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Southern Africa:

Creating a Resilient and Regenerative Built Environment

15-16 October 2013,
Cape Town, South Africa

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SB13 SOUTHERN AFRICA CONFERENCE

Editor
Dr Fidelis A. Emuze, Central University of Technology, Free State, Bloemfontein, South Africa

15-16 October 2013
Cape Town International Convention Centre, Cape Town, South Africa

Department of Built Environment, Central University of Technology, Free State 2013

SB13 SOUTHERN AFRICA CONFERENCE

Editor
Dr Fidelis A. Emuze, Central University of Technology, Free State, Bloemfontein, South Africa

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FOREWORD

On behalf of the Local Organising Committee (LOC), it is my pleasure to welcome you to Cape Town, the host city of the SB13 Southern Africa Conference. The conference is the sub-Sahara Africa version of the Sustainable Building Conference series. Thus, the conference provides an international forum for researchers and practitioners from the region and other developing economies to address SB related fundamental issues that affect the built environment. The broad topics covered by the conference include:

- Adaptation to climate change;
- Building urban resilience;
- Regenerative design and development, and
- Overcoming barriers to sustainable development.

Warm gratitude is extended to the authors who have successfully gone through a two-tier peer review process in order to have their papers accepted and published in this proceeding. The peer review process would have been impossible without the support of the members of the International Scientific Committee (ISC). The LOC is thankful for this voluntary service that is central to the quality of accepted papers.

The conference has outstanding keynote speakers in the persons of Prof Alfred Ngowi, Prof Chrisna du Plessis, Dr Rodney Milford, Councillor Thabo Olivier, Prof John Smallwood and Emilio Miguel Mitre. Acceptance of invitation to speak and the subsequent contribution of these experts are warmly appreciated. Special thank you also goes to all the conference delegates that have travelled from as far as Denmark. Thank you for attending the event and please make the most of your time at the conference while enjoying the hospitality of the 'mother city' – Cape Town.

Dr Fidelis A. Emuze
Bloemfontein, South Africa
01 October, 2013

ACKNOWLEDGEMENTS

The LOC of the SB13 Southern Africa Conference is grateful to the Central University of Technology, Free State, the University of Pretoria, the Nelson Mandela Metropolitan University, and other South African universities for supporting the conference through their valued contributions.

The contributions and unique support of the International Advisory and Scientific Committees, who worked assiduously to prepare refereed and edited papers, which produce this published proceedings that is of the highest standard in terms of satisfying the criteria for subsidy by the South African Department of Higher Education and Training (DHET), is truly treasured. The contributions of Dr Fidelis Emuze, Prof Alfred Ngowi, Prof Ryk Lues and Dr Abimbola Windapo are recognised. The support of Mrs Erica Greyling, Dr Ayodeji Aiyetan, Mr Thabiso Monyane, Mr Mike Border, Mrs Cameron Britz, Mr Stephen Eromobor, Ms Leonarda van Eeden, and Mrs Vivian Eromobor of the CUT Department of Built Environment is also laudable.

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DECLARATION

All the papers in these conference proceedings were double-blind reviewed at abstract and full paper stage by the members of the International Scientific Committee. This process entailed detailed reading of the abstracts and papers, reporting of comments to authors, modification of papers by authors whose papers were not rejected by the reviewers, and re-evaluation of revised papers to ensure quality of content.

THE PEER REVIEW PROCESS

The need for high quality conference proceedings as evident in the accepted papers while complying with the requirements for subsidy of the South African Department of Higher Education and Training (DHET) necessitates a rigorous two-stage peer review process by no less than two acknowledged experts in the subject area. In this context, submitted abstracts were twice blind reviewed.

Authors, whose abstracts were accepted were provided with anonymous reviewers' comments and requested to submit their full papers noting and addressing these comments. Evidence was required relative to the action taken by authors regarding the comments received. The abstracts and resubmitted papers were twice blind reviewed in terms of:

- Relevance to conference theme and objectives;
- Originality of material;
- Academic rigour;
- Contribution to knowledge;
- Research methodology and robustness of analysis of findings;
- Empirical research findings, and
- Critical current literature review.

Authors whose papers were accepted after this second review were provided with additional anonymous reviewers' comments and requested to submit their revised full papers. These final papers were only included in the conference programme and the conference proceedings after evidence was provided that all comments were appropriately responded to. At no stage was any member of the International Scientific Committee or the editor of the proceedings involved in the review process related to their own authored or co-authored papers.

The role of the editor was to ensure that the final papers incorporated the reviewers' comments and arrange the papers into the final sequence as captured on the CD-ROM and Table of Contents. Of the 51 abstracts originally received, only 27 papers were finally accepted for presentation at the conference and inclusion in these proceedings, representing a rejection rate of 47.1%. To be eligible for inclusion these papers were required to receive a minimum score of 3 out of 5 allocated by the peer reviewers during the final review process.

Regards

Dr Fidelis A. Emuze
Conference Secretary
Bloemfontein, South Africa
01 October, 2013

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The peer review exercise for this international conference was expedited through the voluntary contributions of experts and academics from various countries. Sincere appreciations go to the under listed researchers that assisted in the review of abstracts and papers for the SB13 Southern Africa Conference:

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Central University of Technology, Free State

01 October, 2013

Dear Author

PEER REVIEW PROCESS: SB13 SOUTHERN AFRICA CONFERENCE: CAPE TOWN, SOUTH AFRICA 2013

I confirm that the following peer review process was strictly undertaken in this conference. The need for high quality conference proceedings as evident in the accepted papers while complying with the requirements for subsidy of the South African Department of Higher Education and Training necessitates a rigorous two-stage peer review process by no less than two acknowledged experts in the subject area. In this context, submitted abstracts were twice blind reviewed. Authors, whose abstracts were accepted were provided with anonymous reviewers' comments and requested to submit their full papers noting and addressing these comments. Evidence was required relative to the action taken by authors regarding the comments received. The abstracts and resubmitted papers were twice blind reviewed in terms of:

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Regards

Dr Fidelis A. Emuze
Conference Secretary
Bloemfontein, South Africa

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DYNAMIC MODELLING APPROACH FOR DESIGNING SUSTAINABLE GREEN BUILDINGS

SO Eromobor[1] and DK Das[2]

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Abstract

The challenges of resource constraints in terms of water and energy, and the need for a comfortable and efficient environment for higher productivity of human resources brought about the green building concept. The concept visualises improvement in energy utilization efficiency, water use efficiency, comforting indoor environment, and efficient building infrastructures through effective land use and environment, appropriate building orientation for optimal ventilation and daylight, optimized building shape and / or form, use of energy efficient fixtures. In order to achieve sustainability, provision of a high-performance building envelope is the single most significant factor in building design. This entails the reduction of energy consumption through alternative (and low-energy) systems; obtaining of water use efficiency through efficient fixtures, water efficient landscaping and rain water harvesting systems; and creation of proficient indoor environment through enhanced control of thermal quality, indoor lighting and humidity. Therefore, this exploratory paper conceptually analyses the various aspects related to green building principles and their implication in designing new buildings to make the buildings as well as the built environment at micro level sustainable. In this regards, a theoretical conceptual dynamic modelling approach was evolved by employing systems theory to measure the performances of planning and design indicators for building sustainable green buildings under various simulated scenarios. For this purpose, relevant information from the existing literature were derived and utilised for building the model. It was observed that by using green building principles efficiency in appropriate built form, energy and water usage can be achieved which would lead to creation of comforting indoor environmental quality and comfortable outdoor built environment.

Keywords: Built environment, Green building, University, South Africa

INTRODUCTION

The future of sustainable buildings lies in performance-based approach at all stages of the buildings life cycle. This paper reviews literature concerned with green building categories of energy efficiency (EE), indoor environmental quality (IEQ) and water services efficiency, which are significant in maximising performance of the building envelope. The key issues in built infrastructure performance evaluation are efficiency and productivity. Although the most important indicators in this regard are environmental performance in terms of energy use and water efficiency, and whether the building adds value or makes economic sense (Okolie, 2011), there is a need for

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sustainability in the planning and design of buildings (either new construction or renovations) for which a holistic approach is required. In the context of evolving a comprehensive or holistic approach to design and planning, this study explores how built infrastructures and services buildings in universities of South Africa can be planned and designed to be sustainable by using Green building principles. For this purpose the investigation was carried out by considering the buildings of universities of South Africa as case studies. Accordingly this investigation pertains to assessing the various existing buildings of South Africa with respect to sustainability criteria of Green Building principles and evolving design guidelines to develop sustainable built infrastructures and services particularly with respect to energy consumption, water services and congenial indoor environment and their casual relationships.

Almost all existing built infrastructure in the university system of South Africa were built using conventional building codes, and therefore do not adequately address the importance of design for efficiency in energy use, materials use and efficiency in water services.

Thus, most of the existing built infrastructure and services in South African universities are not sustainability compliant, as inefficient use of resources and energy is always encountered. In this context, some of the prominent problems encountered and their causes are:

- Existing university campus buildings are not energy efficient in South Africa. This is partly caused by inappropriate design of building envelopes, inefficient use of daylight and poor quality of indoor environment.
- Existing university buildings have been built by using conventional building materials and therefore do not benefit from the use of alternative GB compliant materials. The use of conventional materials have huge impacts on natural capital including raw materials, and water and the users are exposed to health and safety(H&S) challenges that are not limited to sick building syndrome alone.

Based on the above premise, this investigation pertains to assessing the various existing buildings of universities of South Africa with respect to the sustainability criteria of Green Building (GB) principles and evolving design guidelines to develop sustainable built infrastructures and services particularly with respect to energy consumption, water services and a congenial indoor environment and their causal relationships. The scope of the paper is confined to review of literature concerned with green building categories of Energy Efficiency (EE), Indoor Environmental Quality (IEQ) and Water Services Efficiency which are significant in maximising performance of the building envelope and development of conceptual models by using system dynamics principles.

Principles of sustainable built infrastructure in universities: global perspective

Concerns about climate change, energy consumption patterns and the increasing incidence of threats to the natural resource base have since continued to grow internationally, as is the desire to address these concerns. Accordingly a number of international and national foray were convened to address such issues, including the World Summit on Sustainable Development (WSSD), the United Nations Framework Convention on Climate Change, and all convey one central message - the time has arrived to reassess the way in which humans interact with and use natural resources of water, air, soil and biodiversity (Van der Bank, 2012). In South Africa, the Government is not oblivious to these international developments especially when a very prominent role in protecting the environment is carved out for local governments and a number of such drives are being undertaken including the Municipal Systems Act 32 of 2007, which states that municipalities are to strive to ensure that municipal services are provided in a financially and environmentally sustainable manner.

In recent years, it is observed that universities have come to the forefront of sustainability development. They are dealing with the challenge of sustainable development in many different ways and the approaches vary from aiming to function as an environmentally friendly company to formulating principles and signing declarations, establishing totally new institutions, or focusing the mission and management of an existing university on the quest for sustainability (Van Weenen, 2000). According to UNESCO (1997), education and higher educational institutions are humanity's best hope and most effective means in the quest to achieve sustainable development. It is evident from various examples and practices that universities all over the world are gearing towards achieving sustainability in their campuses through means related to energy management, waste management, use of low cost and appropriate materials, to name a few. This drive for sustainable development has gained momentum in many South African universities too, and the various activities being undertaken include creation of green campus, waste management, etc. However, no much work has been done in the form development of sustainable built infrastructure and services. Most of buildings, built infrastructures and services are still developed based on the conventional national standards.

Achieving Standards using Green building principles

The US Green Building Council (USGBC) defines a green building as one that is built using processes that are environmentally responsible and resource efficient from conception to completion. A green building is also known as a sustainable or high performance building. Goals of green buildings include site structure design efficiency, energy efficiency, water efficiency, materials efficiency, enhancement of indoor environmental quality, operations and maintenance optimization and waste reduction. After the building is built the product is expected to operate and perform in a way that meets these required goals.

The measurement of these efficiencies and aspects are generally done by using Green Building (GB) tools, which include the USGBC's Leadership in Energy and Environmental Design (LEED); Britain's Building Research Establishment Environmental Assessment Method (BREEAM); and the Green Star Rating System used in Australia and South Africa. These rating systems form the assessment tools, which show if a building is actually 'Green' or what category of efficiency in various criteria the building has attained. There is however both in South Africa and internationally, a growing emphasis placed on efficient energy utilisation and GB as a means to achieve ends leading to sustainability (Van der Bank, 2012). GB rating and certification systems are intended to foster more sustainable building design, construction and operations by promoting and making possible enhanced integration of environmental concerns with cost and other traditional decision criteria (Wayne and Horst, 2002). They further indicate that most rating systems, if not all, deal in one way or another with site selection criteria, the efficient use of energy and water resources during building operations, waste management during construction and operations, indoor environmental quality, demands for transportation services, and the selection of environmentally preferable materials while doing an admirable job of fostering and facilitating integrated design practices holistically (Wayne and Horst, 2002).

METHODOLOGY

Identifying parameters that can be measured and adjusted forms one of the significant methods of analysing the performance of buildings in the initial stages of the design process or indeed measuring the performance of existing stock of the buildings. According to Geyer (2012), designers often develop conceptual designs, including building shape and appearance, without considering energy and resource consumption. Furthermore, there is no direct link between energy simulation and design models, which leads to difficulties tracing the effects of changes, this results in probable interdependency neglecting and insufficiently exploiting the energy and resource efficiency potential (Geyer 2012). Based on this premise, it is construed that for sustainability of built infrastructure and services of buildings, the design should present a holistic model to determine how parameters, such as, building form, building materials, insulation and climatic conditions influence the buildings, and its built infrastructure in achieving higher efficiency in energy consumption, water services and creating a healthy indoor environment.

In this context, the methodology of this investigation is set in the context of sustainable design of built infrastructure and services in South African universities. For this purpose the methodology of this investigation constitutes review of literature, survey research method and case study approaches shall be used to assess existing buildings, related built infrastructure and services, in addition to development of theoretical system dynamic modelling for evolving simulated scenarios. However, the methodology in this article is confined to the literature review and application of system dynamics principled for developing conceptual models. The theoretical conceptual models were developed by applying systems theories and system dynamics principles in order to understand the causal feedback relations among the various parameters and their influence on the efficiency of built infrastructure and services, which will enable evolving of design guidelines for development of sustainable built infrastructure and services.

ATTRIBUTES FOR SUSTAINABLE BUILT INFRASTRUCTURE AND SERVICES

Energy Efficiency in buildings

According to Siemon (2009), there are four determining factors of efficiency. These include capital, materials, human efforts, and energy. Each of the factors requires the minimum expenditure of resources in order to contribute towards efficiency. Besides, for an element to be considered energy efficient, the absolute minimum of input and wastage of energy in relation to the results produced must be utilized. In other words, if a very little energy is used, wasted and produced, the results are not very energy efficient. On the other hand, if a very little goes in and a lot comes out without great amounts of waste, the results can be considered energy efficient (Siemon, 2009).

Improvements in thermal daylight and natural ventilation performance of the buildings will indirectly reduce energy consumption and greenhouse gas emission.

According to Harvey (2009), the energy use of buildings depends to a significant extent on how the various energy-using devices (pumps, motors, fans, heaters, chillers, and so on) are put together as systems, rather than depending on the efficiencies of the individual devices. However, it is also indicated that on focusing on building form and a high-performance envelope, heating and cooling loads are minimized, day lighting opportunities are maximized, and mechanical systems can be greatly downsized (Harvey 2009).

The term thermal envelope refers to the shell of the building as a barrier to the transfer of heat between the inside and outside of the building. The effectiveness of the thermal envelope depends on (1) the insulation levels in the walls, ceiling, and other building parts; (2) the thermal properties of windows and doors; and (3) the rate of uncontrolled exchange of inside and outside air which, in turn, depends in part on the air tightness of the envelope. Therefore natural ventilation, building form, lesser use of artificial cooling and heating devices and a thermal envelop will contribute to the energy efficiency of the buildings.

Effects of indoor environment on building performance

IEQ is also a critical element of healthy buildings. Poor IEQ is considered to be the principal cause of sick building syndrome, which according to scientific research has a substantial price tag in lost productivity and even more in health sector costs (GBCSA, 2008). IEQ includes ventilation, thermal comfort, and daylight. It is argued that reductions in energy consumption can easily be achieved by reducing the amount of fresh air delivered to occupants, but this would be at the expense of the occupants comfort and well-being. Thus, according to the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), there is a need for balancing the requirements for achieving good IEQ while concentrating on reducing energy usage.

Role of building materials on improving performance

For a building material to be considered completely sustainable; both the production of the material and the performance of the material in the project are significant. The way, in which materials are produced, the construction processes used for erecting them, their effect on IEQ and energy efficiency during the buildings life cycle are all important. Hazards related to choice of materials include environmental pollution and embodied energy from various processes in their development, and waste disposal after their life cycle. According to Arora (2009), it is necessary to minimize hazardous effects on the environment that occur as a result of various procedures involved with the extraction, transportation, processing, fabrication, installation, recycling, and disposal of these construction industry materials by use of “green building materials” (Arora, 2009). It is also noted that green building material is one that uses the earth’s natural resources in an ecologically sensitive manner and is composed of renewable, rather than non-renewable elements and preferable to be produced from re-cycled materials, although much study have not been done on important performance properties of such materials, such as, in the promotion of energy efficiency and good IEQ.

Water efficiency in design of sustainable building infrastructure

South Africa water has long been considered a precious high-demand resource. South Africa falls in a region with low unreliable rainfall and therefore potable water sources do not get adequate annual replenishment from rainwater (GBCSA, 2008). In the design of high-performance building envelope for achieving water efficiency is particularly important in countries that have unreliable rainfall or problems with limited availability of water. The Green Star SA rating tool encourages and recognizes designs that reduce water consumption by building occupants and credits are given to factors, which enhance water service efficiencies. The various factors which enhance water service efficiencies are:

- Fixtures that minimize water usage;
- Use of rain water systems;
- Re-use of grey water;
- Black water treatment and re-use;
- Installation of water meters for all major water usage;
- Reduction of potable water for landscape irrigation, and
- Reduction of potable water used in heat rejection systems in air-conditioned spaces

CONCEPTUAL SYSTEM DYNAMICS CAUSAL FEEDBACKS

System dynamics archetypes

The system dynamics is a theory of structure and behaviour of system (Forrester, 1968; 1969). It is characterised by the concepts of causal feedback loops and time delays, which represent the dynamic complexity of a system (Sterman, 2000). Causal loop maps are usually employed to describe the elements of the system (Montibeller and Belton, 2006). In the present context, the interdependencies of elements that have logical relationships create specific conditions within a building and related built infrastructures. Therefore, in this investigation the system dynamics modelling principles based on systems concept and theories were employed in developing conceptual theoretical models.

Sustainable built infrastructure system

According to Harvey (2009), the systems approach requires an Integrated Design Process (IDP), in which the building performance is optimized through an iterative process. It is quite clear that the input from IDP can be simulated in building models and specific requirements can be met in a design model. Following this modelling approach this study proposes to establish three main interdependent models and one integrated model for the built infrastructure in following categories:

- Indoor Environmental Quality (IEQ);
- Energy efficiency;
- Water services, and
- Integrated built infrastructure and services model.

The interdependencies of IEQ, energy efficiency and water efficiency all connect to achieve green building standards and qualities. These interdependencies are indicated in Figure 1.

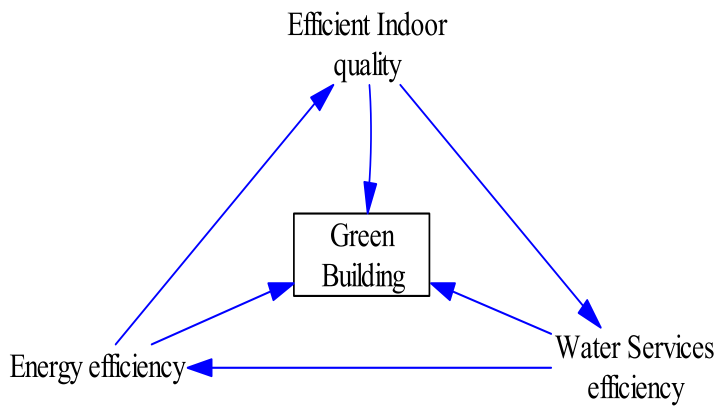

Figure1: Aggregate causal feedback loop diagram for green building and sustainable built infrastructure

Achievement of Energy Efficiency

Figure 2 presents the conceptual causal feedback relationships among the various parameters involved in achieving energy efficiency in a building**.** It is envisaged that energy efficiency is a function of energy consumption. Energy consumption is related to two aspects of a building concerning functions of the building and indoor quality. Thus, energy consumption make a positive causal feedback loop with number of functional areas of the building and functions of the building where by energy consumption will increase depending on the increase in functions (R1). However at the same time it makes a negative causal feedback relationship with orientation of the building leading to higher openings, higher natural lights and consequent indoor quality whereby reducing the energy consumption (B1). The feedback loop R1 will be balanced by feedback loop B1. While the functions of a building is dependent on type of the function, number of functional areas and geometry of the building, orientation is dependent on geometry of the building which is a function of form and size.

Thus, the model indicates that an increase in functional spaces, complexities of geometry and function, can logically or obviously lead to an increase in energy consumption whereas proper orientation, geometry, location and size of openings influences access to natural light will help in reducing energy consumption, which needs design innervations.

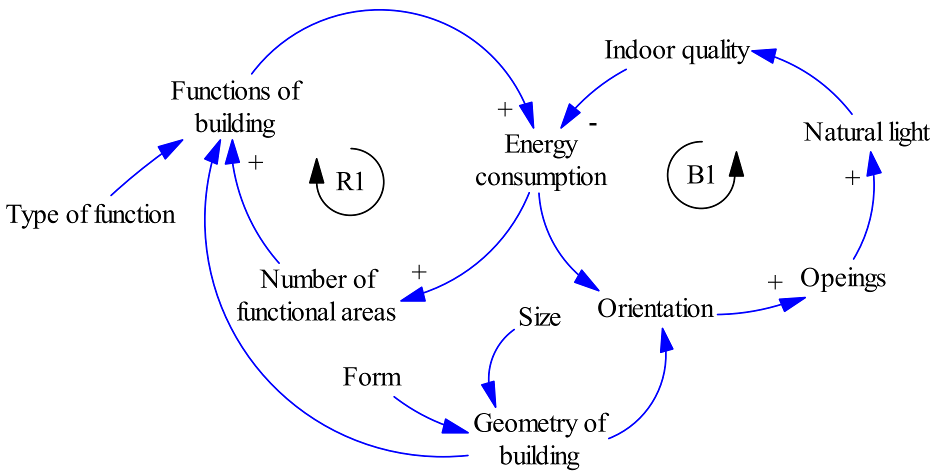

Figure 2: Feedback loop diagram for Energy consumption (efficiency) for green buildings

Water services efficiency

The water service efficiency is measured in two categories such as water use and water pipe length and related plumbing accessories. While geometry of the building leading to the requirement of water pipe and plumbing accessories requirements make a positive feedback loop with water services leading to rise in cost and use of materials (R2), water reuse through water harvesting from the waste water will make a balancing loop to reduce the cost and consumption of water in building (B2). Thus feedback loop R2 and feedback loop B2 will balance the water services and efficiency of water will be dependent on these parameters. However, these parameters shall be influence by the functions of the building. So design interventions are required to optimise these parameters based on the functions of the building.

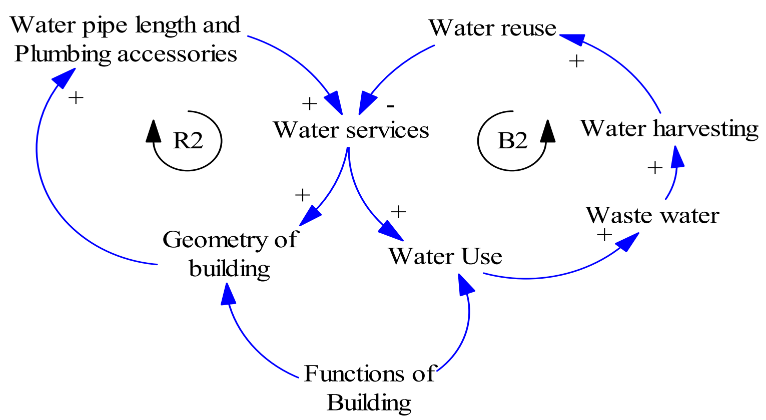

Figure 3: Feedback loop diagram for Water services (efficiency) for green buildings

Indoor Environmental Quality

Achieving good standards of IEQ in the building is interdependent on the following:

- Building geometry: this affects the entire model because it relates to openings which are affected by airflow and access to natural light. This in turn is relates to orientation of the building.
- Orientation: Proper orientation improves natural light and airflow through the building thus improving quality of the indoor. Additionally proper orientation can improve views from the interior with minimal constraints on construction.
- Building geometry: Size and form of interior spaces directly affects IEQ. Appropriate sizes of building forms can improve indoor air quality with regards to daylight access and ventilation.
- Thermal Comfort: This depends on humidity and temperature. Improving humidity and temperature to appropriate levels will improve thermal comfort which in turn will improve IEQ.

- Type of building materials: appropriately selected good quality materials can improve IEQ.

Thus, each aspect will have a causal feedback relationship with indoor quality of a building (figure 4) and the indoor environmental quality will be influenced by the performances of each of these aspects, which needs to be taken care of at the design stage.

