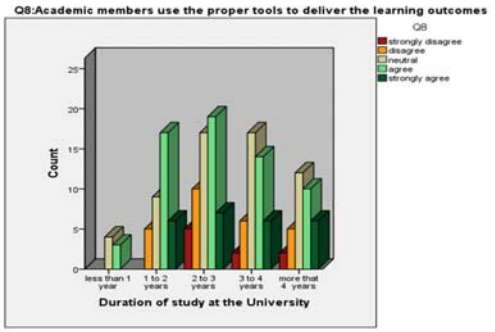
Table 1 List of clustered variables.

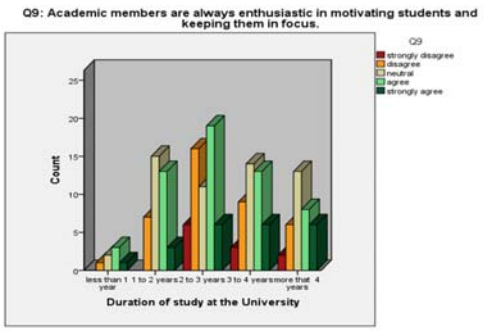
Part A: Professional Competencies	
Q6	Academic members are good followers of updates related to his/her discipline.
Q7	Academic members are good managers of the educational session in class.
Q8	Academic members use the proper tools to deliver his/her ideas.
Q9	Academic members are always enthusiastic about motivating students and keeping them focus.
Q10	Academic members employ their expertise and studies to increase the student's knowledge.
Q11	Academic members urge students to use their own perspectives and points of view.
Q12	Academic members urge students to use their critical thinking and research in education resources.
Part B: Use of Technology competencies	
Q13	Academic members employ the e-learning facility in teaching.
Q14	Academic members urge students about the importance of e-learning.
Q15	Academic members use internet resources as a means of scientific research and a source for knowledge.
Q16	Academic members use technological tools in delivering course content.
Q17	Academic members urge students about using online books, research, and references in their assignments.
Q18	Academic members use university portal and other online means in communicating with students.
Q19	Academic members use the different computer software, such as word, excel, PowerPoint, etc. in preparing for lessons.

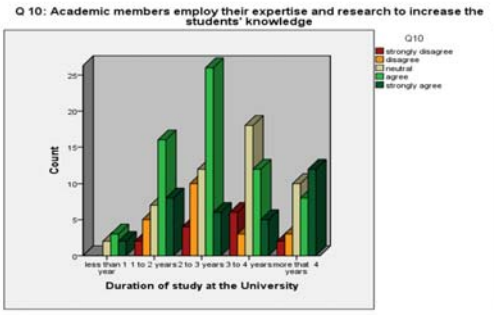
Part C: Humane Competencies	
Q20	Academic members circulate a democratic atmosphere within lectures.
Q21	Academic members urge students to express their points of view freely.
Q22	Academic members accept and embrace students' points of view, even if they contradict with theirs.
Q23	Academic members treat students with fairness and respect.
Q24	Academic members avoid being sarcastic with students.
Q25	Academic members circulate a sense of humor and urges them to like lectures
Q26	Academic members promote the necessary values, attitudes, and ethics for students.
Part D: Assessment and Evaluation competencies	
Q27	Exam questions are varied in difficulty levels
Q28	Academic members prepare students, from the psychological and knowledge perspective, for exams
Q29	Academic members are accurate and fair when assessing summative works
Q30	Academic members use informative and summative assessment
Q31	Academic members follows up activities and assignments, and assigns weight for each one
Q32	Academic members are keen on providing feedback for conducted works
Q33	Academic members are keen on using the feedback he/she receives from students

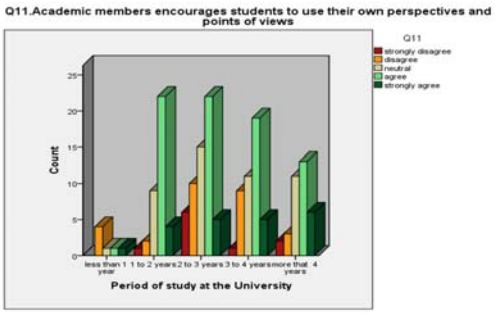












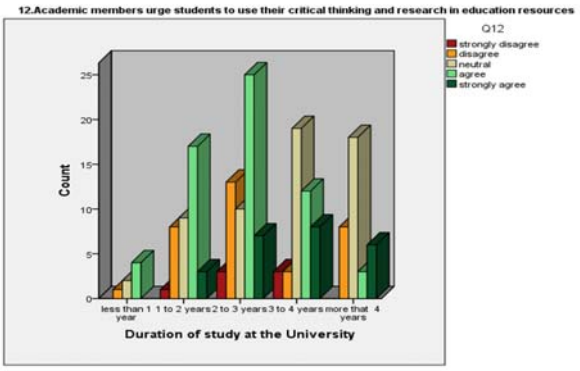
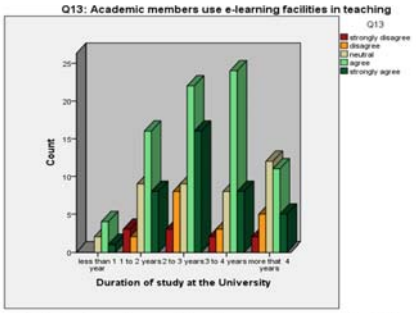
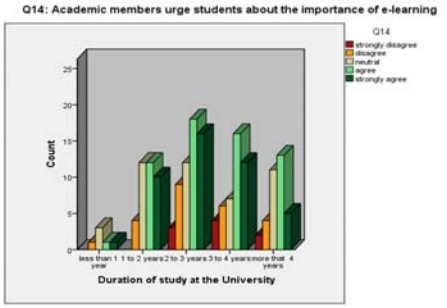
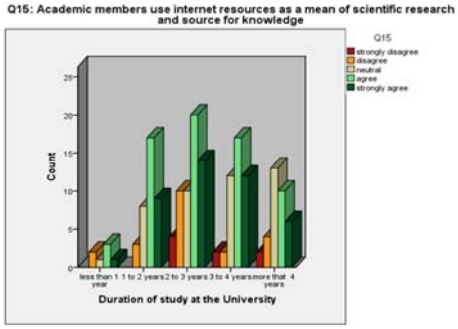


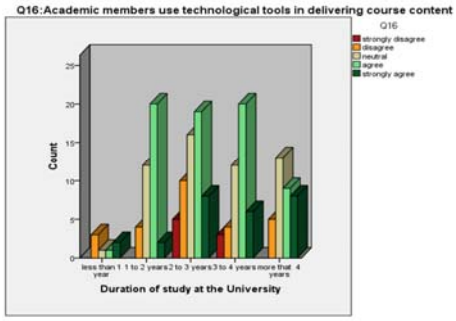
Figure 1 Professional Competencies.

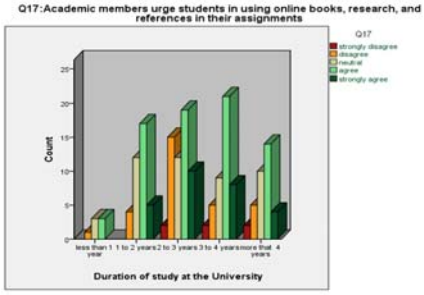
The results as per figure 1 on the professional competencies show that most students agree to strongly agree with the suggested academics' professional competencies in following their updates related to their subject discipline, in managing their educational class session, in using proper tools to deliver their ideas, in using their expertise and research studies to increase students' knowledge. Students regardless their gender, age, employment status, duration at the university and college, they all agree to strongly agree that academics urge students to use their own perspectives, points of views and to use their critical thinking and research in education resources. Students also agree to strongly agree that academics are always enthusiastic about motivating them and in keeping them focus during class.

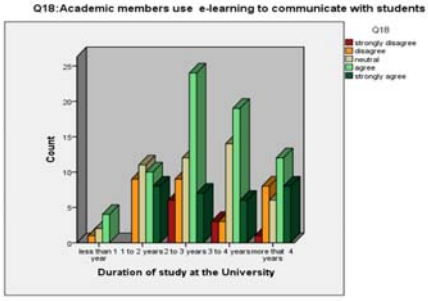












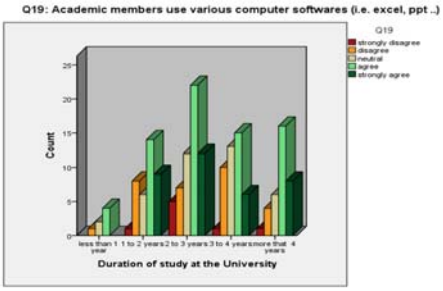
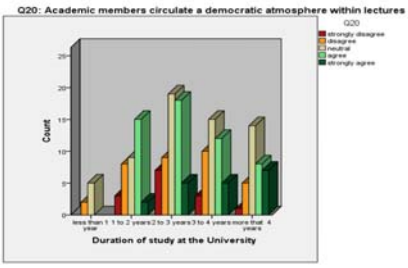
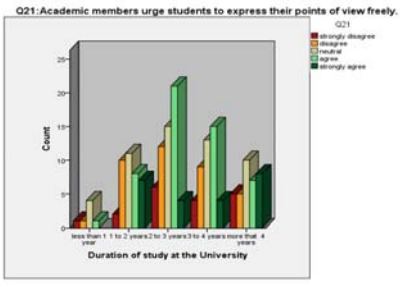
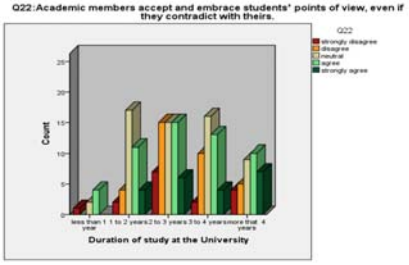


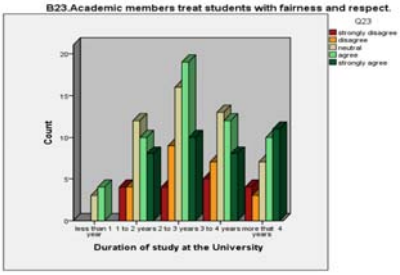
Figure 2 Use of Technology.

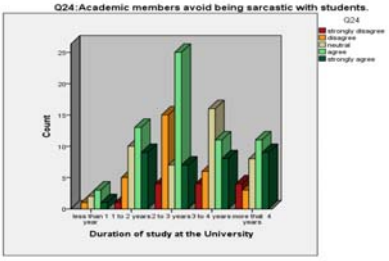
Results on the use of Technology competencies show that most students across the university in all colleges agree that academic employ the e-learning facility in teaching and internet resources and they highlight to students the importance of e-learning facilities within the University.

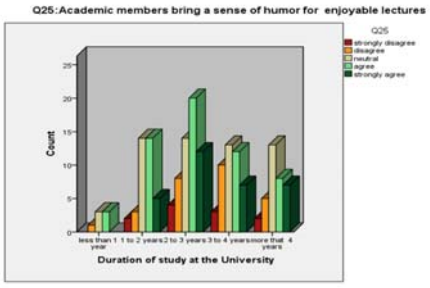












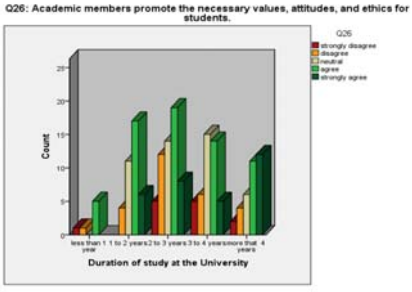


Figure 3 Human Competencies.

The results on the academics Humane Competencies show that students somewhat from impartial to agree over their opinions regarding academics in creating a democratic atmosphere in class, and in encouraging students to do so. The results show the same trend, but more towards agree and strongly agree in their opinions regarding academics treating them fairly, avoiding sarcasm in class, and in creating a sense of humor and the necessary ethical values. The trend tends to be similar across the colleges regardless of age, gender or employment status.

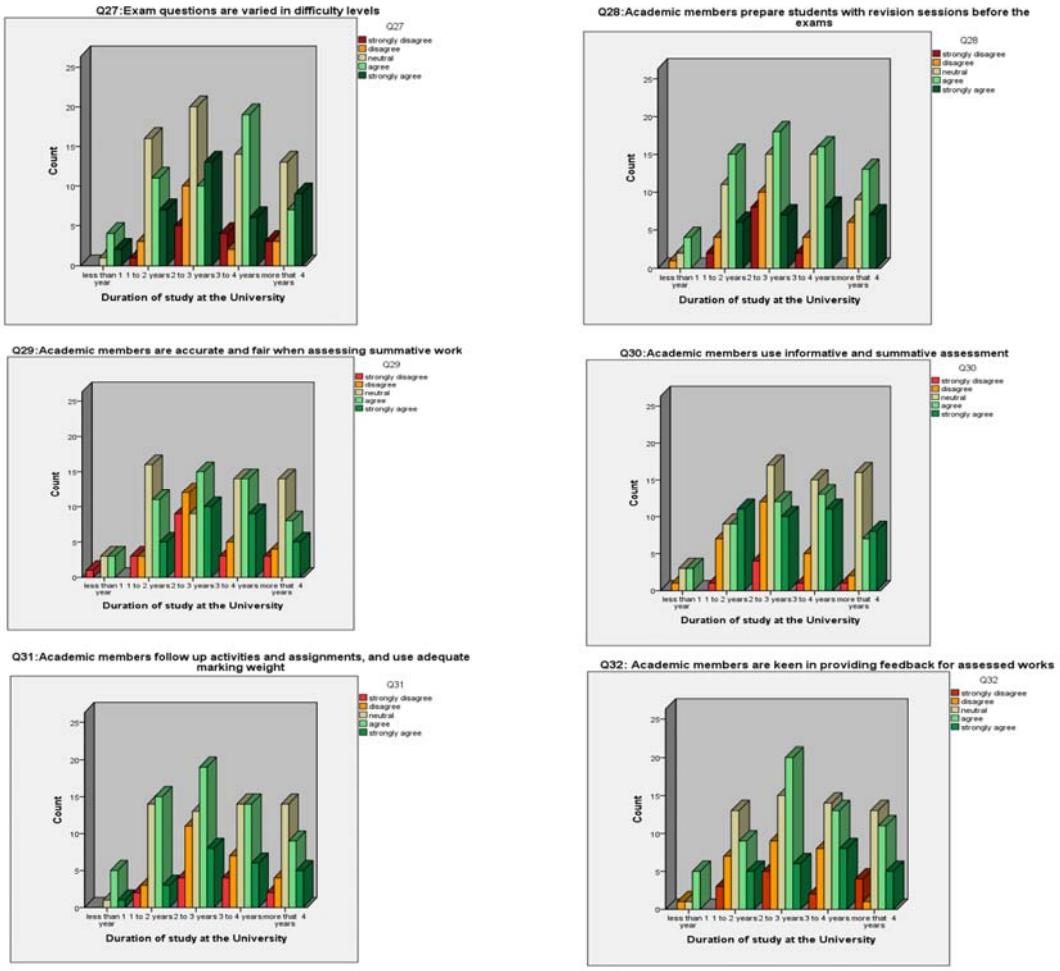


Figure 4 Assessment and Evaluation

The results on assessment and evaluation competencies show similar trends from partial to agree opinions between students regarding the academics that vary their exams questions in difficulty levels also most students agree that academics use formative and summative assessment and they are accurate and fair in their assessments. Students agree that academic staff are keen in providing feedback on students work.

Most of the results show positive feedback on academics competencies and this trend is across the colleges regardless their gender, age, the employment status and their duration of education at the University.

5. Implications and Conclusion

The researchers had to accommodate themselves with such limitations, to include but not limited to, the relatively small sample size in relation to the study population and the time restrictions of the summer semester, in addition to the response rate of the sample individuals.

Findings of the data analysis and the conducted interviews revealed interesting things. Not even one statement received close to 4 in the total average. It means that this process, in spite of the mentioned limitations, does not go in line to some extent with other evaluation processes conducted within the university.

There are some related variables in the faculty evaluation process, such as the diversity of student characteristics, faculty objectives and the different teaching methods, in addition to the institutional contexts. These variables should be considered as an integrated process when developing the evaluation process.

As outlined in this paper, student opinion continues to be a major factor in the evaluation of teacher effectiveness at institutions of higher education. But, students' assessment of their teachers is only one component of an important process. Therefore, it becomes reasonable to expect students to make an important input to the system and it is imperative that teachers be receptive to student feedback. However, there is no one correct method of teaching (Joyce & Weil, 1996).

As Seldin and Angelo (1997) warned regarding the development and administration of student evaluations that "the entire evaluation system, including any rating forms, should be designed to meet a specific set of specific purposes and needs and should have a clear connection to the academic rewards system". Therefore, student evaluation of teachers should be integrated with other steps of the evaluation process to come up with a unified scheme outlining strengths and weaknesses of faculties and to rely on in making development plans. In addition, this process should be revised regularly and compared within time intervals to make sure we are on the right track.

Recommendations include adopting the framework of the higher education academy (HEA) with its five areas of the teaching/learning process capabilities to be the basis for the development of the academic staff within the university. Researchers see that the HEA framework is particularly useful in situating partnership working (HEA, 2015). We see the benefits of partnership with students to be mainly located in the learning, teaching and assessment and curriculum design and pedagogic consultancy areas of focus and the research output. We recommend starting small and that staff and students engage through partnership through students being welcomed into a discipline community and cast as active participants in their learning. This provides the opportunity for staff and students to develop personally and to build capacity for active learning where student and staff interaction builds trust relationships, which enhances student engagement.

Furthermore, such paper should be followed by a similar work, but with limiting the restrictions, such as conducting the study in the 1st or 2nd semester with longer time, and using a wider sample size, and compare results of both studies, in addition to using the five areas of the HEA framework as the basis for the questionnaire used in gathering data and conducting anonymous interviews with students from different colleges and different stages of study to have a comprehensive picture of the students' perspective.

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Section 10

Cultural Issues and Human Resources

Factors Affecting the Equality and Diversity of Ethnic Minority Women in the UK Construction Industry: An Empirical Study

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Abstract

The construction industry has been notoriously known for being a male dominated industry with no room for change. As years have passed by, the industry has sparked a revolution of an increase of women joining the ranks. However, the industry is still known for its inequality and lack of diversity. The aim of this research was to investigate equality amongst ethnic minorities (EM's) in the construction industry, in particular female EM's, and establish the root causes of the lack of diversity. The sample of respondents consisted of construction professionals from all levels, comprising of 15 UK companies ranging from public to private sector firms, large, medium, and small companies. The findings showed 15 challenges and barriers faced by EM women in the UK. The main challenges were personal perceptions of negative treatment but a positive view on the collective of EM's women, EM's still believe that they are not treated equally in comparison to their white colleagues, the ingrained stigma of construction still being considered as a 'man's world' and cultural pressure and opposition from families that still exists in ethnic communities. It was also found that EM's have differing views on treatment and perceptions of the industry. Nevertheless, it was found that the construction industry has made changes. However, it needs to continually improve in order to open up the way for a more diverse workforce that is inclusive and fair for women from all walks of life.

Keywords: construction industry, cultural pressure, diversity, ethnic minorities, and women.

1. Introduction

The construction industry has faced several years of difficulty. An increase in projects has resulted in a demand for more qualified construction professionals, thus resulting in the infamous "skills shortage" that is having a detrimental impact on the construction industry (Gee, 2016). This skills shortage has resulted from factors such as retention, recruitment or just a general lack of knowledge of the industry at school level. However, according to the statistics obtained by UCAS there was a 3% rise in the number of UK students entering higher education in 2015 (UCAS, 2015). There is evidence that people are entering into higher education. More specifically there was a total of 12,910 undergraduate students in total that entered into a degree based in architecture and building and planning; with more female students than male (HESA,2016).

These numbers show that there is an interest in construction and yet there is still a shortage of qualified professionals. Evidently then, there are underlying problems affecting the industry but what are these underlying problems? Could the problem be a lack of interest from women or even women from EM's? The aim of the research was to investigate equality amongst EM's in the UK construction industry. In particular, examine the barriers to entry for

EM's, in particular EM women, into the construction industry by reviewing existing literature and analysing the causes of those barriers and identifying the root causes. This paper has then examined the viewpoints of female construction professionals through questionnaires and has drawn conclusions from that data. Based on the findings of this data, it has determined whether there are any challenges of inequality and how the Built Environment can begin to mitigate these barriers or whether the Built Environment is doing enough in regards to equality and diversity and if these barriers are just isolated instances.

2. Literature Review Findings

This literature review critically analysed established research of the barriers, root causes, available initiatives and drivers. Overall, 14 barriers were found for EM's. The literature review found 6 initiatives and 4 drivers for women and EM women in the Built Environment.

Across the world women face challenges and barriers into the world of construction. According to Gurjao (2014) India has more professionally qualified women in STEM subjects than the USA. This is remarkable in India which is culturally geared towards the favour of men and treating women as second class citizens. For centuries 'sex-selective abortion' has run rampant in India causing many female fetuses to be aborted because of their gender (Abrejo *et al.*2009). In a stark comparison the USA is well known for the 'American Dream,' the land of equal opportunity (Rank *et al.*2014) This dream offered immigrants a chance to build a prosperous life which would not normally be available to them in their country of origin. With that in mind, the assumption would be that the USA would have opened the way to EM's and yet India was leading the way for professionally qualified women. However, the researched examined other countries across the world and found different results. Women in the UAE experienced the barrier through cultural obligations. Omair (2010) found that the obligation for an Emirati woman is to look after the interests of her family and leave the career to the man of the house. Emirati women also have added religious connotations. However, even with the cultural and religious factors, women are able to attain higher roles through the government's Nationalisation programmes. Sadly, this came at a price. A woman would be expected to accept a lower salary to do the same job as a man if he was offered the job. Even though the government was actively encouraging companies to employ women, women still experienced those "glass ceiling" restrictions.

In Australia an investigation into cultural diversity on construction sites found that site managers do not accommodate for EM workers and even subconsciously encourage cultural divides (Loosemore *et al.*2010). They found that those workers who could not speak English proficiently or speak English as a second language were automatically mistreated in comparison to those that spoke English as their native tongue. The language barrier created an "us and them" attitude with those from similar ethnicities gravitating towards each other, rather than integrating with others on site. In comparison, the situation in Hong Kong was very similar to Australia. The majority of the workers on construction sites are from South Asian countries and they experience the same mistreatment and harassment. Wong and Lin (2014) stated that workers were paid less and were not entitled to the same benefits in comparison to the local Chinese workers. They also found that the majority of site based comments identified racial discrimination and bullying which ranged from name calling, racial graffiti, ignorance and social isolation. Ethnic isolation amongst minority groups was a key theme arising from experiences on site i.e. refusing to speak English to those who could not converse in Cantonese. The patterns emerging through these few international studies identified that minorities stuck together and the locals, regardless of their background, discriminated against other minority groups. It was almost ironic how EM's bullied other minority groups. The supposition would be that EM's would coalesce. However, the international research revealed that discrimination exists among any cultural group. So it was not obvious racism such as white and black. Rather, it was an ingrained inclination of "there are more of us than there is of them" which reiterated this "us and them" attitude.

In terms of treatment across the UK, the main factors that affected EM women in construction throughout recent years posed certain similarities to those found internationally. However, there were subtle differences. Loosemore and Higgon (2016) explored the reputation of the construction industry and found that "deep-seated cultural barriers" and an "ingrained stigma" prevented the industry from growing and collaborating with the social enterprise sector. The reputation of the industry appeared to be one reason as to why EM women avoided pursuing a career in the Built Environment. Another issue was the 'leaky pipeline' which is a metaphor used to describe how women 'leak' from STEMM subjects (Science technology, engineering, maths and medicine) at different stages (Resmini,2016). The research suggested that the industry lost women for reasons such as discrimination, unfair treatment and raising a family. Those women started at degree level but rarely made it through to completion due to those reasons. This was supported by the evidence contained in the 'Paula Principle' produced by Professor Tom Schuller. He wrote about the 5 main factors that affect a woman's career progression with one factor being

psychology (Revesz,2017). Brumfiel (2015) also found that psychology was a main factor as to why women leave the Built Environment. Occasionally, a woman's personal perceptions of her own ability to succeed in these fields prevent her from attaining a career in construction. A woman's lack of confidence can stifle her when making bolder career choices thus adding to the theory that a woman can literally be her own worst enemy. Another issue was the existence of the 'old boys club' stifling diversity in the industry. There was a lack of support for BME SME's to get onto any Approved Contractor's Lists. These lists predominantly contain "the more known and larger mainstream companies... 'favoured' contractors who are more likely to be white"(Steele and Todd,2005, pp.1018-1019). In order to alleviate this barrier, an EM individual or contractor would be expected to abandon their cultural heritage in order to fit in (Caplan and Gilham,2005). EM professionals were not encouraged to grow in their strengths or on merit. Rather, there appeared to be a process of breaking EM individuals down and rebuilding them so that they fit into this 'white' mould. It appeared difficult for EM females to fit in with the 'white laddish culture.' A woman may not avidly involve herself in the 'laddish' banter and jokes so she could be seen as a social outcast or even racially 'sensitive' in the workplace. This leads to EM women being excluded from other generic workplace activities and eventually leaving the Built Environment accepting field or profession. Byrne *et al* (2005,p.1032) also found evidence to suggest that EM's believed that they did not 'fit in' on site and were at a disadvantage before they even started work. They felt that the colour of their skin played a major part in how they are treated on site. This created an even bigger issue for EM women who face the potential of both gender bias and racial discrimination. Another barrier faced by EM women was in regards to their cultural obligations. Ceci *et al*.(2011) found that EM women who place having and raising children as a high priority are less likely to apply and hold higher ranking positions. However, women who did not possess this desire were noted as applying for just as many higher ranking positions as men. EM women believed that they could not have it all and they had to choose between having children and having a career. In conjunction with this, Chang (2006) identified that historically in EM communities, having children is seen as a cultural obligation. Due to the socio-cultural pressures, EM women felt pressured to leave their careers to have children. The consequence of this is the industry cannot retain the women it employed, thus losing skilled and qualified professionals.