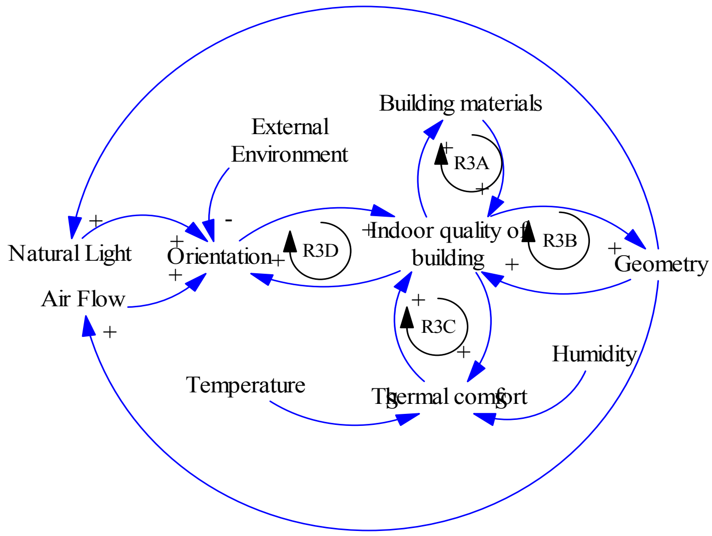

Figure 4: Feedback loop diagram for Indoor Air Quality (IEQ) for green buildings

CONCLUSIONS AND FUTURE STUDY

This investigation revealed that a holistic design approach based the green building principles and causal feedback relationships among the various parameters such as, IEQ, energy efficiency, building materials, and water services & use is necessary in order to achieve sustainable built infrastructure and services in the universities of South Africa. It was observed that the use green building principles and plausible actions based on causal feedback relations among the influential parameters will lead to efficiency in appropriate built form, energy and water usage which would create comforting indoor environmental quality and comfortable outdoor built environment.

It was also observed that as sustainability in built infrastructure and services deals with a complex set of interlinked variables, it poses modelling challenges. However, the conceptual models built on the system dynamics modelling approach with their higher inclusivity and flexibility was found to be particularly suitable for such complex problems. Further, it is also seen that an integrated sustainable built infrastructure and services model based on the aggregate conceptual feedback relations among the most influential parameters of the three aspects such as energy, water services and indoor environmental quality would able to assist in measuring the performance of the parameters influencing sustainability in built infrastructure and services. However, this needs development of computer simulation models by transforming the conceptual models for quantification of the influential parameters, which is the next goal of this investigation. The integrated simulation model will also help to simulate various scenarios based on which design guidelines will be evolved for achieving sustainability in built infrastructure and services. However, at its current state, the conceptual models bring about clarity of the relationships among various influential variables and provide a roadmap to guide the planners, architects, civil engineers and designers to take plausible actions in order to achieve sustainability in built infrastructure.

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PROFESSIONALS’ PERCEPTION ON THE PROSPECT OF GREEN BUILDING PRACTICE IN NIGERIA

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Abstract:

Green Building (GB) is a concept that gains currency as an important mitigating measure against the negative side effects of developmental activities. This is a report on investigation carried out on the problems and prospects of GB practice in Nigeria. This research work entails review of related literature to establish the concept of GB, problems militating against GB and method of constructing GB. The information obtained was then used as a guide to carry out the investigation. A total of 50 structured questionnaires were distributed, out of which 40 were received. Practice of GB in Nigeria, factors hindering the practice and benefits of GB were investigated. Findings reveal that GB is currently not practiced in Nigeria, and there exist need for it. Further, lack of awareness is the most prominent factor hindering the practice of Green Buildings, followed by lack of enabling environment in the form of policy or legislation that will force prospective clients to practice the principle of GB, and the economic situation of the country. Health and productivity gain is identified as the most important benefit of green building, followed by ‘preservation of natural resources while taking care of their health’ and ‘attraction and retention of employee. Recommendations include, Nongovernmental organization, government and professional bodies, should increase level of public enlightenment on GB, the practice of Green building should be encouraged by the government, by requesting for construction environmental management plan from contractors as part of tender documents.

Keywords: Construction, Environment, Green building, Preservation, Sustainability

INTRODUCTION

The activities of human being on the environment, regarding meeting his daily needs, exert pressure on the environment. For instance, construction activities which are regarded as the heart of every development constitute a powerful influence on the environment. The construction industry consumes a major share of resources and produces a lion’s share of waste. According to Agenda 21 in Dahiru (2005), the industry is often referred to as the 40 per cent industry as it is responsible for the consumption of approximately 40 percent of natural resources and about 40 per cent of all waste produced. Dimson (1998) in Gandu (2005) observed that human habitats (buildings) contribute to environmental crises through resources depletion, energy consumption, air pollution and creation of waste. Ajatar (2000) outlines up to ten different adverse effects

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of construction activities on the environment. These include, among others, land misuse, existing site dereliction, habit destruction, misuse of natural resources, and so on. In addition, the on-site construction practices results in a number of health and comfort disturbances, especially to people living where construction activities are taking place. One problem which is of great concern is the observation made by Schmidt (2000) that building activities are responsible for approximately one-third of ecological disasters.

Thus, it can be seen, clearly, that construction activities, have direct impact on man and his environment, in that, it leads to the change on the state or condition of such environment in terms of not only the quality but also the stock of natural resources. One important question that is always asked is: how can we ensure that these activities (construction activities) do not compromise the ability of future generation in achieving their needs. According to Kolawole & Anigbogu (2005), the friendliest way to handle the environment is not to build. However, without construction, life can be miserable and threatening. For shelter is needed, amongst other things, for protection against the inclement weather and for healthy living. Kolawole & Anigbogu '(2005) state that what is needed is a dynamic equilibrium. In other words, production process that is friendly to the ecosystem, yet competitive and possess no any form of threat (Zubairu 2012) Environmentally friendly buildings, popularly called Green Buildings (GB), sustainable or high-performance buildings, seem to satisfy the above mentioned requirements. This is a report on the study carried out on the problems and prospects of Green Building practice in Nigeria with the following as the objectives of the research:

- To establish through literature, the events or circumstances that brings about the concept of GB and find out whether such conditions exist in Nigeria.
- Articulate the concept and principles of GB and identify the important requirements for a structure to be qualified as a GB.
- Find out whether such buildings are constructed in the construction industry in Nigeria identify the factors militating against the practice and prospects or benefits of GB.

CONCEPT OF GREEN BUILDINGS

Green Building (GB) is a holistic approach to programming, planning, designing, and constructing (or renovating) buildings. It is part of the larger concept of sustainable development as it enhances the environment against the negative side effect of construction activities. Besides, that all liabilities of materials, water and energy waste, and pollution emissions are converted into economic opportunities through the realization of environmentally sound, healthier and cost effective project. It has been described as a clear answer to health, economic and environmental challenges (Karolides 2002). Construction of Green Building entails tailoring a building and the site to the local climate, site conditions, cultural and community in order to reduce resource consumption, augment resource supply, and enhance the quality and diversity of life. This is achieved through analyzing important and interrelated issues, such as, the site and climate, building orientation and form, lighting and thermal control system, and materials, while optimizing all these in an integrated design.

In other words, it is a total quality management approach to building in which right from the beginning of the project all the key people that would be involved at various stages of the execution of such project, are brought in. This is to ensure the achievement of synergistic design through interdisciplinary teamwork. Thus, Green Building as rightly observed by Karolides (2002), it is neither, an assemblage of environmental' components nor a piecemeal modification of an already designed standard building. It is neither a building style in which the building (Green Building) is expected to assume certain form or to have a "characteristic look". Rather, it is a building philosophy in which natural and resource efficient features are incorporated in a building. Further, deliberate effort is made towards enhancing the surrounding environment. One major distinguishing feature of GB is that all the professionals that would be involved in the planning, design and construction of such building must be brought early (at the design stage), for professional input in the design of GB. This is in order to achieve synergy. Apart from the key professionals that usually participate in the execution of conventional building projects, such as, Architect, Builder, Engineers and Quantity Surveyor, in the case of GB, there are other professionals who should be involved right from the beginning. They are, land surveyor who is the custodian of land information. The size, topography, features beneath the land on which development is to be built, is determined first by the Land Surveyor. Without this information, no proper execution of project can be carried out. While, the Town planner is responsible for the orderliness in the developmental layout to show the various land use. He prepares the Master Plan, which usually takes into cognizance the population, culture, infrastructural facilities, socio-economic political health, and other human needs. He also undertakes Site Analysis and Environmental Impact Assessment (EIA).

A Town planner also, ensures that the layout is maintained during construction stage. There is the landscape Architect who takes care of the surroundings of the building site by putting in place measures that will enhance the site such as planning the lay out and the topography, which include planting flowers as well as taking care of sustainability of the grounds water and chemical (insecticide, fertilizer) requirements. He is also in-charge of sitting and planting to provide shade and wind breaks. Arguably, that GB makes an attempt to maximize operational energy savings, provide optimally healthy interior and limit the negative impact of construction activities, the professionals that usually participate in the construction of GB, increases considerably. For example, according to Walker (2002) GB design can take 40-100% more effort on the part of mechanical engineer or energy analyst. Apart from the mechanical engineer's role in the design and execution of conventional project, in GB, the calculation of energy use and analysis of the life-cycle energy use is their responsibility. However, this additional role is not restricted to the mechanical engineer all these professionals will carry out various analyses and calculations for optimal design solution, with respect to a specific building. Regarding the construction site selection, since emphasis is made on resource conservation and cultural preservation, renovating an existing building is preferred to new building. If a new building is required, then Green Building 'should always be on those parts of land that are in the worst condition, not the best condition' (Karolides, 2002). Therefore, Infill and Brownfield sites should be considered first. An In-fill site is a vacant site within established urban area, not outskirt, while Brownfield site is an abandoned industrial site that would usually require rehabilitation work. Also site with adequate water sources and access to renewable energy like biomass, solar, and geothermal should be given priority for GB development.

On the other hand, ecologically 'sensitive land, suitable for agriculture, land of historical or cultural importance, or site that is prone to danger such as, flood, and wild fire should be avoided. Likewise, open spaces should not be used. In terms of the planning of settlement and the provision of infrastructural facilities, it is required to cut across all class of people in the society – the rich and poor, young and old. Relative to what is obtained in towns in Nigeria, where there is the Government Reserved Area (GRA). Materials to be used for the construction of (GB) are those that would ensure the achievement of sustainable built environment. This also applies to the actual construction of building that explains the reason why a builder who is regarded as the "brain - box" of the project is expected to, among other things, carry out buildability and maintainability analysis, prepare production management document (PMD), develop elaborate plan for waste management even before the actual execution of the project.

Some Benefits of Green Building

There are numerous advantages associated with the use of GB, prominent among them are as follows:

- Environmental benefit for everyone: The benefits of Green Building do not end with the residents and owners who enjoy the pleasing surroundings and lower utility bills. All of us benefit from the way green communities reduce pollution and preserve our natural resources thereby leading to what is termed green developments.
- Keep forest intact: Recycling wood from old buildings using materials made from agricultural waste, and purchasing wood coming from sustainable forests helps reduce the drain on forests. It prevent sprawl which also conserve land and reduce pressure on wildlife habitat.
- Cut water consumption by up to 50%: By installing efficient fixtures and using recycled site water to flush toilets and irrigate plants, building owners can cut water use and still maintain attractive landscaping.
- Reduce the need for driving: Smart-growth cuts oil use, greenhouse gas emissions, and other pollution from transportation by as much as 50% compared to conventional sprawl.
- Reduce pollution runoff into our waterways: Storm water that drags pollution off roofs, driveways and hard surfaces is the leading cause of coastal water contamination and beach closing. Surrounding homes with permeable surfaces like plantings, grassy channels, and oil allow storm water to seep into the ground instead of into our waterways, and locating homes inn previously developed areas prevents the spread of pavement into new watersheds.
- Financial and economic benefits: Green Building provides financial benefits that conventional buildings don't. These benefits are in the form of energy and water savings. Reduced waste, improved indoor environmental quality, greater employee comfort/productivity, reduced employee health costs and lower operations maintenance costs.
- Energy: Energy is a substantial and widely recognized cost of building operations, that can be reduced through energy efficiency and related measures. According to Gregory (2006), Green Building use 30% less energy when compared to conventional buildings. A detailed review of 60 LEED (Leadership in Energy and Environmental Design) rated buildings (Gregory, 2006), demonstrates that Green Building, when compared to conventional buildings are:
    - On average 25-30% more energy efficient.
    - Characterized by even lower electricity peak consumption.
    - More likely to purchase grid power generated from renewable energy sources (green power and/or tradable renewable certificates).

- Health and Productivity Benefits: Green Building is not only about energy, but also about health, comfort and productivity in addition to the environment. As people spend 90% of their time indoors and the concentration of pollutants indoors is typically higher than outdoors, sometimes by as much as 10 or even 100 times (Karolides 2002).

In view of the fact that the use of buildings has been extended to harsh and hostile conditions, using Green Building by people in such areas has become a necessity because a healthy, comfortable home is an essential part of life. Higher performance Green Buildings typically offer healthier and more satisfying work environment for tenants. Green Buildings use carpets, paints, wall coverings and adhesives that emit low level of potentially volatile organic compounds, which can cause eye and lung irritation and other health problems. Research has shown that people work more under comfortable atmosphere thereby increasing productivity.

RESEARCH METHODS

The research design employed for this work was the descriptive survey in which lecturers in the higher Institutions, professionals in the construction industry (Land Surveyors Town Planners, Architects, Builders, Quantity Surveyors, Engineers and Estate Surveyors) in Nigeria and the prospective beneficiaries of such services (GB) were randomly selected. The areas covered in this research are: The Federal Capital Territory, FCT, Abuja, Kaduna and Kano States, The main research instrument used was a well-structured questionnaire containing closed ended questions with suggested answered measured on a Likert Scale.

Interview with some of the respondents was also carried out. A total of 50 questionnaires were administered, and 40 were retrieved, which equates to a response rate of 80% achievement and were used for analysis. The questionnaire solicited substantial information on the practice, problems and prospects of Green Building in Nigeria, from the various respondents based on their experience. The opinion sampled include, respondents understanding of Green Building, the practice of GB, professionals in the Green Building design team and their numbers, problems of Green Building practice, benefits derived from Green Building, level of importance attached to the benefits and level of awareness of the concept of Green Building in Nigeria.

PRESENTATION AND DISCUSSION OF RESULTS

The data obtained is presented and discussed as follows:

Design Team

It is important to note that the participants of actual construction of GB must be part of the design team. Therefore, the sample frame consist such professionals. Table 1 presented questionnaire response rate.

Table 1: Distribution of Questionnaires

Number distributed	50
Number properly completed and returned	40
Percentage response	80%

As it can be observed from Table 1, the response rate is eighty percent (80%)

Table 2: Profession of Respondents

Profession	No. Distributed	No. of Response	% of Response
Architects	11	8	73
Builders	15	15	100
Engineers	7	5	71
Quantity Surveyor	7	5	71
Town planners	6	4	67
Estate Surveyors	4	3	75
Total	**50**	**40**	

Table 2 indicates a breakdown of the questionnaires response rate based on respondent's profession. Architects returned 73%, Builders 100%, Engineers 71%, Quantity Surveyor 71%, Town Planner 67% and Estate Surveyors 75%.

Need for Green Building in Nigeria

Three factors will be assessed to establish the need for GBs in Nigeria. Firstly, the study tries to establish, whether there are serious side effects of developmental activities in the environment that would call for the practice of GB in Nigeria. Table 3 below shows the results of such findings:

Table 3: Impact of construction activities on the environment in Nigeria

Response	Number of Response	Percentage of Response
Yes(Negative impact)	38	95%
No (Positive impact)	2	5%
Total	**40**	**100%**

Table 3 presents impact of construction activities on the environment in Nigeria. Negative impact (95%) predominates. Respondents were of the view that condition calling for the use of GB, negative impact, such as excessive consumption of resources - materials, energy – hazardous contaminations (toxic wastes, air and water pollution),danger to health and safety of users of building, changes in landscape, depletion of natural resources - do exist in Nigeria while only 5% said "No."

Site Selection

Secondly, condition for the construction of GB is relative to the site selected for such building. It is recommended that sites for GB should be the one that is in worst condition not good as Brownfield – abandoned industrial sites, infill – building on a vacant site within an established urban area. The study sought if professionals were involved in the construction of building on such type of site. The survey results in Table 4 indicates that 87% of the 40 respondents to the questionnaire addressed to professionals said "No" (Disagree) that deliberate effort is made to select construction sites that are in worst condition in order to construct GB While 13% said "Yes" (agree). This shows that one of criterion for the construction of GB has not been fulfilled.

Table 4: Compliance with criterion for Selecting Construction site for Green Building in Nigeria

Response	Number of Percentage	Response of Response
Yes	7	13%
No	33	87%
Total	**40**	**100%**

Synergistic Design

Thirdly, another very important condition for the practice of GB is that each and every member of the construction team, of GB is involved in the design in order to achieve synergy. As such, respondents were asked whether they were opportune to work as a team in the design of GB. Result of the investigation is presented below in Table 5.

Table 5: Participation in the Production of the Synergistic Design

Response	Number of Response	Percentage of Response
Yes	2	5%
No	38	95%
Total	**40**	**100%**

Result in Table 5 above, indicates that 95% of the professionals have not participated in the production of design as a team. While only 5% observed that they participated, this shows that majority of the respondents have not actually participated in the design of GB – hence, the issue of construction does not even arise.

Factors Militating against the Construction of GB

Some factors militating against the construction of GB identified from literature (Means, 2004) were assessed with respect to their severity or importance on a four point Likert scale. Table 6 presents the result. Table 6 indicates responses from questionnaire on the factors hindering the practice of Green Building in Nigeria, on a scale of l to 4 ranging from Not significant to Very Significant. Lack of awareness (MS = 3.28) has the highest rating. This suggests that GB is relatively a new trend. The respondents regard it as significant problem of Green Building practice.

Table 6: Factors Hindering the Practice of Green Building

S/N	Factors	Frequency Responses				Σf	Σfx	Mean (x^1)
		1	2	3	4			
1	Lack of awareness	-	7	15	18	40	131	3.28
2	Developers and builders tend to keep things as simple as possible	11	14	8	4	37	79	2.14
3	Market expectation	5	15	8	9	37	95	2.57
4	No. enabling environment	3	17	3	16	39	95	3.00
5	Economic situation	-	5	15	20	40	120	3.00
6	Lack of professionals to handle the task	22	24	5	5	35	74	2.11
7	Lack of technical know-how	10	13	11	1	35	73	2.09

1=Not significant; 2 Less significant; 3= Significant; 4= Very Significant

Developers and Builders tend to keep things as simple as possible 2.14 (less significant). Lack of technical know-how averaged 2.09 meaning less significant also. This shows that the respondents have various ranking for the factors hindering the smooth take off or practice of Green Building.

Prospects of GB

The prospect of GB in Nigeria was assessed by presenting some of the benefits associated with the use of GB, like reduced capital cost, preservation of natural resources, health and productivity gain, etc.; and requesting the views of respondents on such benefits. Details of the results are presented in Table 7.

Table 7: Benefits Derived from Green Building (Prospects)

S/N	Factors	Frequency Responses				Σf	Σfx	Mean (x^1)
		1	2	3	4			
1	It reduced capital cost	-	-	10	30	40	150	3.75
2	It reduced operating cost	-	-	11	27	38	141	3.71
3	Market benefits (free pass and product differentiation)	-	-	10	30	40	150	3.75
4	Health and productivity gain	-	-	5	35	40	155	4.00
5	It reduced liability risk	-	-	20	20	40	140	3.50
6	Attracting and retaining employees	-	-	8	30	38	144	3.79
7	Waste management	-	-	16	23	39	140	3.59
8	Preserving natural resources	-	-	5	35	40	155	3.88
9	Satisfaction from doing the right thing	-	-	11	29	40	149	3.73

1 = Strongly Disagree; 2= Disagree; 3= Agree; 4= strongly agree

Respondents' view on the benefits derived from Green Building on a scale of 1 to 4 ranging from strongly disagree to strongly agree is indicated in Table 7. As it can be observed, reduced capital cost of building, averaged 3.75 meaning that the respondents have strongly agree as a benefit of Green Building. Reduced operating cost of the building, averaged 3.71 (strongly agree). Market benefits (free pass and product differentiation) averaged 3.75 (strongly agree). Reduced liability risk averaged 3.50 (strongly agree) and attracting and retaining or employees within the building (employments opportunity), averaged 3.79 (strongly agree). Controls waste management during and after construction of the building averaged 3.59 (agree). It helps in preserving natural resources averaged 4.00 (strongly agree). While total satisfaction from doing the right thing, averaged 3.73 (strongly agree). This indicates that the respondents agree, strongly, to all the benefits of Green Building.

Summary of Results

The study found that:

- Conditions calling for the need for Green Buildings exist in Nigeria.
- Majority of the respondents (95%) have not participated on the design of GB: i
- There is consensus of opinion that there is non-compliance with site selection criterion for the construction of GB as 87% of the respondents noted that they had not partake in any rehabilitation of construction site for GB while only 13% of the

respondents observed that they had participated in the rehabilitation of construction sites.

- The problems most militating against the practice of GB, are lack of awareness (MS = 3.28) and no enabling environment and economic situation (MS = 3.00).
- All the benefits outlined in the questionnaire were seen as very important, because they have rating above the mid-point of the mean score. The most important benefits are Health and productivity gain (MS = 4.00), followed by preserving natural resources (MS = 3.88), reduction of operating cost (MS = 3.79), and attracting and retaining employees (3.75).

Oral Interviews

Oral interview was conducted with some professionals in an attempt to ascertain other problems affecting Green Building practice in Nigeria as well as benefits derived from Green Building practice. Besides that issues that were not sufficiently covered in the questionnaire form part of the question asked in the interview, such as, the syllabus of department of Building in the Universities and Polytechnics and the issue of enabling environment for the practice of GB. Below is presented the result of the interview:

Problems of Green building practice in Nigeria

1. No Enabling Environment: Result of investigation reveals that there is no enabling environment in the form of policy, legislation or some form of incentives for the practice of GB. Compared with what is obtained in the developed nation in which government lead by example – through the construction of some public building using the concept of GB.
2. Uncertain Economic Environment: In Nigeria, the private sector has a narrow market base and the formal construction industry overly relies on the government for work, whose work orders fluctuates with income giving volatile oil pricing in the international market. There has also been a reduction in public spending as services previously provided by government are being privatized as a result of poor services to the public. These have brought fluctuation in construction activities which discourage long term strategic planning, and in turn hinder access to investment capital. Delays with interim and final payments, as well as onerous contract conditions faced by construction firms constitute huge constraint on the industry. According to Osanga & Apochi (2000), many indigenous firms have suffered financial ruin and bankruptcy because of delays in payments, which are common with government contracts.
3. Technological Barriers: Technology dependency hinders the autonomous development of own technology. Nigeria needs knowledge and technology that are better adapted to her natural resources than that which is obtained from industrialized countries. For example, the use of earth and timber construction that predated colonialism has been discouraged and no longer popular.
4. Problem of Accountability and Transparency: The absence of transparency in governance translates into a situation where the construction industry becomes a breeding ground for unfair practices, especially corruption of bidding/tendering and contract award practices, as well as the construction process. Overestimation of contract and award on the basis of 10% kick-back, party patronage and favoritism and not on the basis of sound technological know-how of the contractor.

5. Lack of Integrated Research: Another problem is; much of the research in building technologies and planning is not done in a holistic approach. The research institutions, development agencies and other organizations address each issue individually and independently of other issues to which it is linked.
6. Lack of Interest in the Issue of Sustainability: There is a general lack of interest in the issues of sustainability by the construction sectors, indicated by its clients and other stakeholders. This negligence is experienced differently through the various stakeholders such as:

a. Politicians: Environmental Sustainability issues rarely constitute agenda differentiation of political parties or political leadership, except as occasioned by the recent protests in the Niger-Delta of the country.

b. local Authorities: Sustainability issues never forms any requirements for their plan approvals, land use or land subdivision. Local Authorities do not request EIA plan of Environmental Impact Statement (EIS) as a criterion to plans approval. The construction industry is traditionally very indifferent to change, especially when it comes to the construction methods and building materials used.

GB in the Curriculums of Some Courses in the Universities and Polytechnics

Result of interviews with lecturers' shows that the current syllabus of sustainable construction (Green Building) taught in our higher institutions of learning (Universities and Polytechnics) is inadequate to enable the practice of Green Building (Design and Construction Phase) effectively.

Conditions that bring the need for GB

Results of the interview and search of relevant literatures such as Kolawole & Anigbogu (2005) and Gandu (2005) agrees with the results of field survey which shows that the conditions that calls for GB elsewhere — in the developed nation do exist in Nigeria. Especially considering the fact that there is a substantial environmental damage not only from construction work but also from oil exploration in Nigeria

CONCLUSIONS AND RECOMMENDATIONS

In this study an attempt was made to gauge the perception of professionals in the built environment as regard to the respect of GB in Nigeria. First the concept of GB was closely examined – the roles of each professionals involved, processes involved in design and construction of GB and its benefits. This was followed by a preparation of a checklist of the important criterion that buildings must satisfy for it to be qualified as GB. This was used to determine whether or not GB concept is been used in the building industry in Nigeria; effort was also made to establish the existence of conditions calling for GB and the respondents' view on prospect of GB in Nigeria. Based on the results the following conclusions were arrived at.

GB is not practiced in Nigeria; there is no any enabling environment in the form of legislation or policy on Green Building practice; the overall perception of Green Building from all the groups of respondents has revealed, that most professionals are aware of the new trend (Green Building) and enormous benefits derived from it and they see Green Building as a basis for appealing livable homes and preserving natural resources while taking care of their health. However, the general public are not fully aware of this development i.e. level of awareness of Green Building is low.

There is no adequate provision in the current syllabus of some courses in the tertiary institutions on the construction of GB in tertiary institutions in Nigeria. Based on the results obtained in this research, the following are recommended.