The pattern emerging from the research, both nationally and internationally, was that the construction industry struggles to retain women from all backgrounds, particularly EM women. So not only was recruitment an issue, retention seemed to be a bigger problem. This referred back to the theory behind the 'leaky pipeline.' Although, the industry would like to think that there were no 'leaks,' the research showed that it was still an on-going issue. The factors that affected women were not only personal. There were also external pressures such as raising a family, cultural stigmas and overall treatment experienced by EM women both in employment and education. So the problems appeared to vary from country to country but seemed to be the same in the construction industry. EM's facing both cultural and site specific challenges and barriers whilst trying to maintain a successful career in the Built Environment.

The researcher explored the facilitators for EM's in the construction industry and found that there are numerous initiatives in place to help and support EM women. The researcher stated the success of the Athena SWAN Charter, the WISE Campaign as well as the other campaigns and events which are specifically aimed at EM women. One initiative which stood out was the 30% club. This was created to diversify board members in the financial sector. Now, a quarter of the FTSE 100 board members are female. This initiative must be tailored so that the Built Environment can benefit from a similar drive to recruit women into senior positions in construction companies.

The purpose of this research was to investigate the perceptions of EM women, the unseen barriers and struggles faced by EM women in their careers. The results of the research shone a deeper light on ways and methods that could be used to alleviate these barriers. However, in order to establish whether the bias still existed, the researcher looked to define whether the Built Environment in the UK had actively tried to improve recruitment and retention since the research in the literature review was conducted. Henceforth, the data collected from the questionnaires began to provide further insight into the current climate of diversity in the Built Environment in the UK. It also revealed certain patterns and stigmas that still exist in the industry.

3. Methodology

The researcher used a quantitative method in order to analyse both the raw data and the additional comments provided by the respondents. This was to ensure that factual data was analysed alongside participant's perceived viewpoints; in order to provide supportive evidence in the form of real life experiences. The questionnaires were constructed using closed ended questions with a rating scale which enables respondents to answer quickly and honestly (Farrell,2011). The questionnaires also contained 4 open-ended questions which allowed for the expansion of factual data on two questions and provided the respondent the opportunity to submit additional comments.

The sample of respondents were formed using stratified sampling (Crouch and Housden,2003). The sample consisted of construction professionals from all levels, comprised of 15 companies ranging from public to private sector firms, SME's and large corporate companies. In order to collect the primary data, the respondents were refined to a specific group. In this case the strata was female respondents. The researcher emailed the questionnaires to companies.

The questionnaire was created over a period of 2 weeks using findings from the literature review. Questions were structured to test and develop those findings. The researcher then distributed the questionnaires over a period of 1 week to the various companies. The researcher allowed 4 weeks for questionnaires to be completed and returned. Then the researcher began to code the responses and analyse the findings. The response timeframe was restricted to 4 weeks due to time constraints. If the researcher had more time, more questionnaires would have been distributed and a longer capacity of time would have been allowed. This would have broadened the pool of respondents but for the purpose of this research, only 20 questionnaires were analysed **(See Table 1).**

The data from the questionnaires has been analysed using a descriptive analysis. Farrell (2011) refers to a descriptive analysis as exploring perceptions towards a specific subject. This is done using the mode, mean, median and standard deviation. The data was divided into various sections which included graphs which highlighted patterns and comparisons across different ethnicities. Naoum (2013) refers to this as an analytical approach and the researcher found that certain patterns did emerge. There were also linked questions contained within the questionnaire. This enabled the researcher to interpret data in a more concise way by comparing the linked questions and the relationship in the responses.

Table 1 Respondents Details.

Main Details	Results
Gender	**20** Female respondents
Age	Average age: 36
Ethnic Background	White/British etc. = **14** Asian/Asian British = **2** White & Black Caribbean = **2** Black/Black British Caribbean = **1** Other (African Indian) = **1**
Construction Discipline	Quantity Surveyor = **8** Construction Manager = **2** Project Manager = **2** Health & Safety = **2** Site Manager = **1** Other = **6**
Education	Degree = **10** HND/HNC = **6** A levels = **2** NVQ = **1** Other = **1** Post Graduate = **1**
Experience in Years	Mean Experience = **10 years' experience**

4. Findings

As discussed in the literature review, the table below discusses how the respondents replied to the challenges.

Table 2 Respondents overall views.

Challenge	Respondents	Percentage
Negative Reputation of the Construction Industry: "laddish culture"	**17/20** said their experiences in construction were positive **3/20** were unsure	**85%** **15%**
Leaky Pipeline: Leaving the industry	**18/20** said they have not intentions of leaving the industry **2/20** were not sure whether to leave	**90%** **10%**
Personal Perception	**15/20** felt they had an equal opportunity for career progression **4/20** felt they did not **1/20** were unsure	**75%** **20%** **5%**
Fitting in on site	**15/20** felt valued in their current role **3/20** were unsure **1/20** disagreed	**75%** **15%** **10%**
Abandoning their Cultural Heritage	**15/20** agreed that EM women are treated the same as White/British women **3/10** were unsure **2/10** disagreed	**75%** **15%** **10%**
Workplace Discrimination	**10/20** said men and women are treated equally in the workplace **6/20** disagreed **4/20** were unsure	**50%** **30%** **20%**
Cultural Obligations	**16/20** did not feel that their ethnicity prevents them from achieving their goals in the Built Environment **3/20** were unsure **1/20** disagreed	**80%** **15%** **5%**
Community Pressures	**17/20** have not experienced negativity from their families due to the nature of their job role **2/20** have experienced negativity **1/20** was unsure	**85%** **10%** **5%**

Below are the additional highlights from the findings:

- Personal perceptions of negative treatment but a positive view on the collective of EM women which was found amongst all 6 EM respondents
- 83% of the EM respondents still believe that they are not treated equally in comparison to their white colleagues
- 17% of EM women were affected by the existence of cultural pressure and opposition from their families
- Gender bias: an ingrained stigma of construction still being considered as a 'man's world.' 50% of EM respondents agreed with this compared to 79% of White/White British Women that agreed with the gender bias
- Equal pay between men and women: 100% of EM respondents disagreed that men and women are paid equally compared to 50% of White/White British women who also disagreed, 43% that did not know if there was a pay gap and only 7% that agreed pay is equal between men and women in the built environment.

The main findings from the EM respondents were extremely insightful and shed further light onto the culture of the Built Environment in the UK. The main findings were the perception of the industry still being considered a male dominated environment with ingrained stigmas and deep seated barriers. However, as more women enter the industry this is starting to tip the balance of construction being a more acceptable career for women. It was also found that

EM's do not face as much opposition from families and communities although this still exists among some ethnicities. EM women still believe that they are not treated in equal terms with white women regardless of their professional qualifications or workplace position. A major finding was that there was a pattern of EM women answering positively to questions regarding the collective but answering negatively to questions which related to personal experience; thus indicating that personal perception is still proving an issue for EM's. It was also found that it was only the Asian/Asian British women that believed that native workers discriminate against the minority on site. The other minorities did not believe this to be the case. However, as the data showed, it was possible that this question was not properly understood; so this would need further investigating to establish whether this is still the case. One of the most interesting points that came from the research was the difference between EM groups. The Asian/Asian British respondents had a different outlook to the other EM groups. The overall data showed that women that came from EM's such as Black British or Mixed heritage backgrounds generally had more positive responses and agreed that construction has come a long way. The only 2 Asian/Asian British respondents had a very different outlook. This may imply that Asian/Asian British women experience more discrimination or negative treatment than Black British women.

The findings showed that although there are initiatives to get women and EM women into construction, there needs to be a bigger drive. This needs to be done at school level to educate young women into the 'real side' of construction. Education on career choices available to women in the industry needs to be improved and more widely available to a larger audience. It is possible for companies to offer work experience for students so that they can see what it means to work on site and in the various roles that the construction industry has to offer. The industry is at the risk of losing valuable knowledge and expertise unless it is transferred to the younger generation. A method of transferring this experience is to get employers to introduce more sponsorships, so that a company can transfer this experience by assigning an experienced construction professional to each apprentice or trainee. This a joint opportunity to balance the difference in technical expertise and enable women to be as valued as their male colleagues. Employers and educational institutes can join forces to develop the next generation of construction professionals and bridge the knowledge and experience gap experienced by women. This is an ideal opportunity to raise awareness for EM women on developing in construction relates careers thus aiding in the diversification of the industry.

5. Discussion

The responses from EM women indicated that there were still barriers for them in construction and the workplace. The similarities in EM comments were that if you worked harder and prove you belonged, you can have a successful career in the industry. It is possible but it requires a strong character to achieve these goals. EM's still face opposition from their families and communities but do not face as much pressure as they once did. This shows that there has been an improvement in the support from families. Asian/Asian British women believe that native workers discriminate against the minority on site.

Most of the White/British etc. respondents had not had a lot of experience working with EM women in the industry showing that there is a shortage of EM women in construction and the ones that are currently active in the industry had mixed views in regards to treatment.

EM women are still holding themselves back due to their own personal perceptions of success. The implications of this are that EM women cannot move forward unless they focus on improving their own outlook on their careers and treatment in the Built Environment.

6. Conclusions

The results revealed that there have been positive changes and that more EM women are venturing into the construction industry as a career choice. However, the results also reveal that it is not quite perfect yet. There is still room for improvement and there are stigmas and prejudices that still exist. For example, for EM's the main finding was that they answered positively regarding other EM's as a collective. However, when it came to personal experiences EM's answered negatively. It seemed as though EM's personal perceptions of their treatment was negative but they view other EM's as succeeding more in their careers. Another example was that EM's with professional roles and qualifications still believe that

they are at a disadvantage compared to white women. The other finding was that although EM's do not experience the same level of cultural resistance, it still exists in some communities. Some EM's still experience opposition from their families. In comparison, white women do not experience the same level of culturally driven challenges.

The research showed that the stigma of construction being a 'man's world' still exists in the present day. There are initiatives which are in place to support women in construction in education and in the workplace. However, the main finding from the initiatives is that the Built Environment is lacking women in senior and board roles. The implementation of a tailored 30% club for the construction industry is a must if the Built Environment is to drive diversity across all levels. Women across the board are still fighting for their belonging in the industry. Some experiences show that their companies are more acceptable of them whereas others have had bad experiences with their colleagues or companies as a result of attitudes or out dated company policies. Avenues for further research included the potential for additional interviews with more EM women across the board to delve deeper into their perceptions of the industry. It would also provide a way of distinguishing the differences between EM's such as between Asian/Asian British, Black/Black British and Mixed Heritage women. In order to explore these areas, interviews would provide in depth experiences and the reasons behind these responses rather than speculating on the current data.

In summary, it is the responsibility of the construction industry to improve its working practices in order to develop and grow into a more acceptable industry. The onus also falls on EM women to work on improving their own perceptions of the value of their own careers and their belonging in the Built Environment. The potential of changing the outlook and working practices of the industry will begin to change the dynamics of the industry and create more inclusive working practices.