- Public enlightenment should be done by Non-Governmental Organization NGO, government and professional bodies through Continuing Professional Development (CPD) and funded by the same agents.
- The practice of Green Building should be encouraged by the government requesting for Construction Environmental Management Plan from contractors as part of tender documents.
- Designers should adopt a more integrated approach to design and appreciate the fundamentals of Green Buildings.
- Manufacturers of construction materials should use life cycle considerations as the basis of product development and should cooperate with designers in creation of new recycling of materials. Also, they should form partnership with research firms by providing funds for research and development and implementation.
- Government should lead by example through the construction of GB for major public buildings and provide incentive for those that want to construct GB.
- The major corporations operating in the country should be compelled to use GB as their major offices most especially oil companies. They should be made to sponsor researches on GB.
- Part of the Community's Social Responsibility (CSR) undertaken by corporate bodies, especially Oil companies, should be provisions of schools clinics, and made of GB

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IMPROVING HOUSING DURABILITY IN INFORMAL SETTLEMENTS USING AFFORDABLE BUILDING MATERIALS - THE CASE OF KIBERA, NAIROBI

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Abstract:
Durable and affordable housing is seen as a major challenge in most cities in developing countries. This is because poverty, natural population increase and in migration provide a challenge for city planners in keeping up with provision of decent, durable and environmental friendly housing and other infrastructure to its citizens. The end product is usually a colony of informal settlements dotted with non-durable structures. However with the empowerment of youth and communities, education and quality of life could be boosted, there would be the use of indigenous knowledge, development and the sharing of technology to overcome non-durable structures. All informal settlements would have sustainable housing if the problems and challenges of non-durable housing are overcome. The paper has used quantitative methods of research to evaluate a specific community on their access to durable housing. Various parameters were used to cross check if the people live in non-durable housing out of choice. It became evident that affordability and lack of technological innovation on locally available materials were the main culprits for the persistence of living in non-durable structures. As a way of conclusion the study advocates for use of interlocking bricks as a way of mitigating the challenge of non-durable building materials. They are also environmentally friendly for this particular settlement.

Keywords: Durability, Low income housing, Materials, Sustainability, Kenya

INTRODUCTION

Africa is urbanizing at a very high rate with an annual urbanization growth rate of 3.31% (2005-2010) with a projected increase in population from 373.4 million people in 2007 to 759.4 million in 2030. In fact, 38.7% of Africa's population is living in urban areas as documented by the United Nations Human Settlements Programme (UN-HABITAT 2008). Kenya is no exception; in 1962, only one out of every 12 Kenyans lived in an urban centre but by 1999, the proportion of the urban population had

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increased to 34.5%, i.e. one out of every three Kenyans was living in an urban centre. Furthermore, during the period of 1989-1999, the country's urban population had increased by 155% (Government of Kenya 2002). Today, the urban growth factors in Kenya are natural increase and *in-situ* urbanization (the absorption of rural and peri-urban settlements in the spatial growth of a larger adjacent city.)

As the developing countries keep on having a population surge, the worst hit areas of these countries are the urban areas, bringing with them a couple of problems like crime, poverty, lack of sustainable housing and formation of slums. Already this is evident in the continents of Africa, Asia and South America. The cities of Mumbai, Nairobi, Rio de Janeiro and Manila are some of the examples of cities with slums. These slums lack planning, they have poor infrastructural amenities, there is lack of permanency in the structures and a sense of seasonality- though sometimes it spans for 20 years- reflected in the building materials and design. This means that there is a persistent need for housing, and housing which is durable.

Most materials used in the construction of these settlements are innovative but not durable. This is because the slum dwellers build their houses in tandem with their financial ability. Over 60% of these slum dwellers in most of the slums are very poor and cannot afford durable materials for sustainable housing. According to (UN-HABITAT 2003), a house is durable provided that the materials used are structurally permanent, can protect its inhabitants in extreme climate conditions and is built in a hazard free location. Furthermore, every citizen has a right to good housing and should not stay in deplorable conditions like the slums.

Most governments and authorities have resorted to slum upgrading in line with the Millennium Development Goals (MDGs). Kenya is one of them. These responses are aimed at keeping up with the provision of decent and durable housing with an aim of improving quality of life. This paper tries to address the gap found in the provision of durable housing by the local authorities in Kibera-Kenya, which can be bridged by having new appropriate technology, material science and fundamental mechanisms.

DURABLE HOUSING IN KIBERA-NAIROBI, KENYA

Durable housing is a panacea for any development to take root. Through the use of indigenous knowledge, education and development of technology, durable housing is always a possibility. Technology becomes available with access to affordable finance. But most poor people are entangled in the trap where good housing is unaffordable as they do not have access to financial capital or institutions. In Kenya, the informal settlements bear the largest brunt of economic development in urban areas yet there is a lot of potential man power resource inside the settlements. The guidelines in the Poverty Reduction Strategy Paper point out to slum upgrading as one of the key elements of reducing poverty. It states that the slum dwellers should be involved in the designing and implementation of the housing as they themselves can solve these problems. Under the Global Land Tool Network (GLTN), the slum dwellers are empowered through capacity building, research and training

Kenya, working closely with the GLTN and UN-HABITAT has developed the Kenya Slum Upgrading Programme (KENSUP). This program seeks to eradicate slums in the whole country and has a pilot phase in Kibera which is the main focus of this paper. Most homes are generally one-story, one-room, 10 ft. x 10 ft. huts made of mud and precariously placed corrugated tin roofing. Structures are so poor that in case of heavy rainfall or fire, they would be destroyed. In case of such a tragedy, there would be a high number of causalities as there is very little space in between the alleys for people to escape. These intervening bodies have come together to provide durable housing as a wholistic process. In Kibera every effort has been made to ensure that the slum dwellers own and feel that they own their homes, and as such the interventions focus on community participation in the innovation of building materials for their houses.

Objectives of the Study

To achieve the aims of the study the following objectives were used as guiding principles:

- To find out the challenges present in accessing durable housing in informal settlements.
- To identify the presence of locally available materials for constructing durable houses.

RESEARCH METHODOLOGY

Research Design

As this was a specific project being targeted, the sample was drawn from one of the twelve villages in which the intervention was being carried out- Soweto East village. Simple random sampling was used to select the respondents for the study and in total 40 adults constituted the sample. The sample size was selected based on the minimum number of samples being 30 in any sample. People living in durable houses as well as non-durable houses were interviewed.

The variables used included type of housing one was staying in, materials used in housing, body in charge of building houses, improvements in housing, affordability and choice of housing structure, whether one would like to live in a durable house, problems of non-durable homes, challenges of having a durable house and recommendations for a durable housing structure.

Methods of Data Collection

The research depended mainly on primary data though also some desk studies had been done earlier. The data was collected through the use of questionnaires, interviews, focus group discussions, expert interviews and observation.

Data Analysis and Synthesis

From the field data processing was done by scrutinizing the return questionnaires to check for inaccuracies and inconsistencies. Once the data was cleaned, a code book was designed and generated to translate the entries in the questionnaires to a spread sheet. The spread sheet data were then converted to electronic form using Statistical Package for the Social Sciences (SPSS) interface data editor since SPSS was the main analysis platform. The resulting dataset was further subjected to cleaning based on the preliminary frequency distributions.

At the preliminary stages statistical data was subjected to explotary data analysis using statistical tools of descriptive measures including measures of central tendencies and dispersion to assist in accurate description of statistical data. The results of these analyses were presented in tabular form or in graph form and remarks made about them.

FINDINGS

Problems of Non-durable Housing

Out of 40 respondents, 10 (25%) were living in durable homes while 30 (75%) were living in substandard structures. The materials used in the durable homes were 'stones' made from cement and bricks made from cement and sand. In the non-durable homes the materials ranged from rusted iron, paper, mud, cloth and skin. The respondents cited problems associated with living in non-durable houses as shown in Figure 1:

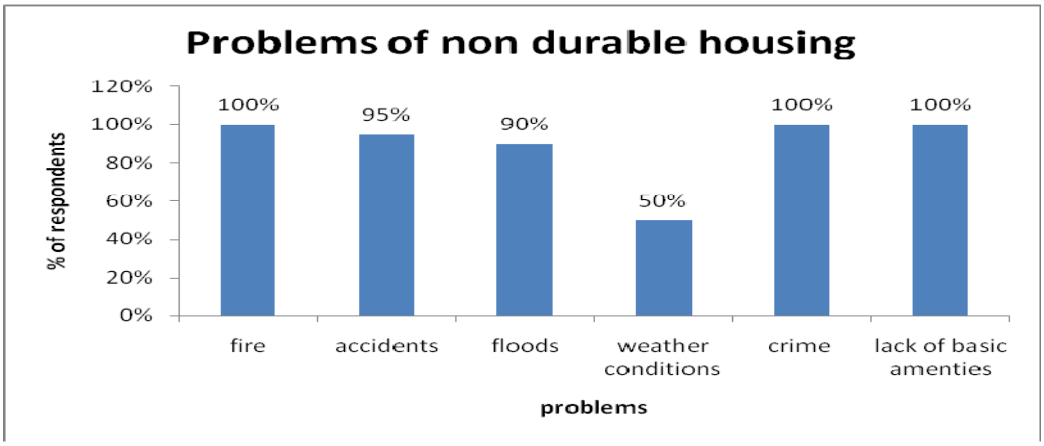

Figure 1: Problems associated with non-durable housing

Ownership of Homes

The respondents were also asked who was responsible for their tenure-ship of the housing structures. 25% of the respondents stated that it was the government together with KENSUP while 75% stated that it was the rich landlords to whom they were paying rent and as such they were not motivated to make any improvements to their housing condition, since it would not amount to any investment on their part.

Challenges to Accessing Durable Houses

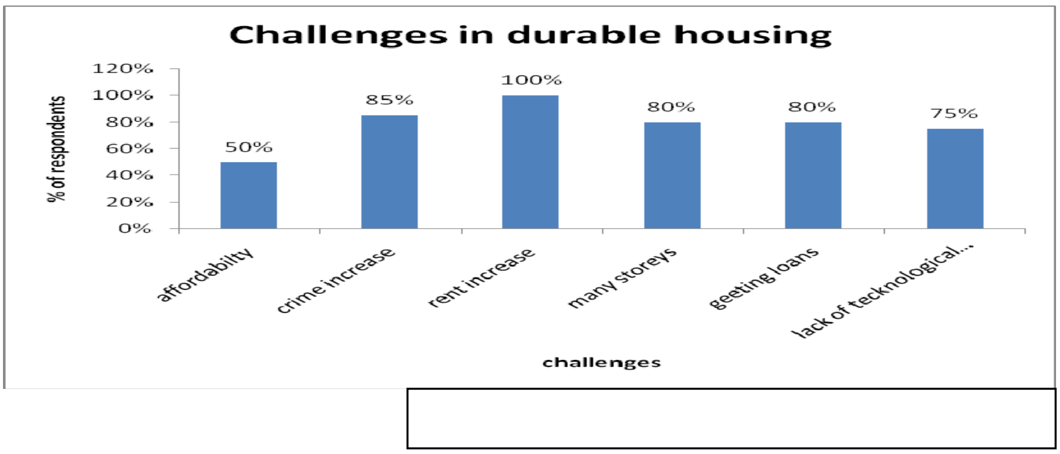

Figure 2: Challenges in durable housing

Various responses emanated from the question relating to the challenges experienced in accessing durable homes. Among them was the aspect of affordability which 25% claimed that it was affordable. This was Figure 2: Challenges of having durable housing the percentage that was staying in areas with durable structures. Of the 75% staying in non-durable housing, only 10 respondents (33.3%) stated that they could afford durable housing. This was due to the fact that they would not afford a bigger chunk of their salary for rural remittance purposes. Other responses about the challenges encountered in accessing durable housing included; increase in crime rates, difficulty in accessing the higher floors in multiple storey buildings, arbitrary rent increments, difficulty in accessing loans without surety and lack of cheap technological innovations.

Recommendations on Material Choice for Housing

Though living in non-durable houses, the respondents were aware of the steps that could be taken to ensure that their houses are durable. Among them, they cited durable and cheaper materials like stones, waste water bottles, corrugated iron sheets and cement. See Table 1. All respondents commented that the cement stones and bricks made by the youths in Kibera were affordable. Further questioning found out that the cement bought by the Youth Empowerment Programme was bought directly from a cement manufacturing company and as the project was for empowering the youth, the cement was sold to them at a subsided price. This encouraged the youth to make cheap stones and bricks. Plate 1 shows youth making cement stones.

Table 1: Affordable and durable material

Type of Material	Percentage Respondents
Stones	90
Waste Water Bottles	25
Corrugated Iron Sheets	80
Cement	75

Source: Field Work 2012

Plate 1: Youth making affordable bricks

DISCUSSION

Majority of the respondents were against the idea of having non-durable housing (plate 2) and opted for durable housing. Challenges like fire, limited access to basic amenities, crime, accidents, floods and weather topped the list. Studies carried out by different researchers have shown accidents, floods, fires and crime to be the main problems associated with non-durable housing in the slums of Kibera. With floods the risks of diseases also increases. In 1997 the El Nino rains created severe floods which led to deaths of humans, destruction of property as well as structures. The flood waters contaminated the fresh water and diseases occurred (Hayombe, 1997). Lack of basic amenities includes access to clean water and sanitation. In fact in most of the non-durable houses, people look for illegal connections or open man holes (Septic tank) so as to divert sewage water to farms causing disease. For instance, in parts of Kibera farmers remove manhole covers and block the city's main sewer, diverting raw sewage on to their land to irrigate their crops (Scott *et al*. 2004). Plate 3 shows the small walking alleys in the informal settlement of Kibera which lead to serious accidents in case of falls.

Plate 2: Non-durable housing

Plate 3: Accessibility in the area

The results indicated that very few people lived in durable housing in Kibera in spite of the fact that they desired to live in them. This is because they foresaw problems of living in durable houses. Increase in rent, crimes, lack of negotiating power for loans and buildings with multiple storeys were rated at or over 80% of the problems. The issue of rent meant that if one lived in a durable house, the landlord would think that the tenant is rich and would keep on increasing the rent at every opportunity he got. This indicates that in the long run affordability would be a hindrance (COHRE 2006). Crimes would also increase in durable houses as it is a perception that the rich live in such houses. Many respondents felt that living in affordable houses was not favourable to them as access to cheap loans was a problem. Only with a good increment of salary, would they be able to afford the loans.

It was also of note that many households had elderly and disabled people; this led to another challenge which was the design of the houses. The durable houses tended to occupy less space horizontally and more vertically and as such they posed a challenge to the elderly who would not be in a position to climb the stairs of multiple storey buildings. Lack of affordable and innovative technology was cited as a major challenge. The residents felt that the solutions being provided in mitigating their deplorable conditions were very generic and revolved around expensive solutions thus not helping them in any way. They thought that if technology was viable and available then, durable, affordable and sustainable materials would be produced for their houses. Some even proposed the use of plastic waste water bottles as affordable material for housing. This was seen as a cheaper option, since the bottles would be recycled as opposed to them being thrown as non-biodegradable waste and polluting the environment. This idea is a viable and sustainable solution as depicted in Dar es Salaam's Chumazi area, where local communities have been building housing using waste plastic bottles (Plate 4).

The respondents in Kibera felt that the use of interlocking bricks should gain more momentum and popularity as it was cheap and sustainable. The interlocking blocks used material that was locally available, thus incurring less cost in terms of production and labour. Plate 5 shows the making of interlocking blocks in Kibera.

Plate 4: Waste water bottles as innovative building material

Plate 5: Interlocking bricks

Through an initiative by KENSUP and UN HABITAT, the youth in the area have been producing 2,500 ‘cement and sand’ bricks per day. They had a finance facility to procure the machines needed. This process is labour intensive and requires one to mix a particular percentage of sand and cement, with cement being more and add water to it. This is then put in the machine which compresses the mixture and produces interlocking bricks. Theses bricks are affordable and require no additional cement for them to stick together; they only require interlocking for a decent and durable house. It costs approximately KES 100,000 (US$ 1,176) to have a 2 roomed house in Kibera made from these interlocking bricks.

CONCLUSIONS AND FURTHER RESEARCH

From the study it is important to note that the respondents had one desire, which was to live in durable, decent and disaster proof houses. They knew what the solution was but a lack of financial resources hampered their progress in attaining their goal. As researchers and people charged with the task of innovating, it will be of paramount importance to look for ways in which affordable building materials can be accessed by all sectors of society. In this particular area; the technological invention that was cited is the use of interlocking bricks to make durable houses. This is a step forward, but could it be made cheaper than what it costs now? Could the idea of recycling plastic bottles be incorporated? If this idea is possible, what would be the cost?

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RAPID URBANISATION AND HOUSING TRANSFORMATION: THE CASE OF THE PERI-URBAN SETTLEMENT OF TLOKWENG, BOTSWANA

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Abstract
The aim of this paper is to explore community resilience in the face of rapid urbanisation taking the peri-urban village of Tlokweng as a case study. While previous studies have identified construction of outbuildings and house extensions as some of the ways for poor property owners to increase residential space for household use or renting, this paper focuses on the commoditisation and transformation of traditional homesteads into rental accommodation. The study utilised both qualitative and quantitative data collection techniques. However, only qualitative data is used in this paper to show that housing transformations in Tlokweng have primarily been driven by the village's proximity to the city of Gaborone, land and housing shortages in the city and diminishing opportunities for subsistence livelihoods within the village. It concludes by noting the role played by the transformation in alleviating shortages for rental housing, providing alternative sources of income and decreasing urban sprawl.

Keywords: Housing transformation, Urban resilience, Tlokweng - Botswana

INTRODUCTION

According to Njoh (2003) and Macionis and Parrillo (2010), urbanisation - especially rapid urbanisation - is always accompanied by numerous challenges and opportunities. While it creates job opportunities and markets for rural produces, it fuels rural-urban population movements and transforms everyday life by reordering existing social structures and introducing new social stratifications, lifestyle patterns, values, attitudes and behaviour. Urbanisation may also lead to the growth of subcultures shaped by unequal access and distribution of income, wealth, political power and other livelihood resources. This paper highlights the impacts of rapid urbanisation on the transformation of modern and traditional housing in order to accommodate poor city migrants. The paper is divided into five parts: this introduction which provides an overview of housing transformation in east and southern Africa; the conceptual framework; study area and methodology; findings of the study; and discussion and conclusion.

Housing transformation

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The term ‘housing transformation’ is used here to refer to informal, extra-legal and unplanned processes through which home-owners extend their houses, erect additional rooms or convert part of their homesteads into rental accommodation. It is similar to ‘rooming’ or multi-habitation – that is, “a situation in which people who do not define themselves as one households share a living space that is clearly not designed for multi-family purposes” (Schlyter, 2003: 7).

In South Africa and Zimbabwe, the transformation takes place through construction of backyard dwellings or shacks (Schlyter, 2003; Morange, 2002; Lemanski, 2009). The shacks are structures often built by occupiers on land belonging to other people. The shack occupiers pay rent to the land owners with whom they share consumption costs for electricity, water, sanitation and refuse collection. The shacks are often “constructed from corrugated iron, metal sheets and wooden planks … with most comprising a single room in which residents cook, eat, sleep, wash and live” (Lemanski, 2009: 473). Lemanski notes that as of 1990 “nearly 60% of Gauteng’s township properties hosted backyard dwellings, housing almost half (44%) of Gauteng’s Black African population … By the late-1990s, virtually every backyard in Soweto township hosted an informal shack …” (Lemanski, 2009: 474). According to Schylter (2003: 22), 60% of all residential plots in Unit N, Chitungwiza Township, Harare, had an illegal outbuilding accommodating lodgers.

Unlike Zimbabwe and South Africa, housing transformations in Tanzania is through addition of rooms to the primary house (Sheuya, 2009). New rooms are incrementally added to the main house or other outbuildings such that the house can have as many as 12 rooms instead of the standard four to six (Sheuya, 2009: 85). A study by Shiferaw (1998) revealed that construction of additional rental rooms was also the major housing delivery system in Addis Ababa, Ethiopia.

Until the 1980s, rooming was unknown in Botswana’s rural settlements although it was quite common in Francistown, Gaborone, Lobatse and other townships (Larsson, 1990). However, a study carried out by the same author in the early 1990s revealed that some households in villages around Gaborone accommodated tenants in their traditional houses (Larsson, 1996). The tenants worked in Gaborone and commuted daily to work. While most previous studies have focused on housing transformation in townships, this paper is an attempt to explore the extent, nature and impacts of housing transformations in traditional settlements taking Tlokweng as a case study.

Motivation and effects of housing transformations

Housing transformation has been attributed to three major factors: restrictive or inappropriate state policies, rapid urbanisation and failures in the formal housing delivery systems. According to Lemanski (2009) and Morange (2002), backyard dwellings became increasingly popular in South African cities during the 1960s because the government halted the construction of houses for rural-urban migrants and/or prohibited the growth of informal settlements. Consequently, the growing urban African population found shelter in backyard shacks where detection could be avoided (Watson and McCarthy, 1998). Watson and McCarthy (1998) and Lemanski (2009) note that the growth of backyard dwellings in the post-apartheid era has been fuelled by state and municipal housing policies, strategies and programmes that focus on promoting homeownership and ignore the rental housing market. Schylter (2003), Sheuya (1998) and Shiferaw (1998) attribute the transformation to housing shortages especially among the urban poor in Zimbabwe, Tanzania and Ethiopia.

The transformation has been applauded on several grounds. First, it is viewed as a "solution adopted by people themselves in circumstances where no other solutions were offered … [thereby enabling] more people to benefit from urban services than was planned" (Schylter, 2003: 9; see also Morange, 2002: 11-12). Second, the sharing of services reduces housing costs. Third, shacks and rental rooms represent capital investments designed to generate regular income to landlords while providing affordable shelter to low income households. Fourth, rental rooms provide working space for home-based enterprises such as shops, salons, carpentry, poultry, laundry and telephone services (Sheuya, 1998; Shiferaw, 1998). Fifth, additional rooms enable house owners to create more space for food preparation and sleeping besides subletting (Shiferaw, 1998). Sixth, backyard shacks in planned areas are said to guarantee more physically and socially stable environments than informal settlements because they are less threatening (Morange, 2002). Last, but not least in importance, backyard shacks and rental rooms provide flexible and personalised relationships whereby tenants and landlords support each other (Morange, 2002). Despite the positive contribution to housing delivery, backyard dwellings and house extensions have been criticised for increasing housing densities (overcrowding); promoting ill health; and compromising building regulations, standards and development control codes (Morange, 2002; Shiferaw, 1998; Sheuya, 1998; Schylter, 2003).

CONCEPTUAL FRAMEWORK

The paper is informed by two independent but interrelated conceptual frameworks: the *Sustainable Livelihood Framework* (SLF) and the *Asset Vulnerability Framework* (AVF). The SLF considers a livelihood to be sustainable if people are able to maintain or improve their standard of living as well as reduce their vulnerability (Allison and Horemans, 2006). Its main dimensions are Vulnerability Context; Livelihood Assets; Transforming Structures and Processes; Livelihood Structures; and Livelihood outcomes. In the SLF setting, individuals, households and communities are viewed to operate in a context of vulnerability utilising several assets in the form of human skills, natural resources, finances, social and physical capital. These assets gain their meaning and value through Transforming Structures and Processes such as types of government support, state laws and policies, cultural and institutional arrangements and private sector participation (DFID, 1999; Kollmair and Juli 2002). Transforming structures and processes influence livelihood strategies that may be adopted by individuals, households and communities in order to achieve their envisaged livelihood outcomes, which may include enhanced incomes, better well-being and / or improved food security.

The AVF on the other hand, seeks to identify asset management practices that promote "resilience or the responsiveness in exploiting opportunities, and in resisting or recovering from the negative effects of a changing environment" (Moser, 1998: 3). It is premised on the assumption that when exposed to some form of either internal or external stress, risks or shocks households tend to develop and adopt certain contingencies in order to deal with their ordeal. According to Moser (1998), urban assets include labour (skills, competencies and inventiveness); human capital (healthy, educated, skilled etc. population); land and housing; household relationships; social capital expressed through solidarity, reciprocity and trust. Moser (1998) further identified housing as a less familiar productive asset that is transformed and managed to reduce vulnerability to external pressures by generating income through, for instance, renting of rooms and the use of its space for home-based productive activities.

Overall, the SLF and the AVF both recognize that urban dwellers, for example, individuals, households and communities have productive assets such as land, housing and its associated infrastructure. When the urban dwellers are faced with adversity, they can mobilize, transform and manage such assets to improve their livelihood. The corollary of such livelihood improvement is resistance to vulnerability brought about by internal-external factors such as urbanization.

STUDY AREA AND RESEARCH METHODOLOGY

Established soon after Botswana's colonisation by the British in 1885, Tlokweng is a peri-urban settlement abutting the country's capital city of Gaborone. At the time of Botswana's independence in 1966, Tlokweng had a population of about 3700 inhabitants. Its population has since increased to about 36326 in 2011 (GOB, 2012). The settlements' rapid population growth is attributable to its close proximity to the city – which it serves as a 'dormitory town'. Tlokweng, together with Palapye, were the first two villages to be granted 'urban' status following the 1981 population census. In Botswana, a village attains 'urban' status when 75% of its population is engaged in non-agricultural activities.

Changing socio-economic and vulnerability experiences in Tlokweng

Besides experiencing rapid urbanisation and population growth, Tlokweng has witnessed several socio-economic and political shocks and stresses. First, when the Batlokwa migrated from South Africa in 1887, they were permitted by the Bakwena chief, Kgosi Sechele I, to occupy the land in Tlokweng on condition that they paid him rent in the form of cattle (Schapera, 1943). However, due to misunderstandings between the Batlokwa chief, Kgosi Gaborone, and Kgosi Sechele I, later ceded the land to the British Government in 1895 without allocating alternative land to the Batlokwa. The British Government formally granted the land to the British South Africa Company (BSA) in 1905. The Batlokwa became tenants and were required to pay rent to the BSA Company. However, with financial assistance from the British colonial government, the Batlokwa reclaimed back part of the land in 1933.

Second, with the coming into effect of the Tribal Land Act (1968) in 1970, the Batlokwa chief and headmen once again lost control over land in Tlokweng. The Act transferred land administration duties from chiefs to land boards established by the state under the same act. In addition, the act vested ownership of tribal land into various land boards. Batlokwa tribal land was vested in Tlokweng Land Board. Third, following the 1993 amendments to the Tribal Land Act, all tribal land (including that in Tlokweng) became accessible to all citizens. The amendment, as Kalabamu (2012) observes, has had the effect of escalating the demand and commoditisation of land peri-urban areas such as Tlokweng and Mogoditshane. Fourth, as a consequence of rapid urbanisation and in response to increased demand for serviced residential land in Gaborone and surrounding settlements, large tracks of land previously reserved for agricultural uses has been converted to urban uses (Kalabamu, 2012).

The above political, social, economic and demographic changes have overtime intensified and increasingly threatened the sustainability of the Tlokweng community. The threat is further aggravated by the shortage of land in Tlokweng and the settlement's location. Tlokweng is hemmed in by the city of Gaborone to the west, South Africa to the east and freehold farms to the north and south. As a result, the village has space for lateral expansion.

Research methodology

The study on which this paper is based sought to identify the effects of urbanisation on traditional settlements in Botswana taking Tlokweng as a case study. The study was divided into three phases. During the first phase, quantitative data was collected while qualitative data was collected in the second phase. The third phase was used to map physical changes within compounds in the traditional or unplanned part of the village. A total of 74 homesteads or compounds were studied. However, this paper utilises data collected through in-depth interviews during the second phase.

In-depth interviews were undertaken by the authors between November and December 2012. A total of nineteen house owners and twenty-three tenants were interviewed using different sets of questionnaires. Respondents were selected through purposeful sampling based on house ownership, existence of rental rooms or out buildings. Plots or compounds without rental rooms or structures were left out. In each compound, either the landlord or a tenant was interviewed but never both a tenant and house owner. Only one tenant was interviewed in compounds with several tenants.

FINDINGS

This section presents and discusses qualitative data collected during in-depth interviews as well as secondary quantitative data obtained from census reports and the mapping exercise.

Renting in Tlokweng

According to the 1991 census, Tlokweng had a total of 2647 households of whom a third (or 33.6%) was renters (Table 1). By 2001, the proportion of renting households had increased to about 57 per cent. The percentage households living in their own houses had dropped from almost 59 per cent to 38 per cent. The percentage of households living in rent free accommodation remained unchanged. Both censuses indicate that private landlords in Tlokweng provided the bulk of rental accommodation – about 70 per cent in 1991 and 80 per cent in 2001.

Table 1: Households by type of house ownership

Type of housing	1991	2001
Owner occupied	58.5%	37.9%
Rented	33.6%	54.1%
Free	7.9%	7.9%
Total	100.0% (n=2647)	99.9% (n=5909)

Source: GOB, 1994 and 2004

Table 2: Renting households by type of landlord

Landlord	1991	2001
Government	7.9%	5.1%
Private household	70.3%	80.3%
Private company	2.8%	1.7%
Free	19.0%	12.8%
Total	100.0 (n=1099)	99.9 (n=3661)

Source: GOB, 1994 and 2004

Rental housing in Tlokweng

Rental accommodation provided by the household sector in the unplanned or traditional section of Tlokweng largely consists of one or two roomed detached houses erected anywhere within the compound – not necessarily in the backyard. Figure 1 shows several units occupied by house owners and/or tenants in various compounds. Units for tenants have separate entrances which open to the outside as shown in Figure 2. Thus once a tenant enters the compound he or she does not have to go through a corridor or share any indoor space with the house-owner or other tenants in order to access his or her room(s). This arrangement is designed to promote privacy and ensure that tenants do not encroach on the private life of the landlord's family. The arrangement borrows from traditional Tswana housing practices whereby parents, daughters, sons and visitors occupied separate units within the homestead or compound.

The mapping exercise carried out during the third phase of our study revealed that there were no tenants in 32% of the 74 homesteads surveyed; 26% of the homesteads were inhabited by only tenants; while 42% were occupied by both owners and tenants – which suggests that Tlokweng communities are not only accommodating tenants within their homesteads but developing compounds for rental purposes only.

Figure 2: Owner-occupied and rented dwellings in Tlokweng (Source: Google maps, 2012)

Figure 3: Typical rented dwellings in one compound, Tlokweng (Source: Authors' photo, 2013)

Drivers for rental housing in Tlokweng

The experience of a 64 year old female respondent summarises the major factors that drive supply of rental housing in Tlokweng. This is what she told us:

> *I was born in 1949 here in Tlokweng. My parents were pastoral and arable farmers… I went up to standard 3. My husband was a professional teacher and I was a farmer. I built this home through cultivation. We used to keep livestock but it has all died due to drought. I am [now] running a business of rental houses… I have two residential plots in Tlokweng… The first house on this plot has since been destroyed because it was too small and primitive. I destroyed it and decided to use modern building materials. I built the main house to reside in it with my children.*
>
> *I started the business of rental houses in 1985 after my husband passed away because things became a little tough for me. I had to pay school fees for the children. Then I realised I had to build a rental house. I am the one who laid the bricks, with the help of my children until we put up a complete structure and I rented it out for P25. From there I saved some of the rental money and extended it gradually until I had a total of six rental rooms. At the moment the rent is around P400 [US$ 50] per*

room. I built an apartment on the second plot. The apartment has a kitchen, bathroom, toilet and sitting room. Its rent goes for P1200 [US$ 150].

The main factor which attracts people to my compound is lack of accommodation. People also want a tidy environment, and they are also after electricity. The crime rate is very high in Tlokweng, which is why I have planted thorny trees around my plot. I have also put up burglar bars in all the houses. This makes my plot less susceptible to theft… Sometimes I even clean the front of tenants' rooms because they are students at the University of Botswana and do not have enough time to clean… I also try my best to make them feel at home. When they are with me I want them to take me like I am their blood parent. Some of the tenants are working, there is even a lawyer renting in one of the rooms. One is a student at Limkonkwing. There is only one working in Tlokweng at Senn Foods, the rest commute to Gaborone.

From the above narrative, vulnerability and threats arising from changes in livelihood resources appear to be the primary force behind establishment of rental business. The respondent lost cattle through drought and later regular cash income through her husband's death. In the meantime, her financial obligations such as payment of children's educational fees had risen. Contributory factors included shortage of rental accommodation in Gaborone where her tenants are studying or working; proximity to Gaborone which enable her tenants to commute to school or work; employment opportunities for non-resident populations; availability of infrastructure facilities (water, electricity and transport); and modern houses. In addition, rental housing appears to be a reliable source of income and not just a poverty reduction strategy.

Another female respondent (82 years old in 2012) also stated that she started rental business after experiencing income and livelihood challenges. This is part of her story:

… I went to school in Tlokweng up to standard 6. I was never married. I never had a permanent job. At one time I worked as a temporary teacher because I did not have enough qualifications … I do not have any ploughing land or any livestock. I used to keep chicken but they all died because of the disease outbreak. I am not running any business. In the past I used to make and sell traditional beer and was also involved in motshelo [loan-scheme]. I built this house [which she occupies] using motshelo when I was still working for the council as a cleaner but after my son had graduated from school. I built the other [tenants'] houses to earn a living because I am not working. I once joined the destitute programme, but was cut off … So renting is my only source of income…

The above two narratives suggest construction of rental rooms or units is initially a hard and demanding task. The first respondent had to depend on her own and children's labour to build her first rental house while the second one rely on cash loans. Other respondents expressed similar challenges. However, some respondents started rental businesses when some rooms fell vacant. "I built that house for my daughter who later got married and moved out. So I rented it out to get some income. I built the other two housing units in 2011 rental. Have six rental rooms in total. They all go for P450 each", said an 83 years old female respondent. To some, renting rooms is undertaken to supplement salary earnings as reported by a 48 year-old man who formerly worked for the Botswana Housing Corporation. "I started the business of rental houses in 1983 – before I got married. I wanted to raise money for my wife and kids while they were still living with my in-laws. I also had to take care of my parents and my salary was not enough …" he said. "After building my own place where I could stay with my family, I built a second one around 1999. The third one was built in 2010 with my retrenchment package. The fourth [last] one was built last year … At this point I have 3 houses with 8 rooms in total which I rent out…" he added.

Subletting in Tlokweng has now crossed cultural boundaries. "I am renting two houses since 2006. My children are the ones who pushed me into it. I did not want to build rental houses because I am a pure Motswana. I don't even want electricity and they forced me to connect. There are four rooms in total which are for rent. They have helped me not to die of hunger" said an 87 female from the royal family.

Tenants had many reasons for wanting to rent dwellings in Tlokweng as expressed in the following selected excerpts:

- *I came to stay in Tlokweng because that is where I conduct most of my work. It is the most convenient location because I do not have to get a bus to go to work (40 year old builder from Zimbabwe).*

- *I work as a crane operator for a brick moulding company in Tlokweng ... I came to rent a house in Tlokweng because the rent is lower and houses are relatively easy to find. I wanted a house which has got electricity, water and flush toilets. All those things are available here. I was also looking at the rental amount which I can afford to pay (28 year old man born at Chadibe, near Francistown).*

- *Before we came here we stayed at Broadhurst [in Gaborone]. We moved from Broadhurst because there were no flush toilets - we were using pit latrines. We wanted flush toilets because they are tidier and we have kids. This place is clean place and the rent is reasonable…" (37 year old woman married to a self-employed electrician from Mahalapye).*

- *Before I came to Tlokweng I lived in Phase 2 [in Gaborone]. I moved because rent there is more expensive. I was looking for a decent complete house with electricity, kitchen, toilet and, if possible, a bathroom ... this is the kind of house I wanted although I think the rent is too high …" (27 year old woman who has just completed her tertiary education in Gaborone).*

- *I came to stay in Tlokweng because of lack of accommodation in Gaborone also because rent in Tlokweng is lower than in Gaborone (28 year old air technology services technician working in Gaborone).*

- *Work as stock packer at … in Tlokweng. I moved from White City [in Gaborone] to Tlokweng after I found a job at … I wanted to live in Tlokweng because I am now working in Tlokweng… (20 years old youth from Bobonong).*

- *I am a student at Baisago University [in Gaborone]. I came to Tlokweng [from Phakalane] because it is still not yet that heavily populated or congested like Gaborone. I* *like Tlokweng because it still has a traditional village set-up like my home. There isn't too much noise and hence I am able to study without being disturbed (24 year old man from Kgagodi village).*

- *I work for a construction company in Gaborone … and my wife also works for a cleaning company in Gaborone. . Before we came to stay here we were staying and working in Palapye … I live in Tlokweng because I found a job in Gaborone and I found accommodation here" (40 year old man from Serowe).*

Reading through the above excerpts, and other narratives that have not been presented here, easy availability and relatively cheap accommodation are the prominent factors which attract tenants to Tlokweng. All most all tenants interviewed perceive rents to be lower in Tlokweng than Gaborone. Other contributing factors are (i) proximity to Gaborone; (ii) proximity to work in Tlokweng; (iii) housing shortages in Gaborone; (iv) availability of infrastructure services (electricity, water, sewage, transport etc.) in Tlokweng; and (v) quiet rural environment, reminiscent to villages where most tenants were raised. It is worth noting that most of the tenants interviewed grew up in rural areas and came to Tlokweng or Gaborone to take up jobs or pursue further education. In addition, most tenant respondents were youths at school or young adults employed in casual or technical jobs. Most land lords were elderly people with neither technical nor professional skills which suggest that they could not readily utilise cash employment opportunities associated with urbanisation.

Impacts of housing transformations in Tlokweng

The transformation of owner-occupied housing to include rental accommodation has had several socio-economic and environmental effects. First, it has enabled Tlokweng communities to cross cultural boundaries exhibited by the array of tenants from neighbouring countries and many villages and ethnic groups in Botswana. Second, it has increased the housing stock within the low income rental market and kept rents within affordable limits. Third, the transformation has increased building density and alleviated the demand for land and housing in both settlements – Gaborone and Tlokweng. Fourth, the process has facilitated increased utilisation of land and infrastructure facilities without causing overcrowding largely because of the relatively large plots, which were initially designed to accommodate cultural ceremonies and other traditional activities. Last, but not least in importance, the transformation has provided indigenous households with new sources of incomes and livelihood – a critical contribution in light of declining opportunities for agricultural employment.

DISCUSSION AND CONCLUSIONS

Like elsewhere in the region, housing transformation in Tlokweng is a coping strategy adopted by households faced with challenging effects of rapid urbanisation – urbanisation characterised by fast population growth, unemployment, inadequate or declining resources and rampant land and housing shortages. Although Tlokweng is a traditional village, it has experienced the effects of rapid urbanisation because of its close proximity to the city of Gaborone and land tenure reforms that have increased the demand for its land and taken away the village community's right to exclude non-indigenous people from accessing their land. In an attempt to supply adequate residential land, the village community has lost its agricultural land, which has traditionally been its main source of livelihood. While loss of agricultural land created vulnerability, housing shortages in Gaborone engendered opportunities for rental housing in Tlokweng. Opportunities for rental accommodation in Tlokweng have been augmented by state provision of electricity, piped water, sewerage, tarred roads and other facilities as well as the generously large residential plots occupied by indigenous residents. The transformation from utilitarian to rental housing has had tremendous advantages to the nation as well as the community and individual residential plot holders in Tlokweng. The advantages include regular incomes to plot holders, savings on land and infrastructure costs, and improved health and wellbeing among Gaborone and Tlokweng residents.

Housing transformations in Tlokweng are consistent with the two frameworks – Sustainable livelihood Framework and the Asset Vulnerability Framework. Urbanisation has not only attracted migrants to Gaborone but reordered social structures, housing and land uses in villages surrounding the city. More critically, it has led to increased vulnerability among households who lost their productive assets in the form of agricultural land. The loss of agricultural land has denied Tlokweng communities opportunities for subsistence livelihoods as well as opportunities for growing vegetables, fruits and cereals or producing milk for sale to workers in the city. Without skills and competencies required by the urban job market, households dispossessed of their farm land assets turned to rental housing as a coping or survival strategy.

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STRATEGY FOR CLIMATE CHANGE ADAPTATION

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Abstract:
It has been a world priority for more than a decade to reduc greenhouse gas emissions within the frame of the Kyoto Protocol. However, since the Kyoto Protocol it has proved difficult to reach an international consensus at the Conference of the Parties on the continuation of a global agreement. This absence of an agreement calls for adaptation to climate change. Emphasis should be put on buildings, as they play a vital economic and social role in society and are vulnerable to climate change. Therefore, the building stock deserves its own policy and implementation plans as well as tools that enable adequate and cost-efficient adaptation to climate change. This paper explains the need for climate change adaptation of the building stock and suggests a pattern for a strategic approach to how to reach the climate change adaptation needed. The suggested and presented need of a strategic approach is based on three main initiatives consisting of the need to examine the potential impacts of climate change on the building stock, the need to assess and develop a roadmap of current and future adaptation measures that can withstand the effects of climate change, and the need to engage relevant stakeholders in the private and public sectors. Furthermore, the paper describes some issues that must be addressed in case a strategic approach is not developed, as the building sector is continuously investing in measures to adapt to climate change as impacts emerge.

Keywords: Adaptation, Buildings, Climate change, Planning, Strategy

INTRODUCTION

Climate change and measures to mitigate its effects have been a world priority for more than a decade. They have been implemented partly by trying to reduce greenhouse gas emissions on an international level and partly through individual national initiatives. On a world priority scale, efforts to mitigate climate change impacts have focused on reducing greenhouse gas emissions within the frame of the Kyoto Protocol (UN, 1998). The Kyoto Protocol came into force on 16 February, 2005. Industrialised countries signatory to the Protocol were obliged to limit their emissions of greenhouse gases between 2008 and 2012. However, reaching a new global international agreement like the Kyoto Protocol, taking over from 2013 and on, has failed.

The effort of elaborating a new climate policy agreement failed at the Conference of the Parties, COP meetings held in 2009 in Copenhagen (COP15), in 2010 in Mexico City (COP16), in 2011 in Durban (COP17) and in 2012 in Doha (COP18). The intention was to continue to follow the Kyoto Protocol by introducing new obligations to limit emissions of greenhouse gases after 2012. At COP18 it was stated that from 2013 only the European Union, EU Member States, Australia, Switzerland and eight other industrialised countries will continue the Kyoto Protocol to 2020 including new Kyoto obligations to limit emissions of greenhouse gases (Doha – news, 2012). In total, these countries are responsible for 15% of all emissions of greenhouse gases.

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Against all odds, the global emission of greenhouse gases rose by 2.6% in 2012, reaching a level higher than 50% above the level measured in 1990 (Børsen, 2012). However, at COP17 the parties agreed on the development of a global, climate agreement that must include all the countries with the largest emissions of greenhouse gases. The global climate agreement needs to be agreed on in 2015 and come into force in 2020. At COP 15, a Green Fund was agreed and at COP17 the fund was designed, with the purpose of aiding underdeveloped countries in meeting the challenges of climate change. The EU countries agreed independently on their own climate visions (CEU, 2009). The ambition was global and aimed to limit global warming to a maximum of 2°C. In this vision, industrial countries need to reduce their emissions of greenhouse gases by a total of 80-95% by 2050 compared with 1990 emissions.

The lack of global agreement on reducing global warming demands a strategic approach to climate change adaptation that complies with the climate change impact. As buildings play a vital economic and social role in society and are vulnerable to climate change emphasis should be put on buildings. The building stock represents 60-70% (inferred from the European Central Bank, 2011) of the economic capital stock. Substantial losses of building stock or loss of productivity will have important implications for the economy at large. For instance, the Danish building stock has a replacement value of approximately €1,600 to €1,850 billion (Valdbjørn Rasmussen & de Place Hansen, 2011), excluding infrastructure such as roads, rails, bridges, embankments, harbours and sewers. The value was determined in 2010 for the whole country based on the built-up area (Statistics Denmark, 2010) with a mean value of 2,400 €/m^2, equalling the value of €325 thousand for each inhabitant. This is equivalent to approximately €216,000 billion for all EU Member States. Climate change has already been observed in Europe (European Environmental Agency EEA, 2012) and is expected to continue noticeably during this century. Even if – somewhat surprisingly – the implementation of increasingly radical emission reduction measures would gain truly global momentum within the next 10 years, and lead to radical greenhouse gas emission reductions in the next decades, global warming and climate change will continue for many decades, if not the entire century. Consequently, the need to develop a strategic approach to climate change adaptation of existing buildings becomes urgent not only in the EU Member States but in all regions of the world.

The paper suggests and outlines actions needed for developing a broad strategic approach for existing buildings to withstand climate change. As effects of climate change are a serious challenge for the design and upgrading of buildings, adaptation must include key requirements dictated by the effects of climate change, which for the time being are uncertain and evaluated differently.

CLIMATE IMPACTS

The adaptation needed in the built environment is closely related to the projected climate impacts. Available emission scenarios A2 and B2 (Nakićenović *et al.*, 2000; DMI, 2005), as well as the EU2C (CEU, 2009) were used as a basis for the strategy for adapting to a changing climate, as they are considered the most likely by the EU Member States. Global surface warming presented in the Intergovernmental Panel on Climate Change, IPCC 4th Assessment report (Nakićenović *et al.*, 2000) is shown in Figure 1. Scenario A2 assumes a world with little global economic integration and slow development and distribution of effective technological solutions that can reduce the emissions of greenhouse gases. Furthermore, it is assumed that population growth will continue to be high (Nakićenović *et al.*, 2000). Like Scenario A2, Scenario B2 assumes a world with little global economic integration and a slow development and distribution of effective technological solutions that can reduce the emissions of greenhouse gases. Scenario B2 considers a situation with more reduced emissions of greenhouse gases than Scenario A2 as a result of moderate population growth and more environmentally conscious consumers (Nakićenović *et al.*, 2000). Scenario EU2C is the scenario that the EU Member States follow as their climate vision (CEU, 2009). The ambition aimed to limit global warming to a maximum of 2°C. This scenario assumes a world-wide implementation of a large reduction of the emissions of greenhouse gases. Consequently, it is stated that global warming will be limited to a maximum of 2°C (Nakićenović *et al.*, 2000).

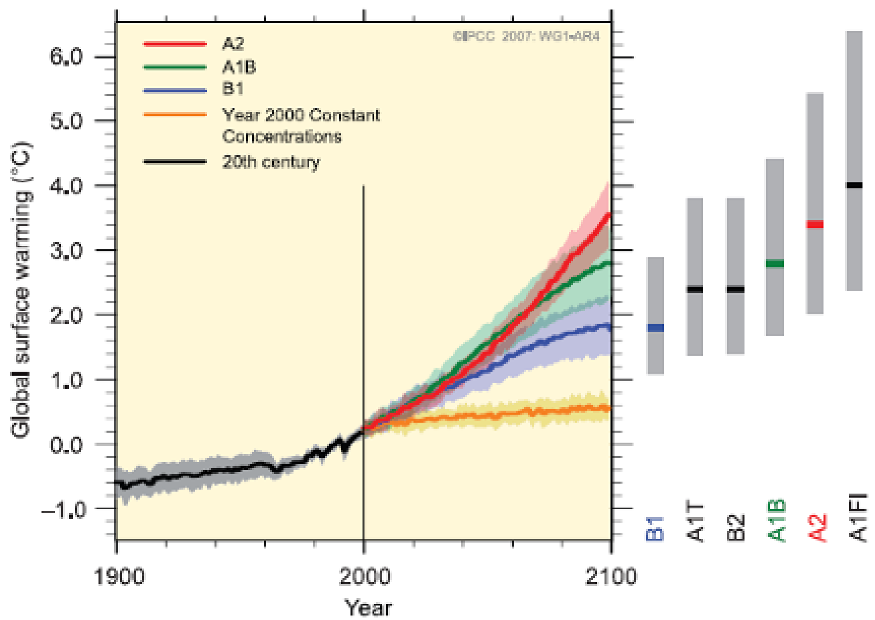

Figure 1: Multi-model averages and assessed ranges for surface warming, figure SPM.5 in the IPCC 4th assessment report. Solid lines are multi-model global averages of surface warming (relative to 1980 and 1999) for Scenarios A2, A1B and B1, shown as a continuation of the 20th century simulations. Shading denotes the ±1 standard deviation range of individual model annual averages. The orange line shows the experiment where concentrations were held constant at year 2000 values. The grey bars at right indicate the best estimate (solid line within each bar) and the likely range assessed for the 6 SRES marker scenarios. The assessment of the best estimate and likely ranges in the grey bars includes the AOGCMs in the left part of the figure, as well as results from a hierarchy of independent models and observational constraints, IPCC 4th Assessment report

MOST IMPORTANT EFFECTS OF CLIMATE CHANGE

For the building stock in the EU region the five most important effects of climate change are:

a. More frequent and heavier rain fall that can cause for instance water damage to buildings, technical equipment and technical plants along with the need for accumulation of rainwater and controlled draining of water
b. More extreme temperatures and heat waves of long duration that will create an indoor environment that can pose a health risk for inhabitants with a weak constitution and create an unacceptable indoor environment for others. More hours of sun create the opportunity to produce energy

c. Warmer and more humid winters that stimulate mould growth and increase the activities of house-dust mites, which can result in inconvenience and induce allergic reactions among inhabitants
d. More frequent and heavier storms that can result in serious damage to buildings
e. Extreme snowfall, which can lead to damaged buildings and to collapse of buildings.

Apart from the five most important effects of climate change, single events like a heavy windstorm, extreme snowfall and heavier rain fall seem to be more frequent.

Heavy windstorm

A heavy windstorm passed over the southern half of Denmark on the 3 December 1999 and caused significant damage to a large number of buildings, see figure 2. The storm is regarded as the worst one for the past 100 years. The mean wind speed slightly exceeded the characteristic value of the design loads given in the load and safety code (Dansk Standard, 1998). This value was expected to be exceeded only once every 50 years on average.

Figure 2: Damage to a building after the heavy windstorm passed over the southern half of Denmark on 3 December 1999

Extreme snowfall

In winter 2007 in Denmark, unusually strong winds packed falling snow so hard in snowdrifts that the roof of 12 large buildings collapsed, see figure 3. Snowdrifts were packed to exceed the weight of 400 kg/m^3 and combined with a change in weather and rain it was expected that the weight at exposed locations increased to a tonne per m^2. The combination of the high mean wind speed and loads from local snowdrifts on the roof might have slightly exceeded the characteristic value in the design loads given in the load and safety code (Dansk Standard, 1998). On average, these combinations of load values are not expected at the design stage of these buildings.

Figure 3: Damage to a sports arena after the roof collapsed, caused by heavy snow loads in 2007

Heavier rain fall

Heavy rain fall has passed over Denmark in recent years, see figure 4. Such a heavy rain fall passed over Denmark on 2 July 2011 and is regarded as one of the heaviest ever measured in Denmark. Within a few hours, 150 mm rain fell which is twice the normal amount of rain falling in the whole month of July. Furthermore, 50 mm fell within 30 minutes and the highest intensity was measured at more than 3 millimetres per minute over a period of 10 minutes.

Figure 4: Flooding after a heavy rainfall in 2009 in the northern part of Zealand

Model for a Strategic Approach to Climate Change Adaptation

A model for a strategic approach to climate change adaptation of buildings requires actions that besides project management and project communication and dissemination include three main initiatives consisting of the need to *examine* the potential impacts of climate change on the building stock, to *assess* and develop a roadmap of current and future adaptation measures that can withstand the effects of climate change, and to *engage* relevant stakeholders in the private and public sectors.

Examining potential impacts of climate change on the building stock

The main objective of an examination is to provide background knowledge on climate change by developing assessment methodologies to delineate and evaluate the likely impacts of future climate change on the building stock. Long-term climate change as well as single extreme weather events associated with climate change will increase destruction of buildings and need to be evaluated according to lifetime issues.

Building typology must be exhaustively listed and used to implement a set of scenarios on the possible evolution of the building stock. Specification and analysis of climate change relevant for the building stock in the specific geographical region must be performed as well as determination of uncertainties in climate change. Finally, the collected extensive knowledge can be used to bring together information including building typology, climate impact for building stock scenarios and uncertainty factors, of both natural (e.g. climate variability) and human origin (e.g. impacts on the vulnerability thresholds of an ageing population inhabiting the building stock), in order to develop a standard methodology to assess the vulnerability of the building stock.

Building typology should include descriptions of buildings according to age, size and other parameters relevant to climate change, such as location in or close to areas exposed to weather events, for instance coastlines, rivers, mountain areas, storm tracks, and vegetation in arid areas.