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Staff Perceptions of the Link between HR Practices and Organisational Performance: A Study of Bahraini Private Universities

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Abstract

Recently there has been an increased focus on the importance of HR practices in terms of how they impact on organisational performance. This has been associated with the change in the role of HR in organisations from being purely operational to being strategic. While the direct link has been well researched and conclusions generally positive, much of the research fails to provide an accurate definition of 'organisational performance' or is methodologically flawed. Also, it is often limited to a very small range or even a single HR practice. Prominent scholars in this area of research have frequently suggested that there is a need to have a better understanding of how HR practices are related to the performance. The research reported here examined the link between HR practices and staff perceptions of organisational performance and examines the effect of key mediating variables – organisational culture, employee commitment and employee retention. The HR practices which are used as the dependent variable are Recruitment and Selection, Training and Development, Contingent Pay and Reward, Performance Appraisal and Employee Retention. A set of research hypotheses concerning the links was formulated and data was gathered using questionnaires. It is very important to note that the research took cultural considerations into account. Most of the research on HRM models or theories in this area have been rooted in a western tradition but it is questionable whether this applies across cultures. Qualitative data analysis (Structured equation modelling using the PLS method) confirmed the positive relationship between direct and mediating variables. Qualitative analysis of the results further explains the nature of these links and explains the relative importance of specific HR practices in the search for improved organisational performance.

Keywords: Strategic HRM; Bahrain Private Universities; Organisational Performance, HR Practices; HR Mediators; Black Box Theory.

1. Introduction

The development of Strategic Human Resource Management and its impact on achieving sustained organisational performance has been the subject of research since the early 1980's (Hicks, 2016). General studies into strategic management by prominent researchers in management practice (e.g. Porter, 1980; Drucker, 1999) contributed to the view that HRM practices are one of the most important sources for sustaining the competitive advantage of companies. This gave rise to considerable body of literature which attempted to demonstrate the direct link between HRM practices and the performance of organisations (Bowen and Ostroff, 2004). However, despite the large body of 'evidence', relatively little research has been conducted into the mechanisms which are significant in that link. Prominent scholars have frequently suggested that there is a need for a better understanding of *how* HR practices are related to the performance of organisations (Boxall, 2014; Mansour et al., 2015). The research reported here, therefore, explores the mechanisms by which performance of organisations, specifically private universities, is potentially enhanced through the adoption of strategic human resource management practices.

2. Rationale for the Research

There are a variety of reasons that have had a significant role in highlighting the importance of HRM as means by which organisations can gain a competitive advantage. These are linked with

the emergence of the 'resource-based view' of organisational effectiveness; the evolution of the concept of 'competencies'; the emergence of the importance of knowledge and its management within organisations; and, the emergence of the concepts of human and intellectual capital (Giannakis et al., 2015).

These led to a focus on changing the role and function of the HR Department. The 'administrative' role of the HR Department as typically being a 'personnel management' department changed to reflect the fact that the HR Department now played a significant role in providing strategic direction and improving organisational performance. (Storey, 1992).

However, a question remains for researchers concerning how it fulfils that role. This is frequently referred to in the literature as the 'black box' problem. (Purcell, 2003). As Wright and Gardner noted:

> "One of the first issues that must be settled in the effort to understand how HR practices impact performance is to theorize the means through which this relationship occurs, in essence specifying the intervening variables between the measures of HR practices and firm performance." (Wright and Gardner, 2000: p.4)

As Boxall (2016) stated:

> "Over the last 20 years, researchers have been trying to throw light on the question of how key variables are connected in 'the murky chain of links between HR goals and performance outcomes" (Boxall, 2016 p.103)

This research builds a model which, through an extensive literature review, identifies the key variables in terms of HR practices which contribute to organisational success and the way they are inter-related. It also considers the key tenets of AMO theory (Boxall and Purcell, 2003) and considers the context in which the HR practices are applied. It also pays particular attention to the role of organisational culture, employee commitment and employee retention as mediators which can influence the outcome of organisational performance (Schoemmel and Jonsson, 2014).

3. Context of the Study - Bahrain Private Universities

This study was conducted in Bahrain and it focused on private universities. The five Bahraini universities who participated in the survey are working in the same environment and must adhere to the same requirements of the national authorities. It is recognised in the literature on higher education that delivery of high quality education is dependent on the quality of the academic staff within the university but there is very little literature specifically dealing with HRM practices in the Kingdom of Bahrain or the Gulf region.

In the private university sector in Bahrain, organisational performance is determined mainly by three factors. Firstly, the financial performance of the university (generally a function of the number of students it can attract). Secondly the success of the university in quality assurance reviews which can fundamentally affect their ability to offer degree programmes, and thirdly the reputation of the University for providing high quality education. Whilst in many western countries a variety of performance measures are available through government published sources (e.g. The Higher Education Statistical Agency in the UK) this is not the case in the Kingdom of Bahrain. This situation is made more difficult because of the competitive nature of the sector and hence an understandable reluctance to openly share accurate data on performance.

4. Organisational Performance

A significant point in terms of the context of the research is how to define and measure organisational performance. Organisational performance is widely used as the dependent variable in any research targeting organisations which seeks to demonstrate an improvement resulting from an innovation or intervention. The study of organisational performance is still ambiguous and consists of a set of 'loose constructs' (Rogers & Wright, 1998). To understand the relationship between HRM practices and organisational performance, there is a need to review measures of performance that are used in HRM research (Wright and Nishii, 2013; Bahri, M. et al., 2017). Financial performance measures are extremely difficult and often inaccurate. HRM practitioners such as Pfeffer (1998) suggest that a focus on financial and accounting measures of performance could ultimately prove to be futile. In addition, as Smart (2003) noted, measuring performance in education is very important but also very complex.

The outputs from universities may, for example be measured in terms of the quality of graduates which they produce or the quality of the research outputs of their staff or the degree to which they engage with the community to disseminate knowledge or expertise.

Because of the lack of accessible data on performance measures the researcher decided to measure organisational performance indirectly by gathering data from staff in the various universities participating in the research on their perception of organisational performance. While there are no formal league tables for the University sector in Bahrain there are shared perceptions within the sector itself on the relative reputation and performance of different private universities and respondents were clearly competent in being able to self-report their views on their own university's performance.

5. HR Practices

Historically the initial attempts to research the link between HR practices and organisational performance were published in the middle of the 1990 and the seminal article in the field which has been repeatedly cited in further studies was by Huselid (1995). The publication of Huselid's empirical study was a catalyst to further research in the area. The following section lists the HR practices used in this study – the reason for selecting these practices was based on their relevance to the Bahraini private universities being studied and on their fit with SHRM practices which have been identified in the literature as having a very specific link with organisational performance.

- Recruitment and Selection;
- Training and Development
- Contingent Pay and Reward Schemes (Compensation System);
- Performance Appraisal, and;
- Employee Relations and Involvement

6. HRM Outcome Mediators

Most prior studies have examined the relationship between the above listed HRM practices and organisational performance directly. It is now, however, accepted that this approach is not the only way in which the link can be investigated as HRM practices can affect performance indirectly through intervening factors referred to as HR outcome mediators. Both direct and indirect influences should be considered in research. This implicitly accepts the arguments of Becker and Huselid (1995), who supported the view that a causal relationship exists from HRM practices to organisational performance, both directly and indirectly. Essentially it is important to ensure that research explores the potential impact of mediating pathways. 3 major mediators were identified following an extensive survey of the literature.

6.1 Organisational Culture

A theory of organisational culture has evolved through a combination of research grounded in organisational psychology, social psychology, and social anthropology (Scott, et al., 2003). It is concisely defined by Hofstede as:

> "Collective programming of the mind which distinguishes members of one organisation from another" (Hofstede, 1998, p.2).

Generally, cultures affect different aspects of life and in organisations it has a significant impact which can be directly influenced by HRM practices and policies. A range of studies have examined this from different perspectives. (Ngo and Loi, 2008; Darwish et al, 2016). Drawing on previous works, the researchers developed a conceptual model that links the constructs together.

6.2 Employee Commitment

Employee commitment has also been studied extensively over the past three decades due to the belief that commitment among employees will result in greater organisational effectiveness and productivity (Fiorito *et al.,* 2007; Meyer & Allen, 1997). The construct received wide attention in organisational psychological research (Wayne et al., 2013). Organisational

commitment refers to the extent to which employees of an organisation see themselves as belonging to the organisation (or part of it) and feel attached to it (Meyer et al, 2013).

6.3 Employee Retention

As pointed out by Noe *et al*. (2003) this includes both voluntary and involuntary termination of service. Involuntary turnover is usually driven by the organisation to remove a chronically low performer or problem employee or to react to external pressures to cut costs. Voluntary turnover is initiated by the employee.

7. The Study Model and Hypotheses

Building upon the previous discussion of HRM practices, organisational performance, outcome mediators, and the need to explore the inter-relationship between these the researcher created model to test the interrelated impacts within these variables. A set of hypotheses were developed to test the link between the variables.

7.1 Study Hypotheses

The researcher formulated five main hypotheses, where each of the main hypotheses from 2-5 is divided into two sub hypotheses.

H1: Staff in Bahraini private universities perceive that HRM practices directly, positively and significantly affect organisational performance.

H2: Staff in Bahraini private universities perceive that employee commitment mediates the relationship between HRM practices and organisational performance.

H2a. Staff in Bahraini private universities perceive that HRM practices directly, positively and significantly affect employee commitment.

H2b. Staff in Bahraini private universities perceive that employee commitment directly, positively and significantly affects organisational performance.

H3: Staff in Bahraini private universities perceive that employee retention mediates the relationship between HRM practices and organisational performance.

H3a. Staff in Bahraini private universities perceive that HRM practices directly, positively and significantly affect employee retention.

H3b. Staff in Bahraini private universities perceive that employee retention directly, positively and significantly affects organisational performance.

H4: Staff in Bahraini private universities perceive that organisational culture mediates the relationship between HRM practices and organisational performance.

H4a. Staff in Bahraini private universities perceive that HRM practices directly, positively and significantly affect organisational culture.

H4b. Staff in Bahraini private universities perceive that organisational culture directly, positively and significantly affects organisational performance.

H5: Staff in Bahraini private universities perceive that organisational culture directly and positively affects the mediation variables; employee commitment and employee retention.

H5a. Staff in Bahraini private universities perceive that organisational culture directly, positively, and significantly affects employee commitment.

H5b. Staff in Bahraini private universities perceive that organisational culture directly, positively and significantly affects employee retention.

7.2 The Study Model

This model developed which was used to test these hypotheses is graphically illustrated as follows:

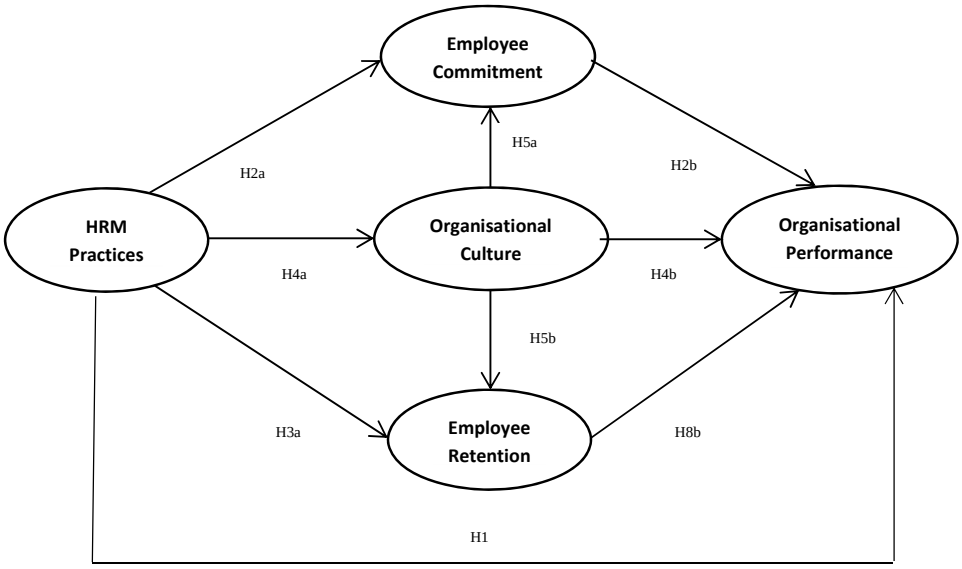


Figure 1 Study hypotheses within model.