Assessing and developing a roadmap of adaptation measures

An exhaustive list should to be established that comprises current and future adaptation measures to climate change for buildings, based on the results of the assessment carried out during the examination for potential impacts of climate change on the building stock. Such measures can be used to develop a comprehensive assessment framework of adaptation measures, including their economic, social, environmental, operational and technical impacts. It can also be used as a key input to a decision-making tool that needs to be provided to stimulate actions among stakeholders in the private and public sectors.

Feasible adaptation measures should be exhaustively listed and supported by technical assessments including their effectiveness, their feasibility, their conditions for optimal use and their applicability in different geographic locations. Furthermore, it is important to include cost-benefit analyses to balance the overall strengths and weaknesses of each of the feasible adaptation measures, as well as related macro-economic impact assessments. If any, such validations need to include support policies at government and local levels to motivate to the adaptation to climate change.

Engage relevant stakeholders in the private and public sectors

It is hugely important to engage decision-makers in the building stock issue, thereby providing a visual decision-support tool with user-friendly access that clearly depict the economic impacts of adaptation measures to climate change for the building sector and their uncertainties. Such a tool needs an optimisation algorithm in order to be able to suggest an optimal solution for a variety of climate scenarios attached to feasible single or interconnected adaptation measures for a particular building identified by its building typology. To engage end-users, the tool needs to provide a set of optimised scenarios that take into account the technologies to be installed and their responsiveness over the buildings' life. Such a simulation environment should also calculate the capital cost versus the operational cost taking into account the various adaptation measures in each optimal scenario. It should also provide decision support from a return-on-investment perspective regarding environmental impact, energy savings and contribution to smart cities or other benefits. End-users, recognised as policy-makers, decision-makers from private companies, urban planners as well as the academic community and the general public, should be helped to explore possibilities and be assisted in the optimal set of decisions when adapting to climate change.

DISCUSSION

Buildings play a vital economic and social role in most industrialised countries. In all EU Member States, it is estimated that buildings have a replacement value of approx. €216,000 billion. The consequences that climate impacts may have on the existing built environment are not known, as climate impacts and hence the vulnerability of the existing building stock has yet to be investigated. This leaves society with major challenges that, if not addressed and taken into account, will grow far more serious as climate change progresses. The need for a strategic approach becomes even more urgent now that the effort of elaborating a global agreement on climate policy and reducing greenhouse gases failed at the COP meeting in Doha, 2012. Until a strategic approach to climate change adaptation has been launched, initiatives to challenge the climate impacts will be ad-hoc and stand-alone initiatives.

Many resources have been spent on defining data relevant for the building sector regarding the impact of climate change, and ever more data are needed as assumptions change over time. Assumptions are closely related to the successful mitigation of climate impacts. The impact of climate change on the built environment is unknown and there are inevitably degrees of uncertainty associated with individual parameters such as temperature, precipitation, wind speed, relative humidity, solar radiation or soil moisture. In addition to the scenarios describing projected climate impacts, most countries have already witnessed extreme single events. Single events have been more intense than predicted. Data clearly show a rise in precipitation in the period from 1874 to 2010 (Drews *et al.*, 2011). Observations from the last 100 years show changes in the geographic pattern of precipitation globally. The connection between a warmer climate and heavier rainfall is confirmed by several studies. Some studies even estimate that the change in the total amount, seasonal variations and the intensity of rainfall estimated by the IPCC (Solomon *et al.*, 2007) is underestimated both for the tropics and for Europe (Allan & Soden, 2008; Lenderink & van Meijgaard, 2008).

Without a strategic approach, building owners have at present no knowledge of which climate impacts would be necessary to address and which scenarios are the most likely to occur. Existing buildings and buildings constructed today should be able to withstand climate impacts at best until 2100, as the main structures of buildings are expected to last for at least 100 years. The challenge of contemporary building requirements is that they should take account of climate impacts for a period corresponding to the service life of the individual building components. Climate impacts therefore pose a serious problem in relation to the design and upgrading of buildings. Climate change scenarios foresee an increased maximum wind load. A heavier wind load calls for stronger constructions. Compared with the safety margin of load-bearing structures in buildings, a 20% increase in the wind load is not critical. However, the heavy storm that hit Denmark in 1999 reached the limit of today's design wind standard and cost insurance companies sums that equal about 10% of the yearly investment in buildings in Denmark (Nielsen, 2006). In addition, it was found that the strengths of the damaged buildings was about half of what is required according to the Danish Building Regulations (Munch-Andersen & Buhelt, 2000). Therefore, a 20% increase of the wind load is supposed to result in a situation for which adaptation measures must be developed, both for existing buildings and for buildings that are to be designed for climate impacts. Such adaptation measures are expensive, but far less expensive than rebuilding damaged buildings after a storm worse than the storm in Denmark in 1999.

Climate change scenarios also foresees more frequent and heavier rain fall in Denmark. Depending on where the rain falls, the damage is more or less costly. The damages paid by the insurance companies resulting from heavy rain falls in the period from 1 June to 15 September in the years 2006 to 2011 reached €1 billion. However, the heavy rain fall that hit Copenhagen on 2 July 2011 was far the most costly with damages amounting to €658 million. Another important climate impact is the possible threat posed by a more humid and warmer climate. This would challenge the building design that provides humans with thermal comfort, good indoor air quality, and durable constructions. Such challenges are unlikely to be met at moderate maintenance costs.

Circumstances demand a continued need for a strategic approach to impacts of climate change and optimised adaptation measures for buildings that also need to be implemented in building requirements generally.

CONCLUSION AND FURTHER RESEARCH

The absence of a global agreement on the reduction of the emissions of greenhouse gases makes it difficult to expect anything but a global economically regulated use of available fossil fuels such as oil, coal and gas. Due to the shortage of available fossil fuels together with an increasing demand and higher production costs, the same economic conditions will drive policy for energy consumption and the development of new and other energy-supply sources. However, the economically regulated use of fossil fuels and hence the emissions of greenhouse gases will lead to climate impacts that are very difficult to forecast and will pose threats as well as opportunities for the design of buildings. Therefore, it is unknown whether or not existing buildings and buildings constructed today will be able to withstand the effects of climate change in 2100 as the main structures of buildings are expected to last for at least 100 years.

As climate change progresses, its effects will change requirements to buildings. However, as the impact of climate change is unknown, it is very difficult to forecast the necessary building requirements. This will leave investments, necessary for the preservation of the value of the building stock to become ad-hoc and stand-alone investments as future climate impacts emerge. Thus the opportunity is lost to upgrade a building to meet key climate impacts as part of the maintenance, which increases the costs of necessary measures. Therefore, the uncertainty of the scenarios leaves major challenges that, if not addressed and taken into account at the building design stage will grow far more serious as climate change progresses. A continuous strategic approach to climate change and adaptation grows ever more urgent as to ensure that the vital economic and social role of buildings in society is kept. Until a strategic approach is launched, initiatives to challenge climate impacts will leave end-users as policy-makers, decision-makers from private companies, urban planners as well as public and private building owners left at a crossroads without knowledge of what climate impacts to address and what scenarios are most likely to occur. A strategic approach needs to be developed to help explore possibilities and to assist in the optimal set of decisions when adapting to climate change.

Circumstances related to national and international policy, economics, energy consumption, emissions of greenhouse gases and the development of new energy-supply sources demand a continued strategic approach to climate impacts and adaptation for existing buildings as well as to building requirements. Further detailed descriptions of the ideas given in this article are found in the proposal *Strategic approach to climate change adaptation in the building sector,* connected with the ENV.2013.6.1-6 Economics of Adaptation of Climate Change – FP7-ENV-2013 programme, on which this article is based.

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CHALLENGES OF URBANIZATION AND DEVELOPMENT IN AFRICA: THE CONTEXT OF CLIMATE CHANGE

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Abstract:

Across Africa, urbanisation presents new and multiple development opportunities and challenges at the local level. Globally more than half of the world's population resides in cities and urban areas, severely increasing pressure on essential services, infrastructure and natural systems which underpins economies and social well-being. Security and access issues pertaining to water, energy and food are projected to be exacerbated through climate change, most affecting the vulnerable within society. Climate change poses a major threat to sustainable urban development in Africa. Changes in the frequency, intensity and duration of climate extremes (droughts, floods, heat waves, among others) will affect the livelihoods of the urban population, particularly the poor and other vulnerable communities who live in slums and marginalized settlements. Extreme changes in weather patterns will increase incidences of natural disasters and impact on all key sectors of the economy, including the urban economy, agriculture and forestry, water resources, coastal areas and settlements and health. Using secondary sources, this paper examines the relations between climate change and urban development in Africa and looks at the role and effect of climate change on urban development. It also assesses the available policy options for adaptation and mitigating climate change effects in urban Africa. The findings show that indeed climate change has had major challenges that adversely impact on sustainable urban development. These challenges call for innovative solutions – A transition in Africa towards embracing urbanization, responding to change and harnessing opportunities. Emphasis should be put on (a) local leadership, financing and accelerated integrated action and (b) greater emphasis on Africa's future cities through building resilience to climate change using various known options and best practices.

Keywords: Climate change, Development, Urbanisation, Africa

BACKGROUND

Climate change is one of today's emerging threats and challenges to humanity. The signs are visible, while the adverse effects of climate change are felt across the globe. The high incidences of flooding and intense rainfall (Trapp *et al*., 2007) drought and heat waves, cyclones, hurricanes, and the frequent erratic weather patterns, which have exacerbated poverty, displacement and hunger among millions of people, are partly attributable to climate change (Pall *et al*., 2011). The term climate change has been defined as a statistically significant variation in either the mean state of climate or in its variability, persisting for an extended period (WMO, 2012). The major causes of climate change include natural variations in sunlight intensity and human activities, which have led to an increase in greenhouse gases and a steady

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rise of the earth's temperatures (Hope, 2011). Global warming, which entails a rise in the earth's temperature, is caused by the use of fossil fuels such as wood, coal, oil, petrol among other industrial processes that have led to a build-up of greenhouse gases such as carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons (IPCC, 2007). Human activities that are related to biomass burning during shifting cultivation and domestic fuel are responsible for increasing greenhouse gases in Africa.

Besides rendering traditional agriculture across African countries less profitable, climate change has driven an unprecedented number of people into cities as they search for alternative livelihoods (Barios *et al.*, 2006). The resultant urban population increase has exerted pressure on urban services and resources such as urban space, urban water supply, and sanitation systems. Apart from posing a daunting challenge to urban planners and policymakers (Thynell, 2007; Choguill, 1999), climate change has become a major national, regional and international problem among developed and developing countries. It has limited human capabilities and undermined the international communities' efforts to attain the Millennium Development Goals (MDGs). Consequently, UNDP has declared climate change "the defining human development issue of our generation" (UNDP, 2007: 1).

This paper looks at the relationship between climate change and urban development in Africa, where urbanization rates are high but with governments having limited resources to cope with it. It examines the role and effect of climate change on urban development. It also assesses available policy options for adaptation and mitigating climate change effects in urban Africa.

CLIMATE CHANGE AND ITS IMPACTS

The Intergovernmental Panel on Climate Change (IPCC) has declared that "warming of the climate system is unequivocal, as is now evident from observations of increase in global average air and ocean temperatures; widespread melting of snow and ice and rising global average sea level" (IPCC, 2007: 30). Consequently, warming of the climate will not only hinder the achievements of MDGs and sustainable development, but it will also increase the risk of violent conflicts and therefore adversely affect human security (Barnet and Adger, 2007). Therefore, concerted efforts to tackle climate change are required, and failure to address this challenge will result in diminished future prospects for humanity.

UNDP (2007) reports that average annual global temperatures have been rising by 0.7^0 C since the Industrial Revolution. The report also notes the rapid rate at which CO_2 concentrations are increasing, leading to rising air temperatures. It is expected that with the rise in temperatures, droughts will be frequent as rainfall patterns change. In the next 100 years, climate-induced temperatures in Africa could increase by between 2^0C and 6^0C (Hulme *et al.*, 2001). This will have adverse effects on agricultural productivity and food security. It will also mean less water for poor people, increased floods and a rise in sea level, thereby posing a great threat to coastal regions and small island nations (Tacoli, 2009). The rise in temperatures will also increase incidences of diseases such as malaria and other communicable diseases.

Unfortunately, climate change disproportionately affects the poor and poor countries since it impacts on the very resources that the poor depend on, e.g. agriculture, forests, rivers and lakes. Most importantly, poor countries are extremely vulnerable to the adverse effects of climate change due to their low physical and financial capacity to withstand the physical and economic shocks triggered by climate change (Ward and Shively, 2012). Some experts argue that although Africa contributes the least to greenhouse gas emissions, it is the most adversely affected by climate change (Hope, 2009). It is estimated that African farmers are losing as much as US$28 per hectare per year for each 1^0C rise in global temperatures (The Economist, 2008), mainly due to the erratic rainfall patterns, increased average daily temperatures, reduced productivity, increased pests and frequent droughts.

Another major impact of climate change is desertification. In this regard, drought affected areas in sub-Saharan Africa could expand by 60 – 90 million hectares, while dry lands could lose about US$26 billion by the year 2060 (UNDP, 2007). Desert conditions are induced by gradual and prolonged loss of vegetation cover over extensive land areas in a country, and/or across two or more countries. Permanent loss of vegetation cover leads to a reduction in soil moisture, hence curtailing productivity. Poor land utilization practices such as subsistence farming and clearing-and-burning agricultural practices in the majority of African countries have accelerated the loss of natural vegetation, exacerbating the problem of climate change. With time, desertification has transformed extensive land areas in and across countries into arid- and semi-arid lands. The capacity of the original vegetation land cover to regenerate has been severely impaired by the near total damage of the ecosystem, and the absence of rainfall in many parts of Africa (UNDP, 2007).

Worsening climatic conditions, coupled with other factors such as political and ethnic conflicts, erosion of traditional safety nets and the deteriorating physical infrastructure, besides the absence of general security in rural areas, have forced some people to migrate to urban areas, exerting further pressure on cities, and compounding their socioeconomic problems (Choguill, 1999). As centres of innovation, cities have the capacity and the technical know-how of dealing with climate change. Unfortunately, they are also the major contributors to greenhouse gases. City-based commercial, industrial and domestic refrigeration facilities, for instance, discharge large amounts of gaseous emissions (Mosha, 2011). There is therefore a need to critically examine the role of cities vis-à-vis the process of climate change and its impacts.

URBANISATION AND URBAN DEVELOPMENT IN AFRICA

The process of urbanisation in Africa is usually highly influenced by the movement of people displaced by drought, famine, ethnic conflicts, civil strife and war. These have resulted into acute levels of urban poverty and haphazard urban settlements. The poor live in slums where they face dire economic and social hardships. Most are uneducated and unskilled workers who have migrated to urban areas, encouraged by the push-and-pull factors associated with rural–urban migration.

As people migrate from the rural areas to urban regions, global settlement patterns are gradually changing. For instance, in 2008, 3.3 billion people lived in urban areas, a number that is expected to reach 4.9 billion by 2030. Despite being the least urbanized continent in the world, Africa has the highest urbanisation rate of 3 per cent per annum. In 2007, the African urban population was 373.4 million, a figure that is projected to reach 759.4 million by the year 2030. It is further projected that more than 1.2 billion Africans will be living in urban areas by the year 2050 (UN-HABITAT, 2008). Table 1 profile the past, current and projected urban population by sub-region between 1980 and 2030. From the data, northern and southern Africa is the most urbanized regions in Africa, while East Africa is the least urbanised (but nevertheless the most rapidly urbanizing region on the continent). This rapid urbanisation can be explained by both the natural growth of the urban population (the net excess of births over deaths in urban areas) and the rural–urban migration. Some attribute other factors such re-classification of small rural settlements as urban to the rapid urbanization process in Africa (Potts, 2012). Other scholars (Zachariah and Conde, 1981; Kelley, 1991) argue that rural–urban migration is the main contributor to urbanisation in Africa.

Table 1: Percentage of African population residing in urban areas by sub-region, 1980-2030

Region	**1980**	**1990**	**2000**	**2010**	**2020**	**2030**
Africa	27.9	32.0	35.9	39.9	44.6	50.0
Eastern Africa	14.4	17.7	21.1	24.6	29.0	34.8
Northern Africa	44.4	48.5	51.1	53.5	56.8	61.3
Southern Africa	31.5	36.7	42.1	47.1	52.3	57.9
Western Africa	29.2	33.0	38.4	44.1	50.1	56.1

Source: UN-HABITAT (2008)

Rural–urban migration has been triggered mainly by both the pull-and-push factors (Barrios *et al.*, 2006) as well as past development strategies adopted by African countries, including socialist-leaning development policies and structural adjustment programmes, which are biased against rural and agricultural development (Hope, 2009). A dismal consequence of these policies is that the non-agricultural population now exceeds the available non-agricultural employment, leading to *over-urbanisation* (Hope, 1998). Urbanization pull factors include, inter alia, the following:

Economic Factors: economic opportunities are one of the biggest pull factors attracting people to cities from rural areas. From blue-collar manufacturing to white-collar professionals, urban areas offer a broader range of employment opportunities than rural areas, where most residents earn their living from agriculture and other sectors dependent on natural resource extraction.

Government Policies: Public policy sometimes acts as a pull factor, favouring urban over rural areas. This is especially true of developing nations in Africa and Asia. The governments of many developing countries often channel a larger share of their budgets toward improvements in cities, even though a majority of their citizens resides in rural areas.

Cultural Factors: Many people believe that city life offers a glamour and excitement that rural life does not. For many people, cities mean diversity, cultural attractions, hip restaurants and exciting nightlife. These act as pull factors, attracting many people -- especially young professionals -- to major urban centres.

Urban economies (weakened by institutional problems such as extreme centralization, rampant corruption and external factors, and unfair global trade practices) have failed to absorb the growing urban populations. As a result, in most cities of Africa, shanty towns and squatter settlements have developed along the periphery of the major cities (Mosha, 2011). The poor who live in these areas face tremendous economic and social hardships since they do not have access to basic human services such as shelter, land, water, safe cooking fuel and electricity, heating, sanitation, garbage collection, drainage, paved roads, footpaths, street lighting, etc. (Tacoli, 2009; World Bank, 2009).

Urban areas in Africa host major government agencies and the private sector. These sectors contribute significantly to economic growth and create much-needed employment. According to the UN-Habitat (2008), urban areas account for about 55 per cent of Africa's GDP. They therefore play a pivotal role in the production of goods and services, besides generating employment for the growing urban populations. Unfortunately urbanisation in Africa is not accompanied with an increase in economic growth or improved living standards. This is a unique phenomenon, which the World Bank has called "urbanisation without growth" (Fay and Opal, 2000; Barios *et al.*, 2006). This pattern of "urbanisation without growth" is the result of inappropriate policies that could not cater for properly managed and planned urban development. In developed countries urbanisation took root during the industrial revolution. At a time when there was "redundant" labour in the rural areas, there was an increase in demand for labour in urban areas (Potter, 1995). The same cannot be said about the process of urbanisation in Africa. Another interesting phenomenon associated with urbanisation in Africa is that the majority of the growing urban population is not absorbed by larger cities but by intermediate and smaller cities. It is contended that intermediate urban centres do improve both the economic growth and equity in many countries in the continent. These centres have a considerable potential role in regional and rural development and in poverty reduction. They can provide local markets for agricultural produce, which are essential for small-scale farmers. They also provide information and credit for farmers.

The impact of climate change on cities and on urban development in Africa

Due to climate change, urban settlements in Africa have are facing daunting challenges. Some coastlines and river deltas are densely populated low lying areas, which could easily be affected by a rise in sea level. Other costal settlements will be subjected to increased coastal erosion. African coastal cities that could be severely affected by rising sea levels include Abidjan (Cote d'Ivoire), Accra (Ghana), Alexandria (Egypt), Algiers (Algeria), Cape Town (South Africa), Dar es Salaam (Tanzania), Lagos (Nigeria), Mombasa(Kenya), Maputo (Mozambique) and many more others (Mosha 2011).

Infrastructure in urban areas is already showing evidence of destruction due to climate change impacts due to the above mentioned problems of erosion and sea level rise. Some of the most vulnerable infrastructure includes plants and products; equipment for producing and distributing energy; roads; ports (for instance, Maputo); and other transportation facilities; residential areas; institutional and commercial properties and coastal embankments. In the semi-arid and arid zones, many urban settlements (such as Gaborone, in Botswana, Dodoma, Tanzania etc.) are associated with inland drainage water sources. Frequent droughts will exacerbate water supply related vulnerabilities. Similarly water supply and irrigation reservoirs in seasonal river catchments might fail, leading to poor sanitation and food shortages in urban areas. Large cities like Lagos, Nairobi, Cairo, Kampala and Dar es Salaam have almost permanent water crisis, which has affected livelihoods as well as industrial production.

Hydroelectric power generation could be restricted during dry periods, and where it is a major contributor to the energy budget, reduced power generation, like what is happening in Tanzania, and Nigeria could lead to a multiplicity of other problems. In this regard, it is advisable for African states to develop other sources of renewable energy. Temperature changes will lead to altered distribution of disease vectors such as mosquitoes, making urban settlements currently free of vector diseases vulnerable. Cities like Nairobi, Harare and many others that never used to experience this problem are now in the midst of it all.

The dry savannahs of Africa are projected as possible future food deficit areas. Recurrent crop failures would lead to transmigration to urban areas, creating more problems for municipal governments. Pastoralists are likely to undertake more trans-boundary migration and probably come into conflict with settled communities. Already, in many African countries, declining agricultural productivity due to climate change related weather patterns, and population pressures, are pushing greater numbers of rural residents towards cities. Even in urban areas food security is now a major problem and no simple solution is available currently.

Lastly most cities are affected by air pollution caused by a rise in CO_2, which in turn leads to more climate change. Many of the mega cities such as Cairo, Alexandria, and Johannesburg are currently chocked with acrid smoke. A study of transport in Senegal found that the health costs associated with vehicle emissions were among the factors costing the country equivalent of 5% of its Gross Domestic Product.(UNEP 2002b).In 1991, the number of cars in the city of Algiers was approximately 560,000 vehicles, and they polluted the city excessively (Benoar, 2004).

Adaptation and mitigation policies: implications for urban development in Africa

Urban governments play a critical role in climate change adaptation and in mitigating (reducing) greenhouse gas emissions. They however need a supportive institutional, regulatory and financial framework, backed by their highest decision-making organs. In addition, low- and middle-income nations need the backing and full support of international agencies (Satterthwaite, 2007). Emission of GHGs is one of the major policy issues that need to be addressed (APF, 2007). Urban authorities in Africa should strengthen the policies and legislation aimed at reducing carbon emissions, but this should be reciprocated by a commitment to the reduction of global greenhouse emissions. For these policies to be effective there must be incentives that recognise the development needs of urban authorities. Africa has legitimate energy needs, hence the problem of carbon emission in her urban centres. Policies encouraging clean energy technologies should be formulated and encouraged through capacity building and financial support from national governments. International partnership should also be established in a bid to bolster these efforts.

Most African urban centres are located within the tropics or sub-tropic regions where solar energy and hydro-power are abundant. Policies encouraging development of Africa's vast solar energy potential and hydro-power should be enacted. The World Bank and the African Development Bank Clean Energy and Development Investment Framework should be fully implemented as a mitigation measure.

In regard to United Nations Framework Convention on Climate Change (UNFCCC), there is a growing realisation that African governments, including urban authorities, should respond with a unified voice in terms of action plans and commitment. This response must take into account Africa's acute vulnerability to climate change, legitimate development needs, and broader principles of equity and fairness. To mainstream adaptation to climate change in urban areas, the strategy should be a continuous process, which addresses both current climate variability and extremes and future climate risks. Africa's urban authorities should take actions that link climate change adaptation to disaster risk management, because many are not doing this at the moment.

Similarly, the city of Durban has also came up with a climate change adaptation strategy that includes human health, water and sanitation, coastal zones, food security and agriculture, infrastructure, and cross-sectoral activities. Many African countries have now recognised that policies on climate change adaptation and mitigation need to shift from a purely environmental concern, to addressing a growing threat to development. Managing both current and future climate risks should be an integral part of development processes at both the national and regional levels, and should involve a cross-sectoral approach that is reflected in the budget, thus the need for greater attention by ministries of finance and national planning.

Urban authorities in Africa should adapt to climate change impacts through: Increased efforts to improve access to climate data; Investment and transfer of technologies for adaptation in key sectors; Developing and implementing best practices for screening and assessing climate change risks in development projects and programmes; and Mainstreaming climate factors into development planning and implementation; and providing significant additional investment for disaster prevention. For Africa to adapt to the impacts of climate change, it will need development partners to deliver on their commitments. Urban authorities in Africa need to access the clean development mechanism (CDM) fund, which has not yet delivered for Africa, so as to promote development projects that reduce emission of greenhouse gases. There is also a need to simplify access to Global Environment Facility (GEF) so that projects which reduce GHGs emission are funded.

Africa's low emissions and extreme energy deficiency demand a more equitable allocation of carbon resources. Assisting Africa's development through its largely unexploited hydropower potential will help to meet her objective of increasing energy access while limiting GHG emissions. Compensation for avoiding deforestation could also be introduced so as to limit GHG emissions; but this will require an understanding of the factors that encourage deforestation. Incentives to landholders could also be considered in a bid to discourage deforestation. It must be recognised that future climatic conditions are likely to be different from current ones. Climate change management policies should therefore make provision for this reality by adopting improved forecasting and planning methods, and developing new coping strategies.

Urban authorities in Africa should integrate climate issues into economic planning and management by putting more effort into assessing development projects and programmes, while at the same time being sensitive to current and future climate risks. They should also attempt to improve the investment environment so as to encourage private-sector investments in carbon activities and improve access to weather and climate-related information. To adapt to climate change, attendant barriers should be removed in order to motivate urban authorities and development partners. These barriers include: Inadequate human and institutional capacity to deal with uncertainty; little guidance and lack of political will; conflict with competing agenda, often driven by external partners; aversion to change; and difficulties in working with non-state bodies and local communities.