8. Data Collection

Primary data collection was carried out through distribution of the self-administered questionnaire to the academic staff, managers, and employees in 5 sample universities. These comprised five parts with total of sixty-five (65) items. 300 questionnaires were filled out and returned to the researcher, of which 280 were eligible for analysis. Therefore, the response rate was 84%. The questionnaires covered the following areas.

8.1 Demographic Information

This section consists of items formulated to collect information about the respondents.

8.2 HRM Practices

This section encompasses 33 items aimed to measure the attitude of the respondents regarding their university's HRM practices within the 5 areas of HR practice identified above. Respondents were asked to indicate their response to the items through Likert scale which ranged from (1) ''strongly disagree'' to (7) "strongly agree". A single overall score to summarise the result for each HRM practice was computed. Standard questionnaires used in previous research into HR practices were used but modified to reflect the context in which they are used in the Kingdom of Bahrain.

8.2.1 Recruitment and Selection Measurement

Snell and Dean's (1992) acquisition scale was used. This scale measures the breadth and depth of an organisation's approach to recruitment. This measure has employed in various other studies and has been reported as having high validity and reliability. The crucial measurement within the questionnaire assesses whether respondents perceive that the university achieves its goal of |hiring the right person for the right job".

8.2.2 Training and Development Measurement

The training instrument questionnaire was also adapted from Snell and Dean (1992) and is a seven-item index designed to gather data on how extensive staff development policies are and whether the procedures operate effectively

8.2.3 Contingent Pay and Reward Schemes Measurement

Questions were adapted from the previous works by Rogg et al. (2001); Kang, Stewart and Kim (2011) and Guerrero and Herrbach (2009). The researcher synthesised an assessment tool to assess HR contingent & reward schemes which consisted of 8 statements.

8.2.4 Performance Appraisal Measurement

Seven questions regarding performance appraisal were designed by to assess employees' perceptions of fairness, the importance of performance appraisals and adequacy of feedback as well as how the performance appraisal benefits their career.

8.2.5 Employee Involvement

The statements used were drawn from a study of literature and the questions are adapted from different studies (Ghebregiorgis & Korsten, 2007; Tzafrir, 2005).

8.3 Mediating Variables

This part of the questionnaire deals with HRM outcomes with the focus on the mediating variables described above.

8.3.1 Organisational Culture

The organisational culture instrument was adapted from Cooper and Viswesvaran, (2011), and Shahzad et al. (2012) and Judge and Cable (2006). The instrument measured three dimensions of organisational culture: Adaptability, Work Environment and Innovation.

8.3.2 Employee Commitment

Mowday, Steers and Porter (1979) and Meyer and Allen (1997) instruments have been widely used to measure employees' commitment. In this study, nine statements from these instruments were found to be appropriate in the Bahraini context and others were omitted.

8.3.3 Employee Retention

Employee retention (or intention to remain) was measured by utilizing 8 items adapted and edited by the researcher from TL-100 ©2010 Manpower Inc. (*us.manpower.com*). This questionnaire needed significant changes to fit in with the Bahraini context where contractual conditions and legal framework for retaining staff is quite different from that in the West.

8.4 Organisational Performance

Organisational performance was measured through 7 items. The measurement is adapted from Katou (2008) to include multiple dimensions of organisational performance. The specific items constituting the organisational performance construct were as follows: *"*Effectiveness*"*, which centres around the fact that objectives (or organisational mission) are being met; *"*efficiency*"*, which means that resources are not wasted and the fewest possible resources are used to meet objectives; and *"*development*"*, which concerns the question of ability of an organisation to develop and react to future opportunities or is prepared to meet future challenges. The questionnaire by Katou had to be extensively modified as it was very biased towards a commercial environment and questions had to be rephrased to fit with the perspective of how a university typically views organisational performance.

9. Data Analysis and Results

To analyse the data collected from the survey, SPSS software was used for descriptive statistics, and structural equation modelling (SEM) was applied using the Partial Least Square (PLS) method for detailed data analysis. The Smart PLS 2.0 M3 package was used for validating the

research model and testing the research hypotheses. A large body of literature has documented the use of SEM in different research fields (Gefen *et al.,* 2000). PLS is considered better suited for explaining complex relationships (Fornell *et al.,* 1990). A two-stage methodology (Anderson & Gerbing, 1988) was adopted. The first step was to test the content, convergent, and discriminant validity of constructs using the measurement model, whilst the second step was to test the structural model and hypotheses.

9.1 Measurement Model

The researcher assessed the reliability and validity of the measurement instrument using content reliability, and convergent validity criteria. The content validity of the survey instrument was assured in that the constructs along with their measures were already validated in previous studies. For reliability Cronbach's alpha was used - a common method used to measure the reliability and internal consistency of scales. (Cronbach, 1970; Hair *et al.* 2006) The reliability of the scale is generally accepted if the value of Cronbach's alpha for each construct is equal or greater than 0.70. The constructs included within the study's model exhibited a high degree of internal consistency as the values of Cronbach's alpha were all within the range 0.87 (Organisational Culture) to 0.93 (HRM Practices), Composite Reliability (CR) and Average Variance Extracted (AVE) tests were conducted to measure convergent validity. Fornell and Larcker (1981) suggested that the value of the AVE must exceed 0.50 for the convergent validity to be assured. The CR and AVE values for the constructs included in the study model, with one exception, are all above acceptable levels. Moreover, the standardized path loadings for all indicators were above 0.50 and thus they are all significant (Falk & Miller, 1992). The exception was the second statement given on organisational performance i.e. '*The University achieved its stated goals over the past three years while providing adequate resources*.' Given that the path loading for this was the weakest it was deleted first and the model were reassessed. Thus, content validity, reliability, and convergent validity of the measurement instrument are all satisfactorily met in this research. Discriminant validity, it is established when the square root of the AVE from the construct is greater than the correlation shared between the construct and other constructs in the model (Chin, 1998). The discriminant validity of the measurement instrument is confirmed in this study given that the square root of the AVE from each construct met acceptable limits.

9.2 Evaluation of model fit

To test the model fit used a Chi squared test. In this case the χ^2/DF was computed as 1.865 which demonstrates a strong indication of the model's fit.

9.3 Structural Model

The results of the PLS-SEM analysis are presented in Figure 2 Results indicated that HRM practices have significant and direct effects on employee commitment, organisational culture, employee retention and organisational performance (β=0.360, p≤0.001; β=0. 0.638, p≤0.001; β=0.392, p≤0.001; β=-0.121, p≤0.05; respectively). Results also revealed that organisational culture is also a major predictor of employee commitment, employee retention and organisational performance (β=0.341, p≤0.001; β=0.461, p≤0.001; β=0.734, p≤0.001, respectively). Further, the results also indicated that employee retention has significant and direct effects on organisational performance (β = 0.149, p ≤ 0.05). Finally, it was found that employee commitment has a direct significant effect on organisational performance (β = 0.130, p = 0.020). The pathways tested can be summarised as follows:

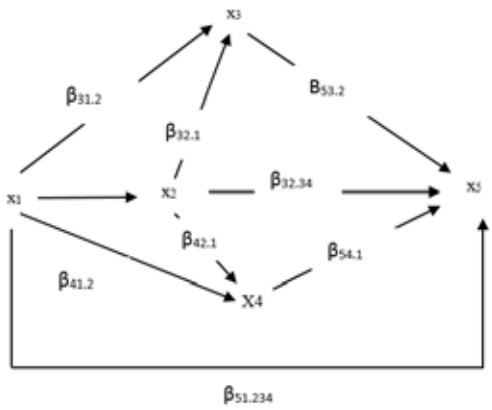
$x_1 = \mu_1$

$x_2 = \beta_{21}x_1 + \mu_2$

$x_3 = \beta_{31.2}\, x_1 + \beta_{32.1}x_2 + \mu_3$

$x_4 = \beta_{41.23}x_1 + \beta_{42.13}x_2 + \beta_{43.12}x_3 + \mu_3$

$x_5 = \beta_{51.134}x_1 + \beta_{52.134}x_2 + \beta_{53.129}x_3 + \beta_{54.123}\, x_5 + \mu_5$



9.4 Testing mediators

Finally, to test the mediating role of employee commitment, organisational culture and employee retention, this research employed the causal steps approach based on the work of Baron and Kenny (1986). Baron and Kenny's paper has been cited over 8,120 times that adds credibility to this method (Bontis *et al.,* 2007). The steps are shown graphically in Figure 3 (below).

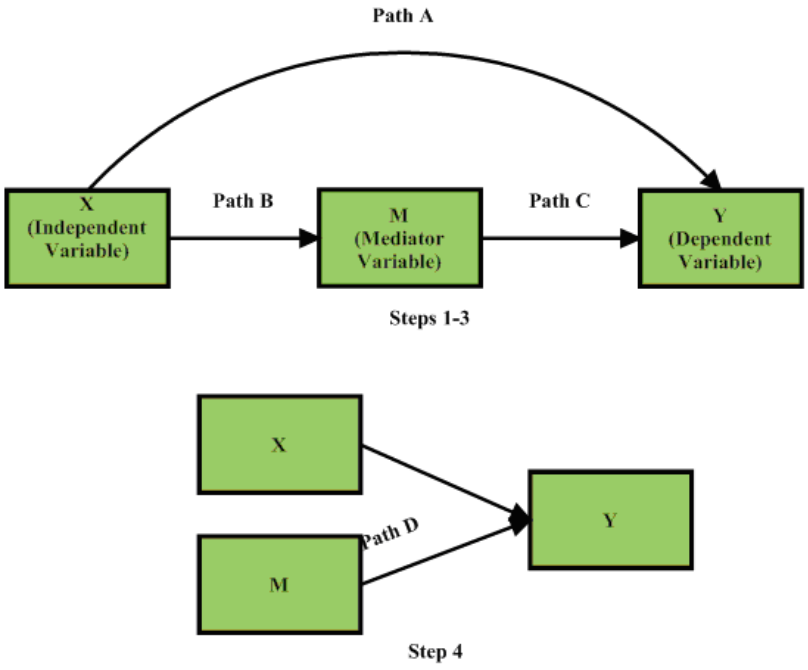


Figure 2 Testing the mediating effect.

The goal of above steps is to establish that zero-order relationships among the involved variables are existent (i.e. Path A, Path B, and Path C are significant). If one or more of these relationships are non-significant, then mediation is not likely.

The following equations depict the forecasting model based on the study model

$y = 2.395 + .513X_1$

$y = 2.321 + .369X_1 + .206X_2$

$y = 1.838 + .291X_1. 151X_2 + .218X_3$

$y = 1.793 + .267X_1. 123X_2 + .190X_3 + .089X_4$

$X_1: Human\ resource\ practices$

$X_2: Organizational\ Culture$

$X_3: Commitment$

$X_3: Retention$

y $: Organizational\ performance$

The results demonstrated that all paths were significant and thus the mediation roles of organisational culture, employee commitment and employee retention were all confirmed as significant.

10. Discussion

10.1 Quantitative Results – Confirmation of hypotheses

All research hypotheses and sub-hypotheses have been shown to be supported from the empirical tests described above. The *results* indicated that the research model explained 64% of the variance in staff perceptions of organisational performance (R^2 = 0.641). The results confirm the theoretical claims of several previous research studies which have been conducted on similar pathways in the model developed by the researcher.

10.2 Questionnaire results and qualitative responses

The data from the questionnaire survey was also put into an SPSS file. This allowed the researcher to look in detail at overall responses to particular questions and where interesting trends were identified the data was explored further. The following observations are therefore presented to give a more descriptive picture of the questionnaire responses and to note points which may also be seen as assisting in 'opening the black box'.

With some notable exceptions, responses displayed a very positive view of how the sector was performing - in particular the implementation of quality assurance procedures and a concern to provide a high-level teaching experience to students. Comments on workload, the difficulty of finding time for research and the burden of administrative responsibilities were frequently made but it should not be concluded that this is particularly a feature of the situation only in private universities within the Kingdom of Bahrain).

10.2.1 Mediating variables – Organisational Culture, Employee Commitment and Employee Retention

In terms of organisational culture, it was clear that from both positive and negative comments this is viewed by staff as extremely important and there is clearly a strong link between how the level of satisfaction with the working environment and how this links with the staff perception of institutional performance. The overall picture is very positive in terms of the satisfaction of staff with the environment in which they work with their colleagues but less so in terms of the communication channels within institutions and relationships with senior management

From a cultural perspective, there is a very strong emphasis in Bahrain on commitment and loyalty of employees. This is very much reflected in the responses in this section. The most significant indicator of the high overall level of commitment was provided in question 7 of the questionnaire on employee commitment, which attempted to find out the extent to which employees felt 'emotionally attached' to the organisation.

The responses on retention and in particular the response to the first question asked in this section of the questionnaire on career development tended to have lower levels of satisfaction. Again, as noted when discussing this aspect of employment in Bahrain this is may be explained

by the working practices and legislation which tend to and approach in which relatively short-term contracts are the norm.

On examining the data in detail two interesting trends are apparent. The first is the trend for non-Gulf staff to rate the potential for career development lower (and to an extent this was also true of their responses to questions 4 (dealing with employee reward and recognition) and question 8 (dealing with university management support for employees). Again, the explanation is probably bound up in cultural differences in how Gulf staff and staff from other geographic regions are treated within employment practices.

The second was a low response to career development by staff who identified themselves as senior management. The results noted above did not significantly skew an otherwise very positive response but it is important to note that such variations are present.

10.2.2 HR Practices in Bahrain

Examining the responses to the part of the questionnaire devoted to recruitment and selection there was a high level of uniformity and a high level of satisfaction with both the processes used by the universities to recruit suitable candidates and ensure that the most suitable candidate was selected.

In the section of the questionnaire dealing with training and development there was a difference in responses from those who were administrative staff and academic faculty. The administrative group of staff were consistently more supportive of training opportunities and the time provided to undertake formal training. On the other hand, academic staff were more critical of the training opportunities and of the amount of money which was devoted to training.

This is best explained by what staff interpreted as 'training'. It was clear from written comments on the questionnaire that some academic staff were not satisfied with the opportunities made available to them for their own subject specific development – in particular the lack of opportunity to attend international conferences and seminars was noted by 23 academic staff. This indicates perhaps that this is an area in which the universities should be more proactive – particularly as some respondents also expressed the view that whether or not a member of staff could get permission to attend conferences was arbitrary and the process for approval not clear.

The questionnaire results show a positive attitude to pay and reward. For both academic and administrative staff, the results show a high level of satisfaction with the reward schemes in place – note was made by 18 staff across 3 universities which indicated they were particularly satisfied that results from good performance in quality assessment exercises were rewarded through bonuses.

The questionnaires show that the performance appraisal system as perceived by the staff is fairly simple but comments on the questionnaires indicated a high level of satisfaction with the systems being used for performance appraisal. The only area in which responses were more negative was around the final question of this section which dealt with the link between performance appraisal and promotion opportunities.

The responses on employee involvement were positive across all staff. Staff clearly feel that they have all of the information they need to work effectively and that they are confident that they can make decisions within their own particular areas of responsibility.

11. Future Research

Future research should include more universities both public and private. In addition, future researchers should also consider moderating variables such as national culture, the labour market and legal and regulatory environment. Moreover, the current study used a cross-sectional design, and it would be valuable to conduct a longitudinal study to examine whether the variables and their relationships are consistent over time.

It should also be noted that the research has collected a large and useful data set which represents a significant population in terms of the employees of Bahraini private universities. There is potential to 'mine' this data further. It would be interesting to examine the data and draw comparisons between some of the different groups of respondents to the questionnaire survey and explore qualitative data more extensively. A balance between a statistical approach to the data and more subjective measures is consistent with the approach advocated by Singh

et al in the case they put forward for subjective measures of organisational performance (Singh et al. 2016).

Finally, the results reached in this study are believed to assist Bahraini universities and other Arab countries with similar characteristics. However, comparative studies would be valuable to compare the findings of this study with other developing countries e.g. in Jordan (Darwish et al. 2013) or Brunei (Singh, 2013). By conducting a similar study on different countries that perhaps share basic characteristics with Bahrain, the findings reached might be compared to the results of this study, and affirm, refute, or extend its results.

12. Conclusions

This research study has thoroughly reviewed the literature related to human resource management practices and organisational performance and developed a model which comprises not only the direct link between HR practices but also takes into account the role of mediating variables. The research has made a significant contribution to elucidating the mechanisms by which HR practices can influence organisational performance It provides a methodological framework which can be replicated in a wide range of contexts. The impact of the research can be seen in its theoretical contribution to the literature on the impact of strategic HR practices on organisation performance and also in terms of the guidance which it provides for practical application of strategic HRM.

It provides empirical evidence based on the rigorous application of statistical techniques of the effect of HRM practices (training and development, recruitment and selective hiring, and compensation) on organisational outcomes related to staff perceptions of organisational performance (innovation, efficiency and effectiveness). In addition, it supports an examination of the "black box" and the way in which a range of variables can affect research outcomes which is on the whole, not dealt with in the current literature (Chowhan, 2016). Through the investigation of the multiple aspects of the internal management process the research contributes to the HRM practices literature by enhancing our understanding of how HRM practices can be implemented and managed

In terms of practice, the results of this study strongly support the view that managers need to understand the significant role played by the prevailing culture in their organisations in order to develop those culture types that encourage employee commitment. Hence, the current study reinforces the need to continuously invest in programs, processes, and systems, which target organisational culture in a way that employee commitment is improved.

Finally, in terms of the central mechanism which supported this research – i.e. the consultation and elicitation of views and opinions of all staff within the organisations being studied, there is an important message for HR managers. Put simply, this is to constantly consult with and consider what their employees value and how they perceive how they can contribute the organisation's primary goals and objectives.

Rather than simply being a custodian and enforcer of established policies and administrative procedures, the HR manager must assume the role of facilitator and guide to ensure that the appropriate use of strategic HR policies ultimately impacts positively on organisational culture and the performance of the institution.

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The Effects of Human Resources Practices in Libyan Banks Sector on Client Behaviour Intention to Subscribe In Islamic Finance System

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Abstract

This study aims to investigate the human resources practices in Libyan public banks and the moderating effects of the government support on the relationship of human resources practices in Libyan banks sector (service quality) and the intention to subscribe in the Islamic finance system in the banking sector. The study looks into the bank's human resources management, service quality provided by the banks. The study reported results of surveys taken by Libyan's bank clients. Using a primary data collection method 400 questionnaires were distributed to target respondents comprising of Libyan banking subscribers from several cities in Libya. 226 questionnaires returned representing 56.5% response rate. The data were analysed using Structural Equation Modelling (SEM) version 22. The study proposes one direct causal effects and one moderating effect variable in the structural model. Service quality provided by banks found to be significantly affected on clients' intention, where government support found to be a valid construct in the prediction of the intention to subscribe in the Islamic finance system in the Libyan banking sector. The study results may lack generalizability. Further research need to be considered using different variables.

Keywords: Islamic finance system, Human Resources Management, Banking Sector, Libya, Behavior Intention.

1. Introduction

Sharia Compliant Financial System (SCFS) is a financial system which is governed by Islamic law (Sharia) principles. The fundamental feature of the Sharia Compliant Financial System is the prohibition in the Quran of the payment and receipt of interest usury (Riba). The strong disapproval of interest of Islam and the vital role of interest in modern commercial banking systems led Muslim thinkers to explore ways and means by which commercial banking could be organized on an interest-free basis.

Basically, unlike conventional finance system, SCFS undertakes its operations with no paying either receiving any Riba "Interest". The first developed of the Sharia compliant financial system was in the 1950s and lead to the establishment of the first generation of the Sharia compliant investment banks in Egypt as well as Malaysia in the early 1960s. There are a big difference between the two systems (Conventional and the Sharia Compliant Financial System) in terms of profitability (Bakar, 2010; Hanif, 2011; Loghod, 2007). This system has spread to become an increasingly significant segment within the global financial market, it has been recognized as a viable model and competitive financial intermediation in the Muslim countries as well as outside the Muslim world and offers a wide range of financial products and services. SCFS has shown that began on a modest scale since its inception as a new vision of Islamic finance banking system in the mid-1970s rapid expansion and development over the past three decades, which become one of the fastest growing industries recorded an annual growth rate of double-digit for almost 30 years (Al-omar & Iqbal, 2011; Macmillan, 2006; Molyneux, 2005).

The amount of the Sharia compliant finance system organization "Institutions/ banks" around the globe are goes above 500 (TheBanker, 2010). More than 284 financial institutions operating as a fully-fledged of Islamic finance system" in 38 countries and manage more than 250 billion US dollars (CIBAFI, 2016). This does not include conventional banks that offer financial products and services through the Islamic window operations "dual-system", which appreciates CIBAFI to manage about 200 billion US dollars (Oseni, 2013). Sharia-compliant

finance system has proved its existence as a new strong competitor to play important role in the financial market. Hence, an amount of conventional banks such as Citibank, Barclays, and so on, offering Sharia compliant products and services (Karbhari, Naser, & Shahin, 2004). The recent unprecedented achievements of Islamic banking have led the International Monetary Fund (IMF) and the World Bank to recognize Islamic financial products as valid means of financial mediation and have published studies and papers to this effect. In Libya, for hundreds of years Islam has been the official religion (Lapidus, 2002). During the 1970s, Islam in Libya played a major role in legitimizing spheres of political and social reform, but not in the realm of economics and finance. Soon after taking office, the revolutionary government expressed a clear desire to exalt Islam and restore it to its proper central place. Several steps have been taken by successive governments trying to prove themselves as a devout Islamic government. During the time of the previous government, Libyan banking sector witnessed the significant transformation, characterized for more than three decades by massive state intervention in the commercial banking sector (Omar & Abdul Ghani, 2016). This transformation has led the sector to unacceptable performance and to be less diverse in term of its banking services and products compared to other developing countries. This study aimed to explore the possibility of practicing the SCFS and its banking method's in Libyan context by analyzing it within the larger body of Libyan banking and the transformation it has taken. The study analysis is purely academic and does not suggest or imply a certain path for the state and monetary authorities to follow. The research simply describes the situation as it is and explains how they could appear in the event of Islamic banking establishing a presence.

2. Research Issue

The market power and pure technical inefficiency that has largely resulted in the overall inefficiency of Islamic banks, does not significantly impact on efficiency in the Middle East; there still ambiguity for that assumption whether Sharia Compliant banks from outside the Middle East region are relatively new and very much supported by their regulators (Tahir, Bakar, & Haron, 2011; Yudistira, 2004). There are very limited studies confined themselves to the conventional bank's clients' satisfaction and leave unanswered questions about the actual reason behind on-going practices and effective use and adopting of the SCFS in the banking sector. Gait, (2009) stated that, there is a need to investigate the relationship between service quality and clients' intention and satisfaction in developing countries. The relationship between service quality CARTER model, behavioral intention to subscribe the SCFS, is inconclusive, in consequence studies provide mixed results with regard to this relationship. A study conducted by Gait and Worthington, (2008), resulted that around 72.3% of the Libyan business firms have the tendency to use the SCFS productions, regardless of informal practice of the SCFS institutions in the country.

In the context of Libyan banking sector, without the cooperation between the government and the banking sector, low development of Sharia financial system industry will arise which will render them unable to tackle the challenges and the issues that are hindering local brand development (Numan, 2008). Kaynak, (2000) revealed how companies in Bangladesh receive government supervision for them to serve the consumers' needs in a superior manner. Several studies have established a positive and negative relationship of perceived behavioural control and purchase behaviour (e.g. Antonia *et al.,* 2009; Marie *et al.,* 2009; Morven *et al.,* 2007). Besides, there is a part of the research problem which is the mixed and inconsistency of findings regarding the service quality (CARTER Model) factors influencing client satisfaction as well as clients' behavior intentions (Ranjbarian *et al.,* 2010; Karim, 2012; Osman, Ali, Ramdhani, Ramdhani, & Kurniati, 2011; Estiri, Hosseini, Yazdani, & Nejad, 2011; Gan *et al.,* 2011).

Moreover, inconsistent findings were found regarding the effect and relationship of CARTER Model and clients' behavior intentions, while some authors indicated a positive relationship between these variables (Marie *et al.,* 2009; Ramdhani *et al.,* 2011; Mangku Rasywal, 2009; Othman & Owen, 2001), others reported a negative relationship and effect (Klein *et al.,* 1998). In addition, the findings regarding the mediating role of purchase intention of the product showed inconsistencies of results (Kaynak *et al.,* 2000; Marie *et al.,* 2009; Lee, *et al.,* 2010; Margaret & Thompson, 2000; Klein *et al.,* 1998). It's worthy to address the issue of the lack of studies regarding client satisfaction as well as behavior intention to subscribe the SCFS (Zolait *et al,* 2009; Morven *et al.,* 2007). Further theoretical and empirical research on the new intervening factors that might effect on consumers' financial decision and economic making is

needed (Gait & Worthington, 2008). Trust, human resource service quality dimensions provided by the banks, uncertainty in many aspects and government support in general are seems to be the main challenges' facing the adopting or developing of any new system in most of the organizations and countries facilities (Omar & Abdul Ghani, 2016). Unfortunately, there are limited studies related to this assumption especially in the case of Libyan banking system.