The planning and development budgets of urban authorities need to take into account the possible impacts of climate change so as to reflect the adaptation efforts. Adaptation is projected to cost African countries billions of dollars a year, hence increasing pressure on development budgets. Changing climatic conditions make it increasingly difficult to extrapolate the costs of adaptation from past practices. The costs arising from the need for Africa to adapt to climate change makes international assistance for adaptation even more critical. This notwithstanding, types of support for climate adaptation have to be clearly stated, especially capacity support, transfer of low-carbon technologies to Africa, and promotion of regional co-operation.

Policies that build on existing strategies to support adaptation to climate change are amongst the most likely to succeed. Growing evidence suggests that mobility, in conjunction with income diversification, is an important strategy for reducing vulnerability to environmental and non-environmental risks (Tacoli, 2009). To urban authorities, especially in the low and middle-income countries, migration is generally considered problematic, with most policies trying to influence the volume, direction and types of movement, rather than accommodating flows and supporting migrants. To most authorities, rural–urban migration is often blamed for the growth of urban populations and urban poverty (Tacoli, 2009). Some of the climate change problems envisaged include drought, desertification, land degradation, floods and the rise of sea level. It is projected that between 75 and 250 million people in Africa will not have access to fresh water by 2030 (IPCC, 2007). Climate stress usually overlaps with other factors in determining migration duration and composition. It is therefore important that socio-economic, political and cultural factors are integrated into the adaptation policies.

The high vulnerability of urban systems and their impact on climate can be reduced through adaptation and mitigation measures based on known technology and design methodology. To counter climate change disasters, African urban authorities must have preparedness programmes and plans, ingredients often lacking in most African cities (WMO, 1994). African urban centres located along the coast and river deltas (or estuaries) are highly exposed to flooding due to their proximity to the sea (e.g. Free Town, Alexandria, Cairo, and Beira). In this regard, mitigation measures required include designing and building appropriate flood shelters, improving and expanding sewerage and drainage systems, and putting in place an information system on climate change effects and responses (WMO, 1994). Governance is an important element in climate change risk exposure. Urban authorities with limited incomes or assets are the most exposed. This is because they lack quality infrastructure and have poor disaster-preparedness provisions for planning and coordinating disaster-response. Besides, the extent to which the poor can buy, build or rent “safe” housing in “safe” sites, and the degree to which the local government creates an enabling environment for local civil-society action to address these issues is limited (Satterthwaite, 2007). Most urban authorities in Africa cannot afford the requisite cost of reducing the impact of climate change. Climate change health adaptation and mitigation measures required in African urban centres include putting in place an information system that profiles air conditions, observation networks and programmes and impact assessments and predictions. Bioclimatic GIS can be a useful tool in urban planning and design, and can be used in predicting climate change impact on mortality.

In terms of the impact of climate change on planning and architecture, there is need to take into account proper use of materials and architectural detailing, as well as drafting plans that maximise on outdoor spaces. Climate-sensitive designs should be done in a way that protects the environment from pollution. Architects and planners should use widely available knowledge and information on climate, while urban climatologists need to simplify the language in which climatic data is availed to planners and architects. Planning and building codes should be made public and their objectives clearly set out. A specific design guide that incorporates climate information is required. In a nutshell, the key to adaptation is competent, capable and accountable urban governments that understand how to incorporate adaptation measures into aspects of their work and departments (Satterthwaite, 2007).

CONCLUSIONS AND FURTHER RESEARCH

Climate change is both a threat and a challenge to Africa. Climate variability affects agricultural production, influences hunger, health, access to water and consequently food security and poverty in the continent. Prolonged droughts and floods, which are associated with climate change, impacts negatively on the livelihoods of farmers, making traditional agriculture across Africa less profitable. This in turn results in a number of people from rural areas migrating to cities in search of better livelihoods. The increased urban population in turn exerts pressure on urban services and natural resources such as urban space, urban water supplies, infrastructure, sanitation systems, creating a challenge for urban planners and policymakers. The effects of climate change must therefore be factored into African countries’ urban policies and unequivocally address the current and emerging urban challenges, especially the rapid urbanisation, poverty, informality and safety.

This paper contends that the most crucial priority should be to deal with the incapacity of urban authorities and government agencies in Africa so as to cope with both rapid urbanisation and climate change. The critical first step for policy-makers is to recognise the rights of poor people to live in cities and to share in the benefits of urban life. The next is to plan ahead (be proactive) for their land and housing needs within a constantly updated vision of sustainable land use. A business-as-usual approach that simply reacts to urban growth will be utterly untenable. The next step is to speed up rural development programmes so as to prevent rural towns from turning into ghost towns. The last step is to address leadership and governance challenges in municipalities, including weak responses and accountability to communities: deal with problems of poor financial management, corruption, insufficient municipal capacity and inadequate human resource. If properly managed and planned for, urbanisation could be an engine of economic growth and industrialization. However, without a proper policy in place, urbanisation will contribute to the rising urban poverty, proliferation of slums, regional inequalities and degradation of urban infrastructure and environment. As a result, some African cities could become centres of crime and slum settlements rather than being engines of industrialisation and economic growth.

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ASSESSING SOCIAL AND ECONOMIC SUSTAINABILITY IMPACTS OF BUILDING MATERIALS

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Abstract:

Measuring sustainability aspects of building materials is complex. Despite this a wide range of different methodologies and systems have been developed. Most of these focus on environmental issues and are based on lifecycle assessment, or similar methodologies. While increasingly sophisticated systems are being developed to capture and represent environmental impacts, limited progress has been made for economic and social impacts. In South Africa and other developing countries there is a strong interest in social and economic impacts of building materials. In particular, there is a desire to ensure that construction processes and built environment investments create social and economic benefits such as jobs and improved health and education. This paper explores the nature of social and economic sustainability impact measurement and representation in relation to building materials. A review of existing methodologies is carried out to understand the field and the applicability of current systems to building material industries in South Africa. The paper concludes that while current assessment systems may be applied locally, none of these support standardised social and economic impact assessments of building materials. It therefore recommends further investigation and development of the most applicable methodology in order to establish whether a standardised process can be developed. In addition, it suggests that an alternative simpler methodology be investigated. In this respect an outline methodology, the Sustainable Building Material Index (SBMI), is proposed.

Keywords: Building materials, Economics, Methodology, Society, Sustainability

INTRODUCTION

This paper investigates social and economic sustainability impact assessment in building materials. In particular, it aims to identify suitable methodologies that can be used to measure and represent social and economic sustainability impacts of building products in South Africa. This objective can be summarised in the following way:

An objective way of measuring, and representing, the key social and economic sustainability impacts related to the building products and their lifecycles, in order to enable building products to be compared.

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This summary raises a number of questions, including:

- How is sustainability defined?
- How are building products defined?

These questions are addressed in order to define the theoretical basis and scope of the paper.

Defining Sustainability

There are a range of definitions for sustainability. The concept of sustainable development was initially popularised in Our Common Future, a report published by the World Commission on Environment and Development in 1987. This defined sustainable development as:

..development which meets the needs of the present without compromising the ability of future generations to meet their own needs (United Nations General Assembly 1987).

In the paper this definition is referred to as the ND-FG definition. Another definition by The World Conservation Union, the United Nations Environment Programme and the World Wide Fund for Nature developed in 1991 is:

...improving the quality of human life while living within the carrying capacity of supporting eco-systems (IUCN/UNEP/WWF 1991).

The first definition is difficult to apply to the building product industry, however the second, which has a very similar meaning, is much easier to apply as it includes objectives that can be quantified. These objectives are: 'improving quality of human life' and 'living within carrying capacity of supporting eco-systems'. These objectives have been quantified in to sustainability targets by the World Wildlife Fund (WWF). WWF defines sustainability as the achievement of an Ecological Footprint of less than 1.8 global hectares per person and the achievement of a Human Development Index value of above 0.8 (WWF 2006). In this paper, this definition is referred to as the HDI-EF definition.

An Ecological Footprint is an estimate of the amount of biologically productive land and sea required to provide the resources a human population consumes and absorb the corresponding waste. These estimates are based on consumption of resources and production of waste and emissions. The area of biologically productive land and sea for each of these areas is calculated in global hectares (gha) and then added together to provide an overall ecological footprint (Wackernagel and Yount 2000). This measure is useful as it enables the impact of infrastructure and lifestyles to be measured in relation to the earth's carrying capacity of 1.8 global hectares (gha) per person. The Human Development Index was developed by the United Nations as an alternative to economic progress indicators and aimed to provide a broader measure that defined human development as a process of enlarging people's choices and enhancing human capabilities (United Nations Development Programme, 2007). The measure is useful as it provides an internationally acceptable definition of quality of life and the data on which it is based is readily available.

The HDI-EF definition of sustainability provides clear, quantifiable targets that can be aimed for and it provides a clear framework against which respective building and construction elements and processes can be evaluated. Therefore it is proposed that this definition is used as a working description of sustainability for this project.

Defining Building Products

Building products are defined in terms of a lifecycle approach and are taken to include all the processes associated with a product, service, or organization from a supply chain perspective, including all phases from raw material acquisition through processing, distribution, use, and end-of-life processes (ISO 2006). In order to support social and economic impact comparisons between building products, building products are defined in terms of quantities of final useful constructed elements such as area of compliant wall assembly. This may be referred to as the 'Functional Unit' and is defined in ISO 14044 as the quantified performance of a product system for use as a reference unit (ISO 2006).

METHODOLOGIES REVIEWED

A review of the field indicates that most of the existing methodologies are not directly applicable to assessing social and economic sustainability in building materials. Three methodologies however emerge as being relevant for further analysis. These are global reporting initiative (GRI), ISO 26000 guidance on social responsibility, and the guidelines for social lifecycle assessment of products.

Global Reporting Initiative (GRI)

The first Global Reporting Initiative (GRI) sustainability reporting framework was developed in 2000 by the Global Reporting Institute. The GRI is an independent institute based in the Netherlands. The organisation argued that the scale of the sustainability threat required organisations to report on sustainability and ensure that they are transparent about their economic, environmental and social impacts. To support this is *a globally shared framework of concepts, consistent language, and metrics* is required (GRI 2011). The GRI suggests that their framework provides this and is:

'*a trusted and credible framework for sustainability reporting that can be used by organizations of any size, sector, or location'* (GRI 2011).

The GRI aims to support accountability to internal and external stakeholders by reporting on organisational performance in relation to the goal of sustainable development. The methodology has a strong emphasis on stakeholder involvement. This is reflected in the way the content of sustainability reports by organisations is developed. The GRI suggests that content can be defined by the organisation itself and stakeholders in the following way:

This determination should be made by considering both the organization's purpose and experience, and the reasonable expectations and interests of the organization's stakeholders (GRI, 2011).

GRI reports are structured around what is called standard disclosure which has three parts. These are:

- ***Strategy and Profile:*** *Disclosures that set the overall context for understanding organizational performance such as its strategy, profile, and governance.*

- ***Management Approach:*** *Disclosures that cover how an organization addresses a given set of topics in order to provide context for understanding performance in a specific area.*
- ***Performance Indicators:*** *Indicators that elicit comparable information on the economic, environmental, and social performance of the organisation.*

The GRI Sustainability Reporting Guidelines contain indicator protocols which include guidance on how to compile reports under the headings: *relevance, compilation, definitions, documentation and references* (GRI 2011). While the methodology does not support a rating or an aggregated quantified measure or index of performance, reports are differentiated by what is termed '*Application Levels*'. These levels are titled C, B and A and indicate increasing application or coverage of the GRI framework. The GRI requires all reports to include a statement of this level in all reports referred to as an '*Application Level Check*'. The GRI recommends the use of external assurance processes in the reporting process. Where this complies with GRI requirements a '+' can be added to the Application Level, so an 'A+' can be achieved (GRI 2011). .

ISO 26000: Guidance on Social Responsibility

ISO 26000 on Social Responsibility is a standard developed by the International Standards Organisations (ISO). The South African Bureau of Standards have adopted this standard in it's entirely and refer to this as SANS 26000 Guidance on Social Responsibility. ISO standards are developed by technical committees and the development of ISO 26000 involved experts from both development and developing countries. The Standard responds to an increasing interest in social responsibility and a need for guidance in this area:

Organizations around the world, and their stakeholders, are becoming increasingly aware of the need for and benefits of socially responsible behaviour. The objective of social responsibility is to contribute to sustainable development (ISO 2010).

It aims to provide guidance and in this respect is significantly different to other ISO standards which describe technical requirements that must be achieved in order to comply with the standard. This goal is stated as:

To provide guidance on the underlying principles of social responsibility, recognizing social responsibility and engaging stakeholders, the core subjects and issues pertaining to social responsibility and on ways to integrate socially responsible behaviour into the organization (ISO 2010).

It defines social responsibility and sets out a number of key principles that should be complied with this. It sets out seven core subjects and provides detailed guidance on each of these in terms of scope, relationship to social sustainability, related principles, actions and expectations (ISO, 2010). The Standard is similar to the GRI system as it advocates active engagement with stakeholders and provides guidance on how relationships between organisations, stakeholders and society should be structured.

Guidelines for Social Lifecycle Assessment of Products (GSLAP)

The Guidelines for Social Lifecycle Assessment of Products was developed by the United Nations Environment Programme (UNEP) in association with a range of industry partners including The Society of Environmental Toxicology and Chemistry (SETAC). The guide was developed by project groups over a period of 5 years, from 2004 to 2009. The terms of reference for this group were:

- To convert the current environmental tool LCA into a triple-bottom-line sustainable development tool;
- To establish a framework for the inclusion of socio-economic benefits into LCA;
- To determine the implications for LCI analysis;
- To determine the implications for LCIA, and
- To provide an international forum for the sharing of experiences with the integration of social aspects into LCA (ISO 2010).

The guidelines were developed to address perceived gaps in environmental lifecycle assessments. In particular, there was a concern that this approach did address key developing country issues:

It was motivated by a consensus that "the use of LCA is hampered in developing countries clearly due to lack of expertise, data etc., but also due to the inability of LCA to engage in developing countries key issues" (ISO, 2010).

With the increasing emphasis in developed countries on sustainability there was also a concern that the existing environmental LCA processes were not comprehensive enough:

Environmental LCA, in itself, does not provide all the information to make decisions in a sustainability perspective. A S-LCA provides complementary information, providing a more comprehensive picture of the products' life cycle impacts (ISO, 2010).

The guide describes a methodology that can be followed to undertake social lifecycle assessments (S-LCA). The recommended process for the S-LCA follows the environmental lifecycle assessment (E-LCA) process as set out in ISO 14044. The guide however indicates that there are differences between the two assessments processes and provides guidance on how to address this. A key difference between an E-LCA and an S-LCA is the intent by an S-LCA to assess social impacts. Social impacts in the guide are defined as:

Social impacts are consequences of positive or negative pressures on social endpoints (i.e. well-being of stakeholders) (ISO 2010).

The guidelines organise social impacts in relation to stakeholder and decision-maker groupings. Stakeholder groupings are defined in terms of whether they have similar interests in relation to the investigated product systems. The first step of the assessment is the goal and scope of the assessment. This establishes the aim of the intended assessment, the functional unit, the reference flow, the product system(s) under study and the breadth and depth of the study in relation to this aim. The functional unit is defined as the quantified performance of a product system for use as a reference unit in a life cycle assessment study (ISO 2006). In the S-LCA the production function also needs to include technical and social utility. The next stage in the assessment is referred to as the inventory phase, in which data is collected and systems are modelled. The guide emphasises that the process is data intensive and that planning for data should be included at the outset of the project, when the goal and scope are defined. In particular, it suggests that prioritisation should take place to ensure that only the most relevant data is collected because of the cost and time involved. Suggested sources of data in this phase include pparticipative methodologies, directed and semi-directed interviews, focus group as well as questionnaire surveys (ISO, 2010).

The guide indicates that an S-LCA is different from E-LCA as it may rely on qualitative and subjective data. It suggests that in some cases this is the most appropriate data. For instance, the subjective perceived worker impressions of their conditions may be more relevant than objective quantitative data such as observed worker arrival time or other attempted proxies. In line with ISO 14044, the guide recommends that validation of data is carried out to confirm and provide evidence that the data quality for the intended purpose of the assessment has been achieved. Guidance is provided on setting out conclusions, recommendations and reporting in assessment reports. It suggests that these should refer back to the requirements set for the assessment. It suggests that reporting should be transparent, with all assumptions, rationales, and choices indicated. Recommendations made in report should provide actions that can be taken as a result of the assessment to improve social impact. These may be presented differently depending on the intended audience.

DISCUSSION

Having reviewed the GRI, ISO and GSLAP methodologies the following questions can be discussed:

- How do the methodologies define social and economic impacts?
- Do the methodologies support social and economic impact comparisons between building materials?

Defining Social and Economic Impact

All of the methodologies state that the reason for assessing social and economic impact is to support sustainable development. Definitions of sustainable development used in the methodologies refer to the ND-FG sustainability definition. While this definition is widely accepted, it is also open to different interpretations. This is evident from the methodologies, which all use different criteria to assess sustainability and sustainable development. The GRI has a comprehensive set of indicators to report on social and economic impacts. The ISO and GSLAP have fewer indicators and these focus on issues such as human rights, labour practices and stakeholder involvement. The selection of the ND-FG sustainability definition also means that the methodologies do not set specific targets that can be strived for. Instead they only suggest the best solution of those being considered, be selected. This approach is problematic for a number of reasons. Firstly, unless sustainability assessment criteria can be justified and a theoretical underpinning provided, it could be argued that their selection, development and structure is arbitrary. For instance, how can the criteria: ‘fair operating practices’ and ‘cultural heritage' be justified? What defines which criteria can, and cannot, be used? Without a firm theoretical basis, it could easily be argued that a wide range of other criteria, such as 'aesthetic beauty' or 'traditional values', should also be included.

Secondly, the variation in range and type of criteria used in methodologies indicates a lack of consensus in the field which makes it difficult for users to have confidence in the tools. Jørgensen attributes this to the fact that field is still new and immature (Jørgensen *et al*., 2008). Thirdly, without specific targets, *any* improvement can be presented as significant success or progress. This may result in methodologies reinforcing poor practice rather than encouraging the actual scale of change required to achieve sustainability, as defined by climate science. Clearly given the scale and urgency with which sustainable development must be carried out, at least minimum performance standards must be set and it is inadequate to only promote what may be very small improvements. In addition, without challenging targets, the development of innovative and alternative solutions which may enable significant levels of improvement relative to conventional solutions, will not be supported.

These problems may be addressed by using the quantified definition of sustainability (HDI-EF definition) referred to in the introduction of this paper. While this is a simple definition, it provides an effective framework for defining the criteria that should, and should not be included. Secondly, it can be used to define targets and minimum standards. Both of these aspects are useful in relation to assessing sustainability (and social and economic impact) of building materials, as it enables the critical criteria to be defined and can be used to propose specific targets and standards within these areas.

Supporting Comparisons between Building Materials

GRI, ISO and GSLAP methodologies do not support comparisons between building materials. The GRI leaves the selection of criteria within the GRI framework to the practitioners undertaking sustainability reports. This means that while the framework is standard, *the way it is applied,* is not. Comparisons are therefore not supported. The only differentiation included by the methodology is at the level of reporting. Reference is made to letters (A, B, C) and pluses (+) to reflect the extent and nature of the *report* but this does reflect *the level performance of the organisation*. Thus an organisation with negative and deteriorating social, economic and environmental impacts could achieve an A+, the highest score, even though it clearly did not support sustainable development.

The ISO methodology repeatedly refers to itself as guidance and warns against any usage of the methodology for certification or assessment. This seems sensible as many of the criteria referred to in the framework such as 'accountability', 'transparency', 'ethical behaviour' and 'respect for international norms of behaviour' are not defined sufficiently for any assessment process to be effective. In general, these criteria are set out as aspirational goals for organisations. Therefore without significant interpretation of these criteria in to standards and specific measureable targets this is not a methodology that can be applied to building industry to compare products and is more appropriate for defining organisational ambitions.

The GSLAP methodology, of the three methodologies, most readily lends itself as a tool for comparing social and economic impacts of building materials. It aligns with a tried and tested methodology, the ISO 14040 methodology, and builds on the experience developed in environmental lifecycle assessment. There are however a number of drawbacks with applying the methodology to building product comparisons. Firstly, it suffers, like the GRI methodology, from non-standard application. Within the GSLAP methodology, practitioners are allowed flexibility to select the criteria and scope of assessments. Secondly, the GSLAP methodology argues that the criteria selected should be dictated by the goal and scope of the assessment. This non-standard application prevents comparisons between industries and products.

In addition, the GSLAP methodology suggests that the use of subjective, qualitative indicative criteria, in particular circumstances, may be more suitable than objective qualitative criteria. While this may be true in certain situations, it clearly does not support comparisons or standardised objective assessments.

CONCLUSIONS AND FURTHER RESEARCH

The GRI, ISO and GSLAP methodologies are relevant and may be usefully applied to the South African building industry. However, none of these methodologies can be readily, and easily, applied to assess and compare social and economic impacts within the building product industry. Of these methodologies, the GSLAP methodology comes closest to meeting the requirements of a social and economic assessment system for building materials that supports comparisons. Further research should be carried out by applying the GSLAP methodology to building materials in order to ascertain whether the methodology can be standardised to support building material comparisons.

In addition, it is recommended that an objective, quantitative methodology be developed and tested. This methodology is referred to as the Sustainable Building Materials Index (SBMI) and would provide a simple index of sustainability performance of building materials. The SBMI would be based on the following specification:

- The methodology would align with the HDI-EF definition of sustainability and aim to support the achievement of quantified sustainability targets, as set out in this definition.
- The selection and development of criteria within the methodology would be defined and delimited by HDI-EF sustainability definition.
- The measurement of criteria would be standardised and data normalised to enable comparisons between building products.
- Where possible, the selection of criteria would be based on data that building product manufacturers had readily available. Therefore compiling an index assessment for building product should be reasonably cost effective and rapid.
- The methodology would draw on aspects of the lifecycle analysis methodology and, in particular, use the concept of the 'Functional Unit' to support comparisons between different building materials.

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USING SYSTEM DYNAMICS PRINCIPLES FOR CONCEPTUAL MODELLING OF SMART CITY DEVELOPMENT IN SOUTH AFRICA

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Abstract:

South African cities are in the process of transition in the changing scenario and need a change in the planning perspective for their sustainable development. The concept of smart city offers opportunities for such development to many middle sized cities of South Africa. Therefore, in this paper conceptual modelling for development of smart cities in South Africa is attempted based on systems concept. The conceptual models are built by using the principles of system dynamics methodology and based on causal feedback relationships among the various factors under different smart characteristics of a city such as, smart economy, smart people, smart governance, smart mobility, smart environment and smart living. The causal feedback loops and interrelationship among various parameters illustrate the dynamicity and influence of parameters on one another, which would able to assist in evolving plausible policy interventions for developing smart cities in South Africa. It is concluded that the modelling approaches presented here could guide the policy makers and city planners to evolve robust and responsive policy interventions for developing smart cities in the changing scenario.

Keywords: Smart city, Smart environment, Smart living, Smart mobility, System Dynamics modelling

INTRODUCTION

While globalization, market economy and technological advances have created an environment for economic, social and infrastructural developments in many regions of the world, their influence provided opportunities for higher influx of people to the cities and added pressure on the civic requirements in the wake of the scarce availability of resources making the cities face physical and environmental ailments (Moussiopoulos *et al*., 2010; Saavedra and Budd, 2009). Many South African cities are not far away from this burgeoning phenomenon. Most of the South African cities have potentialities for both economic advancements and appropriate spatial development. Although the Governance system of the country has taken several proactive efforts for congenital developments of the cities, it is observed that most of the cities are planned and developed conventionally by use of Integrated Development Plans (IDPs). Of course, there is no reason why the IDP process should not bring about appropriate development in the cities, however, the suitability of this conventional approach in the changed scenario of globalisation, and technological advancements is quite uncertain. In the wake of this scenario, there is a need to rethink the planning process to incorporate the fast changing current scenarios and adapt the

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cities to the challenges of future, which warrant a change in planning perspectives (De Swardt *et al*., 2005; McGillivray, 2005; Naude, Rossouw and Krugell, 2009; Ramutsindela, 2002; Saff, 2001) and move from the normal planning process (Horn, 2002; Kotze and Donaldson, 1998; Lotter, 2002; Nomdo and Coetzee, 2002; Prinsloo and Cloete, 2002; Saff, 1995; Turok, 2001; Visser, 2001) towards smart growth and development process based on smart city concept (Farmer *et al*., 2006; Giffinger *et al*., 2007; UN- Habitat, 2009).

However, the development planning process for transforming the existing cities to smart cities requires dynamic principles for evolving plausible planning policy interventions. In this context, the systems dynamic principles based on systems thinking approach perhaps could provide an avenue for future planning of the cities of South Africa. Therefore, this investigation pertains to conceptual modelling to develop policy interventions in order to transform the South African cities as smart cities by using system dynamics modelling approach based on systems thinking and make them economically, socially and environmentally sustainable. For this purpose, conceptual causal feedback relationships among the various parameters of each characteristic of a smart city have been developed to create a road map for evolving policy interventions to build smart cities and realise the intended outcomes.

In this regard the scope of the paper is limited to development of causal feedback relations among various indicators under smart characteristics of cities of South Africa by using system dynamics principles, which shall enable developing policy interventions for future development of smart cities in the country.

Understanding the Problem

Smart city concept

A smart city is a well performing forward-looking middle size city built on the smart combination of endowments and activities of self-decisive, independent and participative responsive citizens (Giffinger *et al*., 2007). The smart city concept is not considered in a holistic manner rather with reference to various aspects, which range from Information and Communication Technologies (Digital) districts to smart populace in terms of educational level. Use of modern technology in everyday urban life, which includes innovative transport systems, infrastructures and logistics as well as green and efficient energy systems are often integral part of a smart city. Further, there is a strong relationship between city government and citizens in terms of good governance. Additionally, certain other factors of urban life associated with smart city are participation, security / safety, and cultural heritage (Giffinger *et al*., 2007; Komminos, 2002; Lombardi, 2011; Shapiro, 2008). The concept is derived from the combination of concepts of the connected city (smart logistics and sustainable mobility), the entrepreneurial city (economic vitality), the pioneer city (social participation and social capital), and the liveable city (ecological sustainability), which were envisaged as per the policy vision of European Union for developing smart cities in Europe (Nijkamp, and Kourtik, 2011). Although, there is no agreement on the exact definition of a smart city, a number of important dimensions of a smart city are identified, such as, smart economy (related to competitiveness), smart mobility (related to accessibility and connectivity); smart environment (related to natural resources); smart human capital (related to people); smart living (related to the quality of life) and smart governance (related to participation) (Giffinger *et al*., 2007; Komminos, 2002; Lombardi 2011; Shapiro, 2008; Van Soom, 2009).