3. Research Objectives

Driving from the aforementioned research issue formulation, this study devoted to achieving the following research objectives:

- To determine the effects of the human resource management service quality dimensions (CARTER model) on the behavioral intention to subscribe the SCFS.
- To what extent government support effects on the relationship between the SERVQUAL (CARTER model) and behavioral intention to subscribe the SCFS.

4. Literature Review

The following reviewing of the relevant studies and underpinning theories which addressed the client behaviour intention, as well as the relationship between targeted variable's, in this study.

4.1 Underpinning Theories of Study

Where the behaviour intention discussed in several theories such as (e.g. Theory of Reasoned Action, Theory of Planned Behaviour), however, this study focuses on the CARTER Model and used as the main underpinning theory of the study, which will be discussed in the following discussion.

4.2 Service Quality Theory and (CARTER Model)

CARTER is an extension of the SERVQUAL model, this new model was developed by Othman & Owen, (2001); it is the outcome of an effort to implement the achievement of service quality measurement in the banking services business based on Sharia principles. The CARTER model contribute by adding a one dimension to the five dimensions model of SERVQUAL; namely (Compliance) which defined as "the ability to fulfil with Islamic law, and operate under the principles of Islamic Banking and economies" (Ramdhani, Ramdhani, & Kurniati, 2011). However, as to the traditional interpretation the quality definition's refers to compliance with internal prescriptions and standard; then it was identified with suitability for use; in the most current interpretation of the word, quality means not just meeting/exceeding consumer or clients' needs, rather than meeting/exceeding environmental, social expectation see figure 1.

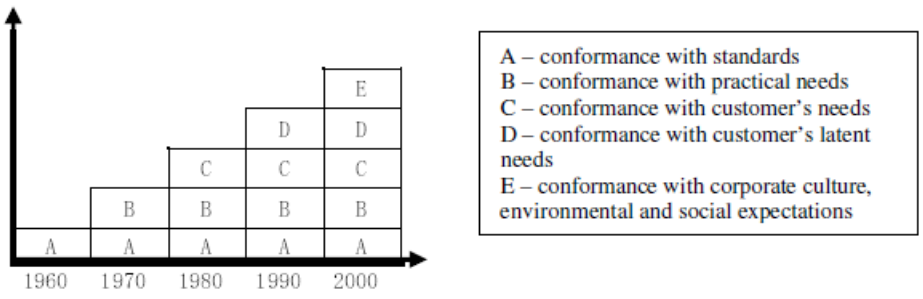

Figure 1 The interpretation development of quality: Source: Becser, (2007), Kormos & Dörnyei, (2000).

The reason for adopting this model is because it emphasizes on quality which is an important to the client or the person's behaviour intention as well as clients' satisfaction. However, it is verified in meeting client's requirements, specifically in terms of its importance feature and that is compliant with Islamic law. According to Parasuraman, Valarie. Zeithaml, (1988) there are

some general dimensions of service quality of any service provider, these dimensions can be summarized below:

- Assurance: personnel's ability to exhibit her/his communication skills and to deals with clients' desires and needs in a confidential manner.
- Reliability: knowledgeable and polite personnel and their ability to win clients trust and confidence and
- Tangibility: physical facilities, tools, machines, personnel, materials and communication channels.
- Empathy, and responsiveness.

Therefore, any bank that fails to surpass its client expectations and meet client satisfaction will not be able to compete with other banks. It is a real challenge for any bank if its clients transfer their accounts to rival banks because of bad services. This empirical research intends to evaluate six dimensions of service quality (CARTER model) according to the both Abdulqawi Othman and Owen, (2001) models, each dimension of CARTER model will be treated as independent variable. However, most of the researchers in this approach "service quality model" agreed with the following service quality's definition quality which is "what is the client says it is", (Othman & Owen, 2001). Therefore, it's not an easy task for SCFS to guarantee and provide services which are judged 100% satisfactory of 100% of their clients. In such a matter, to run such system and model, they would have to ask, observe, find out from the clients themselves and see whether they recommended such system or not.

Therefore, focus on the clients is the key to adopt and deliver service quality or entire service quality management. However, Sharia Compliant Financial method bankers and financiers have to think about quality and service this way since it figures out what is the clients like and delivers it the same in every time; they will come back and tell others about bank services and successes. However, Othman and Owen, (2001), model was an output of hard work to put into practice the achievement of service quality measurement in the banking services based on Sharia compliance and principles. The CARTER model has new added factor to the five dimensions of SERVQUAL model, it's the compliance, which defined as "the ability to comply with Sharia principles and operated by running the banking and economic principles of Sharia" (Ramdhani *et al.*, 2011). There are several pronounced performance gaps when it comes to the reality of banks performance criteria included, Transparency, Innovation, Service, product quality and the customization (Ernst & Young Global Limited, 2012). According to Othman & Owen, (2001), there are several gaps in addressing the service quality framework:

1. Client expectations to management's perceptions.
2. Management's perceptions to service quality specifications.
3. Service quality specifications to service delivery.
4. Service delivery to external communications.
5. Perceived service gap.

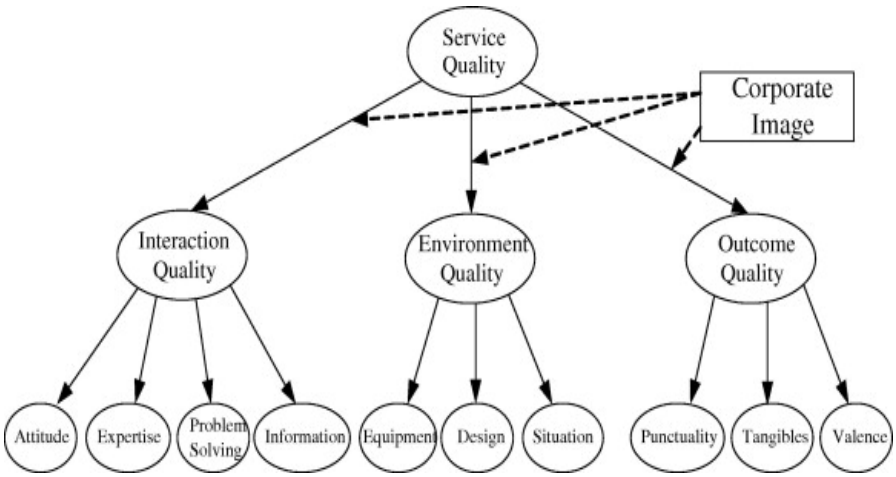

Figure 2 A multidimensional and hierarchical model of mobile service quality**;** Source: Lu. Zhang, & Wang, (2009).

4.3 Behaviour Intention and the Service Quality

Behavioural intention has been defined by Swan and Trawick, (1981) as an individual's planned future behaviour. It has been associated with observed behaviour by Ajzen & Fishbein, (1977), which is grounded on three constructs, namely attitude, subjective norm and perceived behavioural control. However, the literature is reach of several studies and theories which have been addressing the behaviour intention in different aspects (Ajzen, Lcek & Fishbein's, 1992; Ajzen, 1991b; Ajzen & Madden, 1986; Netemeyer & Bearden, 1992; Netemeyer & Ryn, 1991). Nevertheless, in comparative study between these well pronounced theories: theory of reasoned action, theory of planned behaviour and the Miniard and Cohen Model, conducted by Netemeyer, Andrews, and Durvasula, (1993) reported that, intention represents the direct antecedent to behaviour the perceived behavioural control component of Theory of Planned Behaviour (TOPB), as stated by the Theory of Reasoned Action Behaviour (TRAB) (Wungwanitchakorn, 2002). Taylor and Todd, (1995) studied the consumer adoption intentions for a new product, they offer an alteration of TRA by classifying attitudinal beliefs into relative advantage, compatibility and complexity, which were found to be related to attitude, which in turn is related to costumers' purchase intention.

According to ZeithamI *et al.,* (1996) they suggested a conceptual model discusses the behavioural intention of the clients as one of the service quality elements consequences. However, in their model; they argue that the level of the client and propose service quality elements as well as the behavioural intentions are related; therefore, services quality are contributing factors of whether a client in the end will remains with or abandoned/defects from a company. However, ZeithamI *et al.,* (1996) proposed that; positive behavioural intentions are associated with several quality elements' of service. Moreover, the authors suggested that more research on this regard need to be done specially; when it comes to the reliability and the measurement scale and items. It's worthy to mention that clients usually seats more weight on the moderators factors and issues such "bank's reputation, good dealing of bank staff act.." (Othman & Owen, 2001). All of these elements give the impression to be basis probably influence the level of client behaviour intention in both systems either conventional or Islamic finance system banks/institutions. Furthermore, once the clients' perception of any service quality is high; the behavioural intentions will be high as well, which will make relationship with the organization stronger and vice versa.

This intention of the behavioural assumed to be an indication of clients' behaviour which can be as consequences of the attitude based behavioural. Valarie, Leonard Berry, & Parasuraman, (1996), recommended behavioural intentions to be indicators, which showed whether clients had remained with or had defected from the organization. Hence, the concept of behavioural intention is a vital part of the model. Yet, the relationship between service quality dimensions and the multi-dimensional model of behavioural intention has not been adequately investigated in the service quality literature (Baker & Crompton, 2000; Bloemer *et al.*, 1998). Contradictory results were reported in terms of the relationship between the overall service quality and behavioural intention (Bloemer et al., 1998) Ravichandran *et al.*, 2010; Cronin, & Taylor, 1992). According to Boulding, Kalra, Richard Staelin, & Zeithaml, (1993), overall service quality perception has a positive relationship with willingness to recommend, and negatively related to switching and complaining behaviour. Research in regarding service quality using other service qualify scale to examine the relationship between service quality of behavioural intentions is needed. Furthermore, the relationship between service quality dimension and the multi-dimension model of behavioural intentions is still limited (Valarie *et al.,* 1996; Liu *et al.,* 2013). Actually, this controversy left the door opened and have generated a new call for research. Indeed, there is little empirical research demonstrating the importance of service quality dimensions in determining behaviour intention of clients (Baker & Crompton, 2000; Bloemer *et al.,* 1998). The causal relationship among service quality and behaviour intention is still an area under discussion of great academic debated and no consensus has been reached (Joseph Cronin *et al.,* 2000; Theodorakis & Alexandris, 2008). Nonetheless, there are several studies which had identified several dimensions which can determine client behaviour intentions' in the banking industry as well as other sectors in a variety of countries. Therefore, based on the previous discussion, the following hypothesis was formulated to be empirically tested:

Hypothesis 1: *Service quality dimensions (CARTER model) will have a direct relationship with the client behaviour intention to subscribe the Sharia compliant financial system.*
Hypothesis 1a: *Compliance will have a direct relationship with the intention to subscribe the Sharia compliant financial system*.
Hypothesis 1b: *Assurance will have a direct relationship with the intention to subscribe the Sharia compliant financial system*.
Hypothesis 1c: *Reliability will have a direct relationship with the intention to subscribe the Sharia compliant financial system*.
Hypothesis 1d: *Tangibles will have a direct relationship with the intention to subscribe the Sharia compliant financial system*.
Hypothesis 1e: *Responsiveness will have a direct relationship with the intention to subscribe the Sharia compliant financial system.*
Hypothesis 1f: *Empathy will have a direct relationship with the intention to subscribe the Sharia compliant financial system.*

4.4 The Relationship between Government Support and Behavioural Intention

Mahul and Stutley, (2010) defined the government support as the market and regulatory impediments which are often invoked to justify public intervention in the provision of any new market or industry, which need to be identifying and address by the government support of its impediments to help the industry in order to complement their risk management activities with potentially cost-effective financial tools such as insurance. Offering government's support for certain industry is part of the government's overall policy, which may seek to correct the market and regulatory inefficiencies and be part of broader objectives. In the other hand, Triandis, (1979), defined the government support as facilitation of the condition which translates into how available the resources which are needed for the behaviour are to be carried out. Nor, Bin, Rafi, and Yaacob, (2010) stated that, business support can be divided into two categories:

1. Government or organization can financing "financial support" the institution as a sort of support (e.g. Property loan, working capital and grant, etc.) and;
2. The nonfinancial support such as courses, advisory, management, distribution, research and development (Yusoff & Yaacob, 2010).