Smart economy refers to parameters around economic competitiveness such as, innovation, entrepreneurship, trademarks, productivity and flexibility of the labour market as well as integration in the national and international market. Smart people are essentially described by the level of qualification or education of the citizens as well as by the quality of social interactions and integration, participation in public life and the receptive attitude, and openness towards the outer world. Smart governance encompasses facets of political participation, services for citizens and the functioning of the administration. Local and international accessibility in the form of sustainable physical transportation system, and Information & Communication technologies refer to smart mobility. Smart environment is expressed by attractive natural conditions, i.e., climate, green open space, level of pollution, resource management and efforts towards environmental protection. Smart living includes various indicators of quality of life such as, culture, health, safety, housing, tourism (Giffinger *et al*., 2007). Thus, a middle-sized city is considered to be a smart city if it demonstrates forward-looking development in these six important characteristics on the basis of a combination of local circumstances and activities carried out by politics, business, and the inhabitants (Lombardi, 2011; Komminos, 2002; Giffinger *et al*., 2007; Shapiro, 2008; Van Soom, 2009).

Transforming or developing a city to a smart city is based on the coordinated performance of these smart characteristics of a city and it is imperative that the city planning process needs to be different from the normal urban planning processes. Further, the smart growth principles advocate that the growth of a city is to weave together the various discourses of physical and spatial issues into a rational sustainable development that integrates economic, environmental and social equity issues. It also integrates the micro level design aspects, with the macro level policy and planning aspects which invokes the notions of urbanity, and physical integrity to create a sense of coherent community (Calthorpe and Fulton, 2000; Kunstler, 2001; Nijkamp and Kourtik, 2011; Turner, 2007). It is a strategy that targets the physical development of urban regions having strong social, economic and political components with public participation and inclusive multi-actor planning processes (Jailly, 2008; Scot, 2007).

Potential and challenges in South African context

In South Africa about 47% (112 cities and towns) out of the total number of 234 cities and towns have a population, which range between 100000 and 1.0 million (Statistics SA, 2011), which can be considered as medium cities. Out of these 112 cities, about 58.93% falls in the range of population 100000 to 200000, 32.14% have population of 200000 to 500000 and only 8.93% falls in the population range of 500000-1000000. In the absence a clear cut definition of medium cities and assuming that the cities with higher population (200000 to 1000000) have potential for higher economic development and challenges for infrastructure and environment than cities with lesser population, about 41.1% of the medium towns and cities or about 19.6% (46 in numbers) of all the cities can be considered to have the potential to become smart cities based on population criteria alone in a conservative scale.

Further, some of the development authorities and municipalities responsible for city development in the country envisioned to make their cities globally safe and attractive places to live work and invest, and to improve social and economic livelihoods through public participation, effective and efficient integrated governance systems and programs. For realization of this vision a few among the important future guiding principles stressed upon are economic growth and jobs creation, building community resilience and self-resilience, services excellence and sustainability, civic leadership, common purpose, etc. The strategies thought of to achieve the objectives are through stimulating integrated and sustainable economic development prospects, improving and sustaining financial, human resource excellence, management excellence, evolving institutional excellence through a thoroughgoing institutional re-engineering process, effective leadership and effective long range development planning (IDP, 2012 Mangaung Metropolitan municipality), etc., which in fact complement the smart city concept.

However, there are several challenges which the cities are currently facing or expected to face in future. With the gradual change in the economic scenario, most cities are increasingly embracing multifunctional economic activities divorcing from earlier unitary economic activities, for example with the closing of mining operations in predominantly mining cities, they are either languishing or striving to keep up with incorporation of other industrial and / or service activities. It is also natural that the cities will embrace more and more diverse economic activities in future. Besides, the opening of economic opportunities will attract higher influx of people to cities increasing pressure on the existing infrastructure, which will require building of more infrastructures and in turn demand for higher investments. On the other hand, the economic development in the cities will strengthen the existing phenomenon of predominantly individually driven cars for movement in the cities leading to environmental as well as spatial development concerns. In the absence of adequate public transportation system, the problem is already felt in many cities through congestion, increase in travel time, long queue length at intersections, high carbon emission, etc., and consequent environmental pollutions. Thus, in the changed scenario large scale influence on the spatial development, as well as infrastructure and environmental consequences are also expected in the future. Based on this premise the clusters of main issues extracted are:

- How cities will cope with the challenge of changing economic scenarios in the wake of globalisation as well as expected local change in their economic functions?
- What will be the consequent spatial, infrastructural and environmental problems the cities will face in the wake of higher economic opportunities and influx of people to them?
- What are the improvements needed in the social capital and general local governance issues to face the challenges?

Therefore, the concern arises in such scenarios is that will the strategies outlined in the IDPs based on which cities are developed be adequate and competent to stand to the challenges of the future or what kind of policy interventions are needed to cope with the future development and transform the cities to smart cities.

METHODOLOGY

This investigation was carried by employing survey research methodology - discussion with people involved in the urban planning process and experts, review of the IDPs and literature review for understanding the problems, factors and characteristics, which contribute to the development of smart cities followed by application of system dynamics principles based on systems thinking for conceptual modelling.

Epigrammatic outline of systems thinking and system dynamics

According to Von Bertalanffy (1974), a system constitutes a set of subsystems or in other words components, which are interlinked and interdependent on each other to perform a function as a whole. The subsystems of the system can be systems themselves. In a system, if a subsystem performs at a higher efficiency than others or becomes defunct then the effect is felt on the whole system. As a result the whole system may perform at a lesser efficiency or even may become paralysed. In order to the system to perform at a higher efficiency all the subsystems of the system are to work in a coordinated manner. While planning, a city as a whole can be considered as a system with its various components, such as people, economy, social aspects, movement and communication, other infrastructures, governance, environment, etc., as its subsystems. All these components are inter-linked and interdependent as the case may be and work in a coordinated manner for the sustainable development of the city.

Scholars such as Wolstenholme (1992) and Robinson (2008) outlined a conceptual model as a consistent and unifying theory of behaviour taken from bits of information about the real world. The rigorous structural framework provided by system dynamics assists in eliciting and displaying information used to build a conceptual model (Forrester, 1994; Lane and Oliva, 1998). Essentially, system dynamics methodology amalgamates ideas developed in various systems theories and is a result of cross-fertilisation of ideas from traditional management, cybernetics, and computer simulation (Shen *et al*., 2009) and is especially designed for large-scale, complex socio-economic systems to understand how and why the dynamics of concern are generated and to search for managerial and development policies to improve the situation. It is a theory of structure and behaviour of system (Forrester, 1968; 1969) and is characterised by the concepts of causal feedback loops and time delays, which represent the dynamic complexity of a system (Sterman, 2000). Causal loop maps are usually employed to describe the elements (Montibeller and Belton, 2006) of the system. The use of system dynamics in solving real world urban development related problems are rising since its early application by Forrester in 1969. It has been applied to develop policy interventions for alleviating urban problems or understanding the dynamics that flows in the urban areas (Chadwick 1971; Checkland 1981; Lee, Choi and Park, 2005; Park *et al*., 2013).

Conceptual Modelling, key causal relations and broad policy interventions

The six major components or characteristics such as, economy, people, mobility, governance, environment and living conditions of a city, which are critical for development of a smart city are analysed by the help of conceptual causal loop and feedback relationships augmented by system dynamics principles. It is hypothesized that each characteristic creates a positive causal feedback loop with the smart city and the influence of each characteristic is felt on the other characteristics directly or indirectly (Figure 1). Each characteristic is analysed by considering its endogenous parameters and their causal relationships and their influence on the city as a whole as well as on other characteristics to understand and develop policy interventions based on their positive and negative influences. For the purpose of this analysis the various smart factors and parameters under smart characteristics developed by (Etzkowitz, 2008; Etzkowitz and Zhou, 2006; Giffinger *et al*., 2007; Lombardi *et al*., 2011) have been adopted and modified to suit the local conditions. The various conceptual models are discussed in the following subsections.

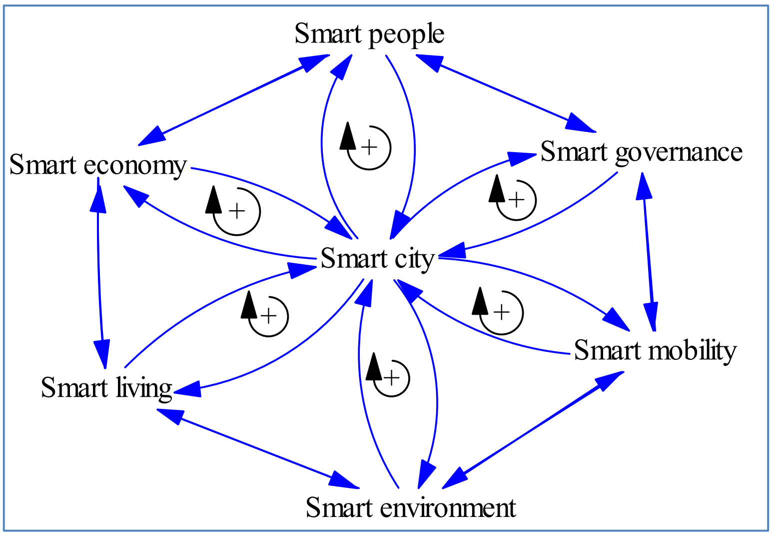

Figure 1: Causal feedback relationships among the characteristics of a smart city

Economy

The smart economic conditions of the city are characterised by factors such as, level of entrepreneurship, innovative spirit, international embeddedness, economic image and trade mark, and importance as decision making centres. Figure 2 presents a system dynamics causal feedback loop structure of the economic characteristics of a smart city. As envisaged earlier economy of a city has a positive feedback relationship with the smart city, which means if the economy of a city is enhanced, it will reinforce the development of the city (ER1). However, amongst other factors entrepreneurship is considered as the key factor, which defines the economic characteristics of a smart city. A higher level of enterprising activities in a city will lead to enhancement of economy, which in turn would facilitate location of corporate offices or business decision making centres. The location of corporate offices will increase inter-(national) embeddedness enhancing both communication and business relations, which will have a positive influence on the enterprises located in the city as a feedback to the system. This relationship is presented by the reinforced loop ER2 in the feedback loop diagram. Besides, entrepreneurship will bring in innovative spirit, which will positively influence productivity in the city. Higher productivity will enhance the economic image and trade mark of the city creating a congenital environment for entrepreneurship development as a feedback, which is presented by the reinforcement loop ER3 in the diagram. Thus, the causal loop ER3 reinforces the loop ER2, with entrepreneurship remaining as the key factor in smart economy of a city development. Similarly, feedback loop ER5 reinforces loop ER3 and vice versa through increase in productive and its causal relationship with Gross Domestic Product (GDP) of the city or per employed person. Further, location of corporate offices or decision making centres in the city will enhance the importance of the city as a decision making centre (loop ER4), reinforcing the economic image of the city and trademark and as a result reinforcing the loop ER3. Thus, all the factors are reinforcing each other through dynamic feedback relations ultimately enhancing the economy of a city and transforming it to a smart economy. However, it is also observed that the each factor is influenced by certain parameters. For example entrepreneurship is dependent on self-employment rate, new business registration, flexibility in labour market, etc. Similarly international embeddednes is dependent on air transportation facilities and Information communication technologies (ICTs). If these parameters are conducive, then they will reinforce the system with a positive influence and if they are of opposite nature, they will create disturbances in the system or balance the development.

Therefore, policy interventions are needed to enhance the positive parameters and alleviate the shortcomings, if any. South African cities observed to be lack in international embeddedness, innovative spirit and in turn large scale entrepreneurship. The R & D expenditure and registration of patents are insignificant and negatively influence innovative spirit, although employment in knowledge intensive sector influence positively to a certain extent. Similarly, air transport of freight and ICT limits the international embeddedness. Lack of flexibility in labour market, low number of new business registration and self-employment rates drag entrepreneurship and stand in the way of development of a smart economy, which require appropriate policy interventions.

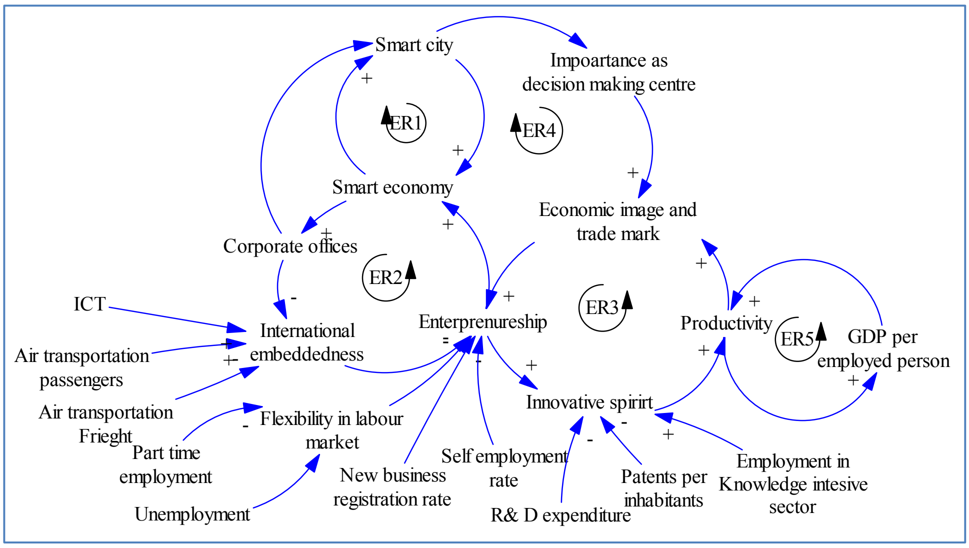

Figure 2: Casual feedback relationships for development of smart economy

People

The factors, which characterise smart people are level of qualification, creativity, affinity to lifelong learning, flexibility, social and ethnic plurality, cosmopolitanism / open mindedness, and participation in public life. Each factor is also influenced by their endogenous parameters. Figure 3 presents the causal feedback loop diagram for smart people in a smart city. It is envisaged that smart people, level of qualification and smart city are interlinked through a positive feedback loop (PR1) as each factor influence each other. This feedback relationship is reinforced by the feedback loop PR1A through participation of people in public life as observed in South African cities. However, lack of social and ethnic plurality is influencing cosmopolitanism or open mindedness negatively and in turn is discouraging people away from participating in public life, thus create a negative feedback loop (PB1) with smart people. Similarly, the scenario of inflexibility and lack of affinity for lifelong learning develop a negative feedback relationship with people (PB2), which along with the feedback loop PB1 influence development of smart people in the city negatively and either disturbs or balances the development. Simultaneously the feedback loop (PB3) based on the lack of cosmopolitanism discouraging immigration of people, and peoples' lack of interest in the knowledge about country and province act as deterrents for creation of cosmopolitanism. Although, adequate knowledge about country and province would reinforce voters turn out and is expected to reinforce public participation in a feedback relation (PR1C), yet lack of it disturbs the development of smart people. Similarly, creativity leading to affinity to lifelong learning would result a positive feedback relation with smart people (PR1B), however, it is observed that meagre number of people working in the creative industry and lack of participation of people in lifelong learning influence the loop negatively. Therefore, the factors, such as flexibility, affinity to lifelong learning, cosmopolitanism, immigration friendly environment, development of creative industry, etc., which are currently influencing negatively need to be addressed, while the positive factors such as, level of qualification, participation in public life, etc., need to be strengthened through appropriate policy interventions.

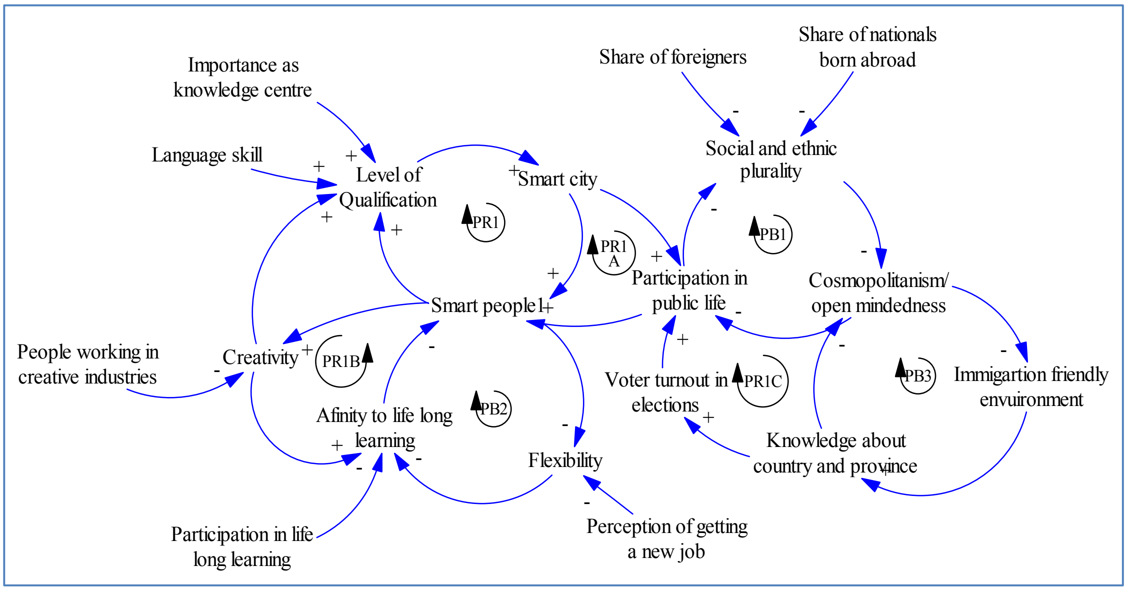

Figure 3: Casual feedback relationships for development of smart economy

Governance

The governance system of the South African cities are observed to be based on the characteristics such as, participation in decision making, transparent governance, public and social services, political activity of inhabitants, city representatives', female city representatives, and importance of politics for inhabitants. Each factor is also dependent on its indigenous parameters. The figure 4 depicts a causal feedback loop structure for smart governance of South African cities. It is visualized that smart governance will have a positive influence on people's involvement in decision making process, which will lead to transparency in governance system and as a feedback will strengthen governance system of the city (GR1). The transparency in the governance is influenced by transparency in bureaucracy and perception of fighting against corruption. Political and social services are influenced by quality of school, care for children, expenditure on residential suburban areas and participation in voluntary work. The performance of the feedback relations GR1 is dependent on the performance of these parameters. Similarly, participation in decision making will positively influence political activities of inhabitants and provide opportunities for adequate female and city representatives in the governance system, thereby reinforcing the participation in decision making through reinforcing loop (GR2). The governance system developed through loop GR1 reinforced by the reinforcing feedback loop involving smart governance, smart city and participation of people in decision making (GRA1). Further, the importance of politics for inhabitants, participation in decision making along with political activity of people develop a feedback relation (GR2A) with the loop GR2 and reinforces loop GR1. Thus, all the feedback relations reinforce and strengthen the governance system and consequently are creating an environment for development of a smart city. With a democratic set up and adequate local governance system, there is an opportunity for development of a smart governance system in the cities of South Africa, if policy interventions are made to make people politically active; create an environment to involve people in social and political activities by encouraging participation in voluntary works, child care, making equitable expenditure in suburban areas and developing quality schools; allowing them to be a part of decision making process; and build transparent bureaucracy and eradicate corruption.

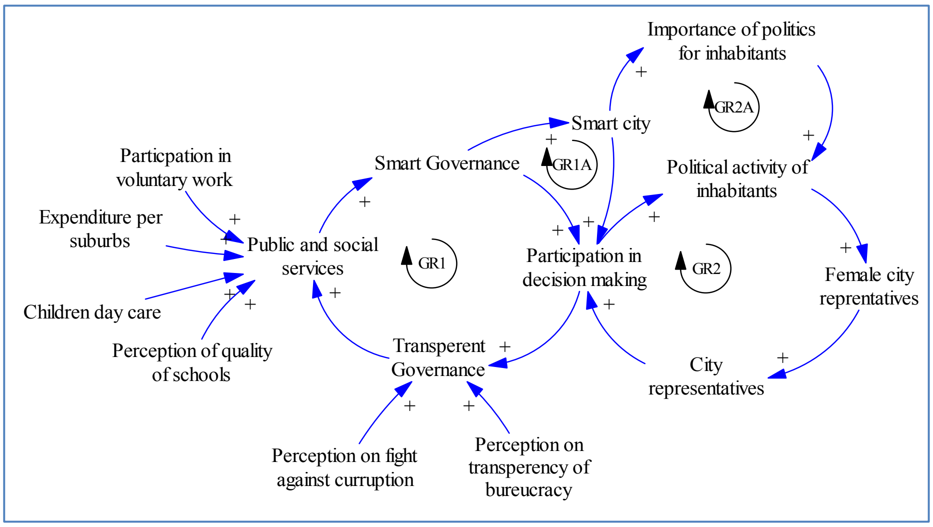

Figure 4: Casual feedback relationships for smart governance

Mobility

Smart mobility has two significant components such as, physical movement at the local level and international accessibility through information communication technological system and international transportation system. In the South African context, it is based on three major reinforcing causal feedback loops involving factors such as (1) sustainable, innovative and transportation system, (2) availability in ICT infrastructure, and international accessibility and (3) local accessibility (figure 5). It is envisaged that a sustainable, innovative and safe transportation system and effective local accessibility create a feedback relationship with smart mobility (MR1). The sustainable, innovative and safe transportation system is influenced by use of economical cars, green mobility share and traffic safety at local level, which need to be addressed to enhance performance of the accessibility in a city. Simultaneously, smart mobility creates a feedback relationship with ICT infrastructure, international accessibility by both air transportation and broad band system (MR2). Availability of ICT infrastructure is designated by computers in households; and international accessibility is influenced by broad band in households and international flights connecting the city. Both the loops in turn reinforce smart mobility of a city. At the same time public transportation network, quality of public transportation system and access to public transportation develop a feedback loop (MR3) with local accessibility, which reinforces feedback loop MR1. Further, feedback loop MR1 is reinforced by feedback loop MR1A involving smart city, smart mobility and sustainable, innovative and safe transportation system; and feedback loop MR2 is reinforced by feedback loop MR2A involving availability of ICT infrastructure, smart mobility and smart city. Therefore, augmentation of both sustainable, innovative and safe transportation system and ICT infrastructure are highly essential for creating smart mobility system and in turn a smart city. Thus, policy interventions for enhancement of sustainable innovative and safe transportation system, which can be achieved by enhancing traffic safety, use of economical cars, and increase in green mobility share are highly essential. This should be complemented by adequate quality public transportation system providing easy accessibility to people. Further, policy interventions are also needed for increasing use of computers by households; expansion of broad band, and enhancement in international flights to such cities.

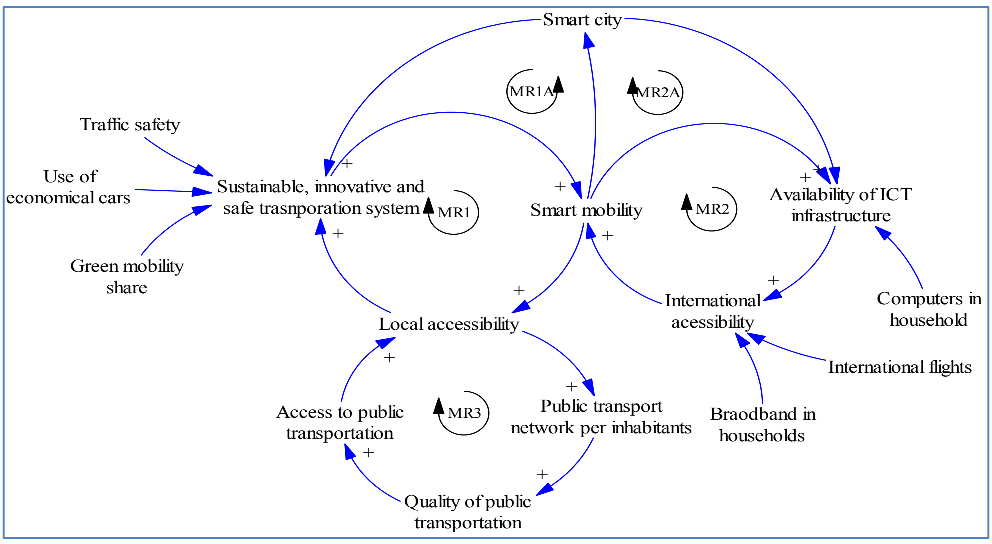

Figure 5: Casual feedback relationships for smart mobility

Environment

The environment sector is essentially characterised by sustainable resource management, environmental protection and attractive natural conditions. It is envisaged that sustainable resource management will lead to environmental protection, which will protect the attractiveness of the natural conditions of a city leading to a smart environment. Thus, in South African cities these factors are interconnected by a positive feedback relationship (ER1) enhancing each other (Figure 6). Smart environment, which would lead to development of a smart city develops a causal feedback loop ER1A connecting at sustainable resource management and reinforces loop ER1. Thus, sustainable resource management becomes highly essential for smart environment. However, on the contrary in the absence of proper environmental protection and availability of particulate matter in the city leads to pollution and consequently cause chronic diseases. Thus, these factors make a negative feedback relationship with environmental protection (EB1) and impact the smart environment negatively. Therefore, policy interventions in terms of reduction of particulate matter through sustainable resource management would reduce pollution and increase environmental protection. Further, environmental protection can be enhanced by creating public opinion and taking proactive measures for increasing individual efforts for environmental protection. Also, sustainable use of water and electricity will help sustainable resource management. Enhancement of green space and Sunshine, which measure the attractiveness of natural conditions, need careful attention.