The variables for government business support will be measured in terms of the extent of Sharia-compliant financial institutions support business management, encourage business innovation and expansion; improve business efficiency (Gait & Worthington, 2009). The government use to have a significant influence on the development of any emerging financial business or service e.g. Sharia-compliant banking products (Hamid, 2006). This study hypothesizes that business support of Sharia-compliant financial banks and agencies that provide Sharia-compliant financial system will moderate the relationship of SERVQUAL (CARTER) dimensions the level of the users of Sharia-compliant financial system productions satisfaction which will shed light on the intention to subscribe within the Sharia-compliant financial system as well. However, as suggested by Kaynak *et al.,* (2000) through their conducted in Bangladesh, financial institutions and banks can get government supervision so that they can serve the needs of consumers in a better way.

Based on Antonia *et al.,* (2009) reported that, economies may exhibit a competitive outcome in the global market in cases where government policies promote the local product brand. Government policies facilitating the promotion of local product brand's development and dynamic innovation provide firms with an environment characterized as competitive for survival as well as the labour laws and appropriate staff legislation. Both elements can impact employment and economic progress viability. Gary and Knight (1999) stated that, national governments are desirous of reducing imported products through their influence on consumer purchase behaviours and actual behaviours to purchase local products. Knight suggests that, "consumers provide a little consideration to the importance of a given product to the national manufacturing base". Hence, education programmers should maximize consumers' awareness of the importance of production. However, in the context with Libya, without the cooperation between the government and the banking sector, low development of Sharia financial system industry will arise which will render them unable to tackle the challenges and the issues that are hindering local brand development (Numan, 2008). In addition, Kaynak *et al.,* (2000) revealed that, how companies in Bangladesh receive government supervision for them to serve the consumers' needs in a superior manner. Amin, Rahman, and Hwa, (2011), conducted study

by using two full-fledged Sharia compliant banks in system in Malaysia and concluded that; more similar research is hoped to be carried on regards to the use of the emerging Islamic financial product. Other potential determinants of the intention to use Islamic personal financing have to be considered (Amin *et al.,* 2011). Previous study emphasized on the need of study the on the culture moderation effect in the relationship between service quality and behavioural intention (Theodorakis & Alexandris, 2008; Yavas, Benkenstein, & Stuhldreier, 2004). On the basis of the above discussion, the following hypotheses was formulated:

Hypothesis 2*: Government support will moderate the relations between SERVQUAL dimension's (CARTER model) and the intention to subscribe the Sharia compliant financial system.*

Based on that, this study addresses the following assumptions which will be formulated as study's hypothesis, Figure 3 displays the direct hypotheses testing of research structural model before and after fit.

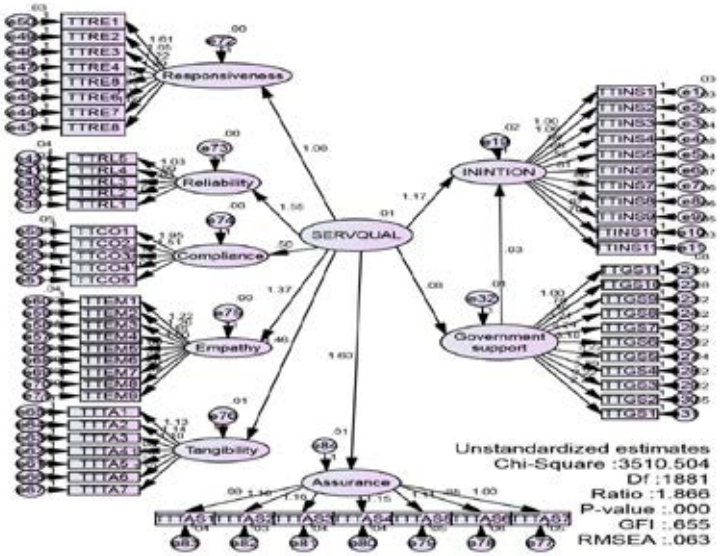

Figure 3 Research framework. Direct Hypotheses Testing Model before fit with all items.

5. Research Methodology

The study employed quantitative research design by administering primary data collection via a questionnaire. The study is conducted in Libya. Out of 400 questionnaires distributed to Libyan bank subscribers, 226 respondents completed and returned the questionnaires, represents about 56.5% percent response rate.

5.1 Instrument

In order to examine the research questions of the study and testing the hypothesis, the questionnaire was used as a medium to obtain the data needed, which was developed depending upon the previous instruments as follows: Behavior Intention to subscribers the Sharia Compliant Financial System, CARTER Model elements, Government support, measures were adopted from several sources such as: Triandis, (1979); Amin, Rahman, & Hwa, (2011); Othman, & Owen, (2001); Sadek *et al.,* (2010); Parasuraman *et al.,* (1988); Ananth *et al.,* (2011); Kumar *et al.*, (2009). The questionnaire comprised of five pages divided into four parts comprise of 7-point Likert scale to evaluate the level of agreement of respondents with the variables.

5.2 Data Analysis Procedures

The data were analysed through Structural Equation Modeling (SEM) AMOS version (21). The confirmatory factor analysis of measurement models indicates adequate goodness of fit after the elimination of few items through modification indices verifications.

6. Findings

6.1 Demographic Profile of the Respondents

The respondents' ages ranged from nineteen to forty-six years old averaging 31 years old. The male respondents were 86.9% and the female respondents were 13.1%. Most of The respondents were government staff with (64.2%) followed by private sector bank subscribers (21.2%) and self-employed (14.6%). Their education varies from the tertiary school certificate (48.6%), Master's degree (18, 5%), Bachelor's degree (18.7%), PhDs (9.3%) others (4.9%).

6.2 Goodness of Fit of Structural Model

To arrive to the structural model, Confirmatory Factor Analysis (CFA) was conducted on every construct and measurement models. The goodness of fit is the decision to see the model fits into the variance-covariance matrix of the dataset. The CFA, measurement and structural model have a good fit with the data based on assessment criteria such as Goodness Fit Index (GFI), Comparative Fit Index (CFI), Tucker Lewis Index (TLI), Root mean square Error Approximation (RMSEA) (Bagozzi & Yi, 1988). All CFAs of constructs produced a relatively good fit as indicated by the goodness of fit indices such as CMIN/df ratio (<2); p-value (>0.05); Goodness of Fit Index (GFI) of >0.95; and root mean square error of approximation (RMSEA) of values less than 0.08 (<0.08) (Hair *et al.,* 2006). Finally, the goodness of fit of generated or revised model is achieved see figure 4. GFI of the revised structural model is 0.936; Root Mean Square Error Approximation (RMSEA) is 0.006; p-value is 0.460, CMIN/df ratio is 1.007.

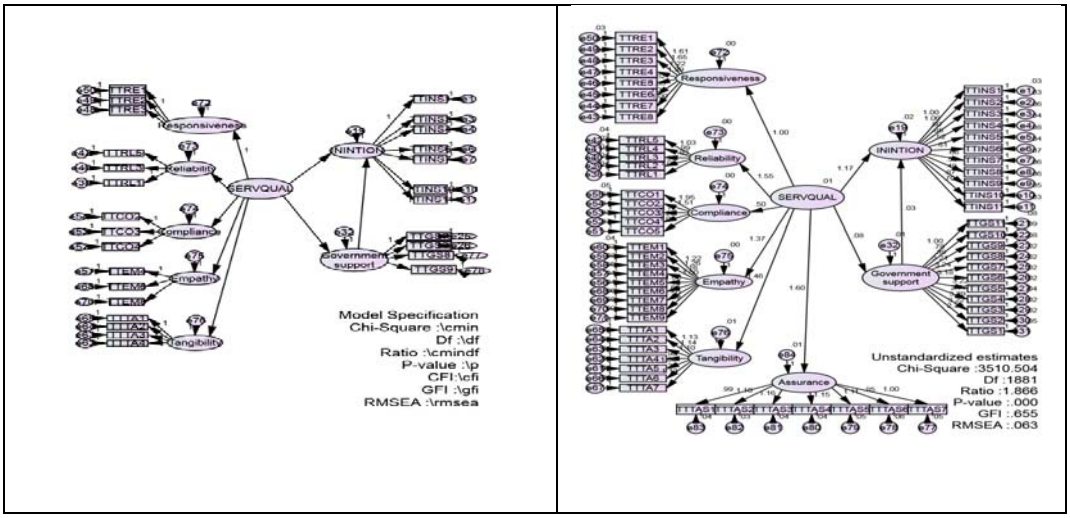

Figure 4 Research framework. Direct Hypotheses Testing Model before fit with all items.

6.3 Hypotheses testing

From the analysis result of the hypotheses, it can be conclude that out of five proposed hypotheses three hypotheses were founded to be positively, where the behavioural intention found to be have no relationship with clients compliance, this however, it can be explained in the view that; people do not have enough confidence to be copolined with the IFS in Libyan banks contact. Table 1, was made as summary to these hypotheses result:

Table 1 Regression Weights: (Group number 1 - Default model).

Hypotheses					P	Status
H1	Intention	←	SERVQUAL CARTER		***	Supported
H1a	Intention	←	Compliance		***	Supported
H1b	Intention	←	Assurance		***	Supported
H1c	Intention	←	Reliability		***	Supported
H1d	Intention	←	Tangibility		***	Supported
H1e	Intention	←	Empathy		***	Supported
H1f	Intention	←	Responsiveness		***	Supported
H2	Intention	←	Government support	SERVQUAL	***	Supported

The findings of this study indicated that the SERVQUAL factors CARTER model is a valid model in the prediction of the consumers' intention to subscribe SCFS. Where, SERVQUAL factors "CARTER" dimensions found to be also positively related to the intention to subscribers the SCFS. The paper extends the understanding of SERVQUAL factors "CARTER" elements to newly emerging contexts such as SCFS products, usage behaviour intentions and government support of the Sharia Compliant Financial System. The finding supports seven hypotheses (H1, H1a, H1b, H1c, H1d, He, H1f, H2, H3 and H2). Government support confirmed to moderate the relationship between SERVQUAL dimension's (CARTER model) and the intention to subscribe the Sharia compliant financial system.

7. Discussion and Conclusions

To recapitulate, the main objective of this study was to investigate the direct relationship between SERVQUAL (CARTER model) and the behavioral intention to subscribe the SCFS in Islamic countries such as Libya, where the paper aimed as well to understand the moderation role of government support in between this relationship. The study has established three direct causal effects: 1) SERVQUAL (CARTER model), and behavioral intention to subscribe the SCFS; 2) and behavioral intention to subscribe the SCFS; and 3) and government support and behavioral intention to subscribe the SCFS. Interestingly, this study also managed to present first-time findings on two moderating effects: 1) government support, moderating the relationship between SERVQUAL (CARTER model), and behavioral intention to subscribe the SCFS; and 2) moderating the relationship between SERVQUAL (CARTER model) and behavioral intention to subscribe the SCFS. Empirical evidence from this study shows that there is a significant and positive relationship between overall SERVQUAL (CARTER model), and behavioral intention to subscribe the SCFS in Libya. This result indicates that Libyan consumers have high intention to subscribe SCFS. The study has some limitations which could create opportunities for future research. A dealer of a particular type of SCFS production categories (e.g. Mudarabah) needs to be investigated. Therefore, product categories should be examined in future research.

Hence, the findings of this empirical study hoped to provide insights for literature and even to the decision-makers in Libyan banking sector. The findings of this study is an important in terms of the theoretical view as well, it is due to its contribution in the way of insight on how human resource management in the banks deals with such new promising system that being adopted either dual or fully Islamic banking systems in order to give further consideration to it is clients, where it is obvious from the study result that clients are becoming more conscious about SCFS. Finally, there are limited studies on SCFS, particularly in North Africa countries, a lack of studies regarding clients intention in the human resource perspectives is very obvious; whereby, few studies limited themselves on the client's behaviors in terms of market needs from the management and government support. This study has applied CARTER model in order to explain client's intention to subscribe SCFS. The study reported that service quality elements have an important role in the clients' intention to join the SCFS. The Libyan government should give more intention to such market, where it is indicated that there is a very low support to this industry. It is important that, government has to work in line with the private sector in the way to motivate them to operate in a smooth way and invest in this promising system.

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