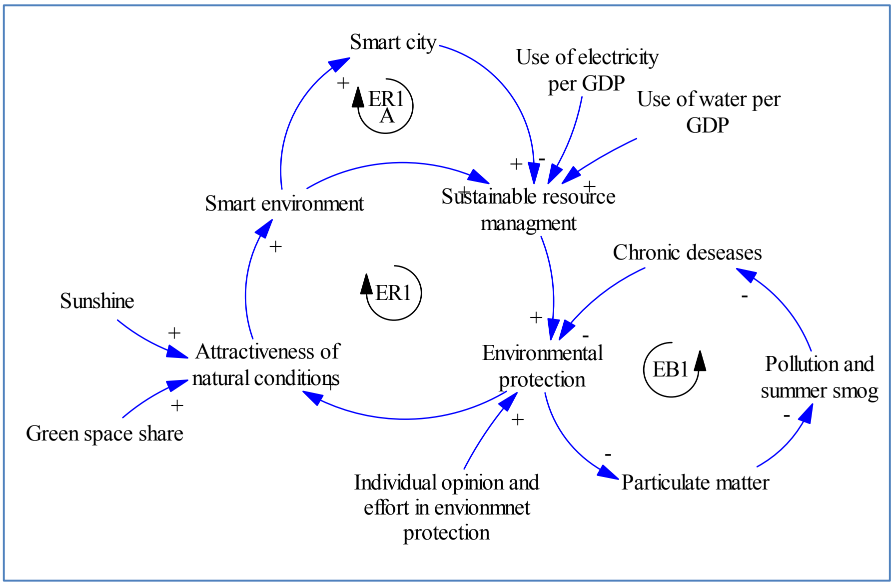

Figure 6: Causal feedback relationships for smart environment

Living

Living conditions of a smart city is influenced by six factors such as, cultural facilities, tourist attractiveness, housing quality, health conditions, educational facilities and social cohesion in South African cities. It is envisioned that each factor will develop individual causal feedback loops with living conditions and smart city development as represented by feedback loops LR1, LR2, LR3, LR4, LR5, and LR6 respectively in figure 7. However, each factor and consequent feedback loop is influenced by several parameters governing them. Cultural facilities are governed by cinema theatre attendance and museum visits, which are essentially observed to be low in South African cities. Tourist attractiveness is influenced by factors such as, importance of tourist locations and overnight stay, which vary from city to city. Housing quality is measured by share of standard quality of housing, average living area per person, and people's satisfaction with housing condition, which essentially are location specific. Health condition is characterised by hospital beds per inhabitants, doctors per inhabitant, perception of quality of health system, life expectancy, and individual safety & crime rate. In this case, although, many of the major cities have standard health facilities, the health care system is observed to be expensive. The life expectancy is quite average and almost similar (about 55 years) all over the country. However, individual safety & crime, which is a function perception of personal safety and death rate by assault is a major concern almost in all the cities. The educational system is indicated by quality of education, students per inhabitants and access to quality of education. It is apparent the Government has a quality system in place of educational system although accessibility to quality education and number of students in particularly higher education in many cities are cause of concern. Social cohesion is characterised by poverty rate and perception of personal risk of poverty, which is essentially indicated by high unemployment rate in the country and more so in the cities. Thus, the living condition of South African cities although not highly deplorable is a cause of concern from several accounts. Therefore, policy interventions based the designed feedback loops and their influences are needed to augment almost all aspects characterising living conditions in the cities for creating smart living conditions and in turn development of smart cities.

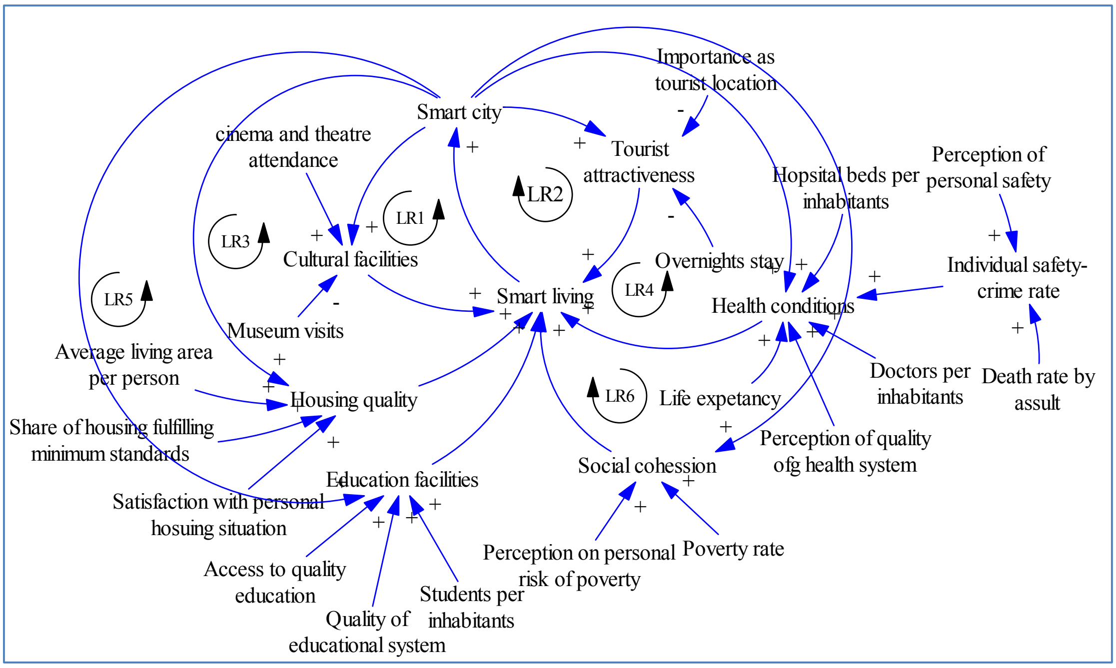

Figure 7: Causal feedback relationships for smart environment

Validation of the causal relations

The conceptual models for each smart characteristic were developed by using the most important factors, parameters under each factor and their causal feedback relations (c.f sections 4.1-4.6). The status and influence of these factors and parameters are critical for the success of the policy interventions evolved based on the causal feedback relations in the models for the development of a smart city. Therefore, to observe the validity of the causal relations developed, a validation effort was made to measure the status and influence of these factors and parameters on the smart city development. The validation was done by considering the various factors and parameters under each smart characteristic of Bloemfontein city- one of the growing middle sized cities of South Africa. The index values of parameters under each factor (appendix 1, Figure 8) indicated that the status and influence of the various factors and parameters under smart characteristics of the Bloemfontein city closely matched to the factors and parameters considered in developing the causal feedback relations in the conceptual models, thus validating the causal relations.

Policy Interventions from Conceptual Modelling

According to the causal feedback relations, it is observed that each smart characteristic is governed by a set of interdependent parameters either individually or in combinations. Further, some parameters of different characteristics influence each other. Therefore, policy interventions need to be developed based on their inter-linkage and feedback relations. While it is necessary to augment the positively influential parameters, the negatively influential parameters need to be strengthened through appropriate policy interventions. The various intended broad policy interventions derived from the feedback causal loops of the conceptual system dynamics models are:

- The scope of the IDPs need to reviewed in the context of the fast changing scenario of the cities. They need to be strategized according to the city type and its potential for future functions instead of conventional method of plan preparation.
- Most of the municipalities or agencies involved in city development process have a vision for their cities, however, instead of outlining a farfetched vision, which shall be difficult to realise within a certain plan period, more practical and potential based visions may be framed. For example if the city has potential to develop as Knowledge based industrial city, then focus should be to strengthen it, while other aspects of the city should complement it.
- The essential change that needs to be augmented in development concept is to see the cities as national / provincial cities with inter-(national) embeddedness and economic activity generation point in the future as against their current status.
- The focus should be on prioritized indicator driven development process where micro level development would complement the macro level development.
- Cities are known as the engines of development in a country. It contributes largely to the GDP of the country and provides opportunities to the people for their economic development. As it is observed from the economic characterises, economic development would lead to inter-(national) embeddedness, innovative spirit and more importantly entrepreneurship**.** Entrepreneurship development should be at the core of the development. Opportunities for new economic avenues under the changing economic pattern of cities are essential and creation of an environment for attracting both foreign direct investment and domestic investment.

- Human resource is the backbone any development, who contributes immensely to economic development and in turn to the city as a whole. Therefore in order to develop smart people, efforts should be made to enhance qualification of people, and create opportunities for lifelong learning. At the same time the cities should embrace flexibility, cosmopolitanism, immigration friendly environment, and development of creative industries.
- Public transportation and green mobility should be augmented at a large scale while discouraging individual cars in the cities to provide sustainable, innovative and safe transportation and to protect environment with low carbon emissions.
- International accessibility for both freight and people transportation depending on the potential and capacity of the city may be created.
- The cities should be fully connected by broadband internet. ICT connectivity should be seen as an element to provide economic generation opportunities than simply looking at it as digital connectivity.
- The democratic set up of the country provides opportunity for open and responsible governance of the cities. Care should be taken to make the common people politically active, and participative in decision making in addition to create a transparent bureaucracy. Transparent governance and no to corruption should be the motto in the development and decision making process.
- Most importantly the city development governance process must be done based on smart growth principles in which the strategy should target the physical development of the urban region having strong social, economic and political components with public participation and inclusive multi-actor planning processes, i.e., participative decision making by participation of all the stakeholders (people, merchants, academicians, entrepreneurs, students, professional, local political leaders, etc.,), which in effect will aid the decision makers to plan, implement and manage according to the requirement of city and its gentry.
- Environmental protection should be the responsibility of each individual citizen of the cities. It can be enhanced by creating public opinion and taking proactive measures for increasing individual efforts. Judicious use of natural and renewable resources will help in protecting the environment and enhance attractiveness.
- Plan should be made to create better living condition of the all the people than offering opportunities for better life style to a few. Housing, health facilities, cultural facilities, tourism facilities, and educational facilities should complement the requirement of other smart characteristics of the cities. Social cohesion and total eradication of the crime can be achieved with better provision of economic opportunities.
- Spatial development should complement economic development but not the vice versa. With limitation of resources, cities need to increasingly base their development and wealth on their strengths such as, natural resources, tourism and natural heritages, and their renewable use, whereby achieving a balance between the growth enhancing measures and protection of weak links.

CONCLUSIONS AND FURTHER RESEARCH

A smart city is essentially regarded as a well performing city in all its characteristics and the development is based on self-decisive and citizen participation. According to scholars a city becomes smart if investments in human and social capital, traditional (transport) and modern (ICT) communication infrastructure, judicious utilisation and management of scarce resources, and participatory governance stimulate sustainable economic growth and a high quality of life

(Caragliu, Del Bo and Nijkamp, 2009). There is also need for adaptability of the people in terms of their learning and innovation (Coe *et al*., 2001) and able to utilise the technology and benefit from them. The purpose of developing such a city is to enhance the capability of the potentials of the city and judicious resource management for optimal development of the city. This is more so important for the South African cities and this investigation provides an analysis keeping these factors in the eye for sustainable development of these cities.

However, development of smart cities pose specific modelling challenges that include interdependency, inter-linkage and causal relationships among the various parameters influencing smart city development, compounded with lack of adequate and reliable data, uncertainties, role of stakeholders, and other prominent aspects such as, people, governance, environment, living conditions, etc., which are not easily amenable to quantification. This investigation shows that system dynamics with its integrative nature is well suited to undertake such modelling challenges. It was observed that it has provided a framework to elicit system description, which conveyed complex and dynamic inter-linkages based on which policies can be generated to augment the strengths and alleviate the weaknesses in an urban system (cities) in order to facilitate development of smart cities in South Africa. Therefore, application of system dynamics methodology in this context is particularly valuable.

The primary goal of this study was to develop conceptual models, which would show the causal relationships among the various influential parameters in each aspect of a smart city and develop a roadmap to create smart and sustainable cities in South Africa. However, there is also a need to transform these conceptual models to computer simulation models, which would reveal the gaps and inconsistencies in the conceptual models, and that is the next goal of this investigation.

Further, the process of rigorously extracting a conceptual model from apt understanding of the smart city concept brought about clarity and awareness of the interdependencies and causal feedback relationships among various influential parameters of cities and their implication on the future development. This could guide the policy makers and planners for plausible actions for developing smart cities, which is perhaps the most significant contribution of this work.

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GRADUATE STUDENTS' PERCEPTIONS ON THE MSc BUILT ENVIRONMENT CURRICULUM FOR SUSTAINABLE DEVELOPMENT EDUCATION

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Abstract:
Sustainable development has social, economic and environmental implications. Key drivers of sustainable development (SD), especially in the context of developing countries, are incomplete without the contributions of experts and academics in the field. The literature points in the direction of the importance and benefits of the propagation of tenets that are inherent in SD. Based on the aforesaid, the contribution of a built environment post graduate programme, in terms of knowledge and / or awareness creation, cannot be over emphasised. The study uses a descriptive approach. This research paper surveys the perceptions of MSc (Built Environment) students on the curriculum's emphasis on sustainable development, green building, and climate change mitigation efforts. An online questionnaire administered to randomly select past and present students was utilised as the research instrument. The findings indicate that limited emphasis and attention is given to the SD topic within the Built Environment modules. For academia, the importance of the findings of this project is to clearly identify the specific areas in need of revision in the Built Environment curriculum. The knowledge created will in turn inform practice in the industry.

Keywords:
Built Environment, Pedagogy, Sustainable Development, Tertiary Education

INTRODUCTION

The term 'sustainable development' was used by the Brundtland Commission which coined what has become the most often-quoted definition of sustainable development namely, "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Smith and Rees, 1998). The concept of sustainable building has since the 1970's evolved from its infancy and currently encompasses principles of natural resource efficiency, waste management, pollution reduction, green building, recycling and rehabilitation of the environment (Sassi, 2006). According to Hayles *et al.* (2008), there is a need for reduction of the energy consumed by buildings and the utilisation of renewable materials that are not harmful to the environment. This is because clients are becoming more conscious of the benefits of green buildings and the need to conserve the environment and, therefore, require more green

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or sustainable buildings (Hayles, 2010). Sustainable building and green building are changing the way buildings are designed, structures commissioned and constructed (Hayles, 2010). Studies indicate the importance of this phenomenon. Otegbulu (2011) emphasises the point that buildings influence the environment through direct land use, water use and other raw material usages. This in turn has serious implications for the built environment practitioners and construction of buildings based on the training acquired from tertiary institutions.

Furthermore, in order to produce built environment graduates who are ready to overcome sustainable development challenges, tertiary programmes have to equip students by incorporating sustainable development philosophies and techniques in their academic curricula (Hayles, 2010). Consequently, Education for Sustainable Development (ESD) has become increasingly significant within the built environment higher education curriculum (Cowling, *et al.,* 2007).

This paper explores the perceptions of MSc (Built environment) students in a South African University regarding the emphasis of the curriculum on sustainable development and green construction for the benefit of institutions of higher learning and the built environment profession. The study was guided by the following research question:

'To what extents have the courses / modules in the MSc Built Environment addressed sustainable development?'

LITERATURE REVIEW

Sustainable development generally refers to development that meets the needs of society and environment without compromising the ability of future generations to meet their own needs (Otegbulu, 2011). De Francesco and Levy (2008 cited in Otegbulu, 2011) define sustainability as the maximisation of the positive effects and the minimisation of negative effects associated with property ownership, building design and building development in a way that is consistent with benefits to the environment. According to Kats (2003), this benefit comes about due to the fact that sustainable development effectively uses key resources such as energy, water, materials and land. This is because sustainable buildings use more natural light, natural heating and natural building materials. Research by Dawe, Jucker and Martin (2005), and Cowling *et al.* (2007), however, reveals that SD is still not widely developed. Within Built Environment education the need is significant, given the acknowledged impact that buildings have on the economic well-being of a country, the social well-being of people and the impact on the environment (Cowling *et al.*, 2007).

The "education for sustainability" agenda has emerged as a significant area of development within the Higher Education sector (Wals and Corcoran, 2004). Teaching, training and learning which emphasises sustainable development is a critical element in moving forward the agenda of sustainable building, green construction and adaptation to climate change (Ellis and Weekes, 2008). According to Sassi (2006), to be an effective practitioner promoting sustainable development, a graduate has to be aware of the need for sustainable development, be technically equipped, skilled and knowledgeable. The *status quo*, according to Ellis and Weekes (2008), is that there is insufficient training and focus in built environment curricula to hone in the skills of ethical judgement and challenge dominant ideologies of contemporary building philosophies.

A curriculum that would fulfil such a function of equipping students with sustainable development know-how should, according to a study by Sassi (2006), address the following topics in the curriculum: environmental and social concerns, concepts, principles and historic developments, environmental ethics, social ethics and professional ethics, sustainable communities and urban environments, politics, economics, environmental law and implementation approaches to sustainable design strategies. Nikel (2007) explored how students understand sustainable development and education for sustainable development. The results suggested that the built environment offers one of the key areas for addressing the challenges of sustainable development.

Sustainability was assimilated into planning practice following the 1992 Rio Summit and was further strengthened by the requirements of the governing professional body in the UK, the Royal Planning Institute (RTPI). However, a critical review suggests that sustainable development fails to be reflected adequately in day-to-day planning decisions. A theme for enhancing sustainable building draws on the model of enquiry-based learning (Hutchings, 2006). This can take place in both classroom and experiential settings.

The pedagogy that has had some influence is the concept of 'action competence' developed in a Nordic context of environmental education. This is defined as the 'ability to take into consideration the social factors and human conflicts of interest that lie behind environmental questions and sustainable development (Lundegard and Wickman, 2007). Alternatively, Schnack (1996) argues that capability-based critical thinking adds value within counter-actions during the thinking process. This function produced an approach that encourages students to understand the causes of environmental problems rather than the symptoms. It also transforms students from being passive receptors of knowledge to those who engage in such issues through independent thinking within the concept of sustainable development.

More recently, it has been suggested that a more consistent analytical breakdown is needed to distinguish four domains of economic, ecological, political and cultural sustainability. An area of opportunity where sustainable building focus can be introduced is when students undertake their research in the form of a dissertation or treatise (Ellis and Weekes, 2008). On a one-year or two-year masters' course, the implications are that students should be encouraged to undertake research on sustainable development from an early stage of the programme. Ellis and Weekes (2008) indicate that such an undertaking should be done not in a team work environment or group work but on an individual basis. This is because research on the impact of integrating sustainable development into teaching, training and learning at tertiary level has a positive impact on students' perceptions and awareness of sustainable development (Hayles, 2010). According to Sommalisto and Brorson (2008), the typical elements that should be included in the modules should also include environmental policy, environmental aspects, strategic alignment of sustainability and non-conformity reporting.

METHODOLOGY

In order to explore students' perceptions and awareness of sustainability and whether the MSc (Built Environment) curriculum promotes sustainable development, a quantitative research methodology was used. The main question addressed in this research is 'to what extent have the modules in the MSc Built Environment addressed sustainable development?' In order to address this research question, respondents were asked to indicate to what extent they agreed or disagreed with the following statements:

- Research methodology promotes sustainability topics;
- Strategic concepts taught include sustainability issues;
- Sustainable development forms the nucleus of some modules;
- Climate change features in some modules;
- Social aspects of sustainability are present in certain modules;
- Environmental aspects of sustainability feature in certain modules;
- Economic aspects of sustainability are discussed in certain modules;
- The use of IT to address climate change is addressed;
- Lecturers refer to sustainable development challenges in classes;
- Elements of sustainable construction materials are included;
- 'Strategic management' addresses sustainable development;
- Sustainable development is addressed in design management;
- Sustainable development is not mentioned at all in the programme, and
- Sustainable development literature is recommended in courses.

A web based questionnaire was administered to selected MSc (Built Environment) students. The sampling method was random so as to give both past and present students equal chance of participation. Respondents were required to indicate the extent to which they agreed with a particular statement on a five-point scale; "strongly agree, agree, neutral, disagree, and strongly disagree." Out of the 100 students requested to respond to the survey, 26 responses were received, indicating a 26% response rate. Out of the 26 respondents 6 (23%) were females.

RESULTS ANALYSIS

Most (65%) of the students agreed that the research methodology module promotes research that deals with sustainability. This indicates that the lecture is sensitive to the sustainable development topic and does encourage research in the topic.

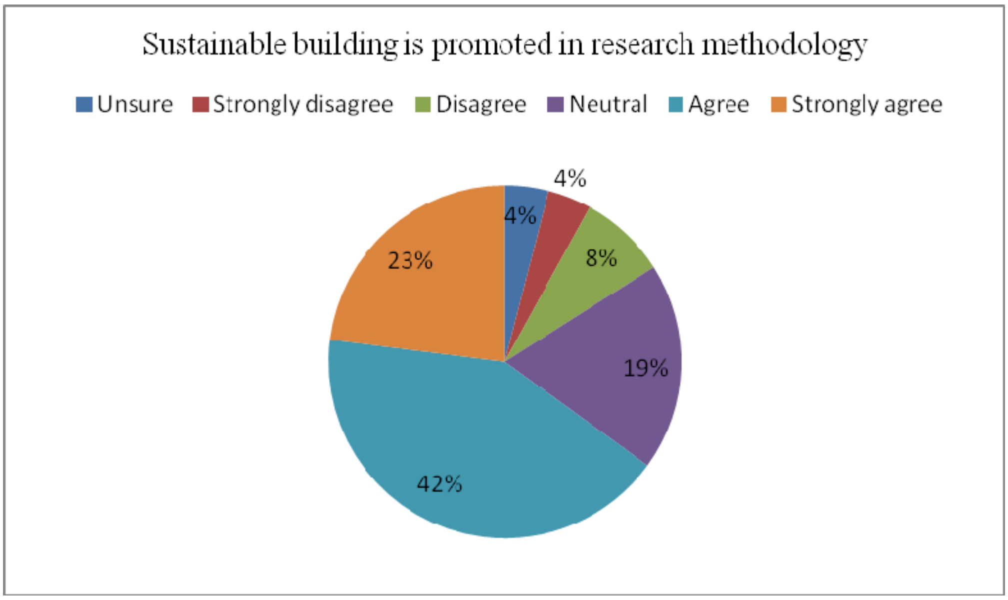

Figure 1: Distribution of respondents regarding the promotion of sustainable building

The study revealed that 66% of the respondents agreed that strategic management concepts include the focus on sustainability within the built environment. However, 14% of the respondents disagreed, which indicates a need to pay more attention to SD in strategic management modules.

Responses to the statement, 'sustainable development forms the nucleus of some modules' indicate that 8% of respondents were unsure, 4% strongly disagreed, 16% disagreed, 20% were neutral, 44% agreed, 8% strongly agreed, and one respondent did not answer the question. The results imply that students do not perceive that SD is the nucleus of some modules and more needs to be done.

The results of the study on the perceptions of students regarding the emphasis of the curriculum on the topic of climate change are in Figure 2. The results of the survey indicate that there is room for improvement in integrating climate change topics in the curriculum.

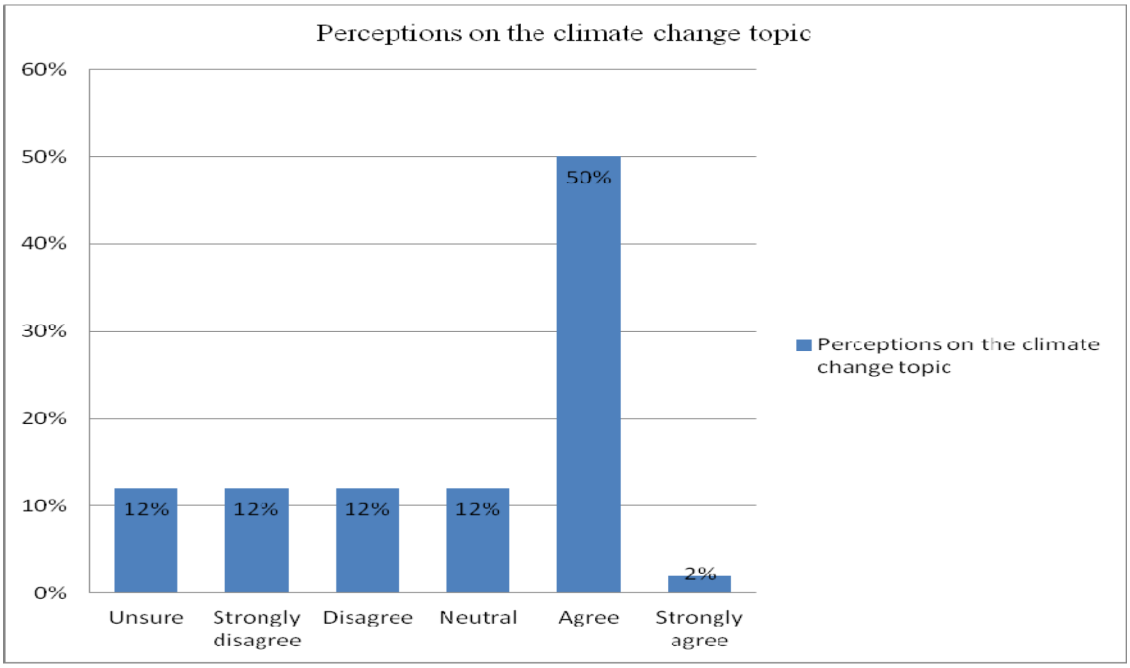

Figure 2: Responses regarding the focus of the curriculum on climate change

When students were asked to respond to the statement, 'the social aspects of sustainability are present in certain modules, none of the respondents was unsure, 8% strongly disagreed, 15% disagreed, 23% were neutral, 46% greed, two respondent did not answer the question and 8% strongly agreed. The results of the study show that most students do not think that social aspects of sustainability are present in certain modules.

When students were asked to respond to the statement, 'environmental aspects of sustainability feature in certain modules', 4% of the respondents were unsure, 8% strongly disagreed, 4% disagreed, 27% were neutral, 42% agreed, and 15% strongly agreed. The results show that most students agree that environmental aspects of sustainability feature in certain modules. The prevalence of the economic aspects of sustainable building in some built environment modules is emphatically confirmed by the respondents as is apparent in Figure 3.

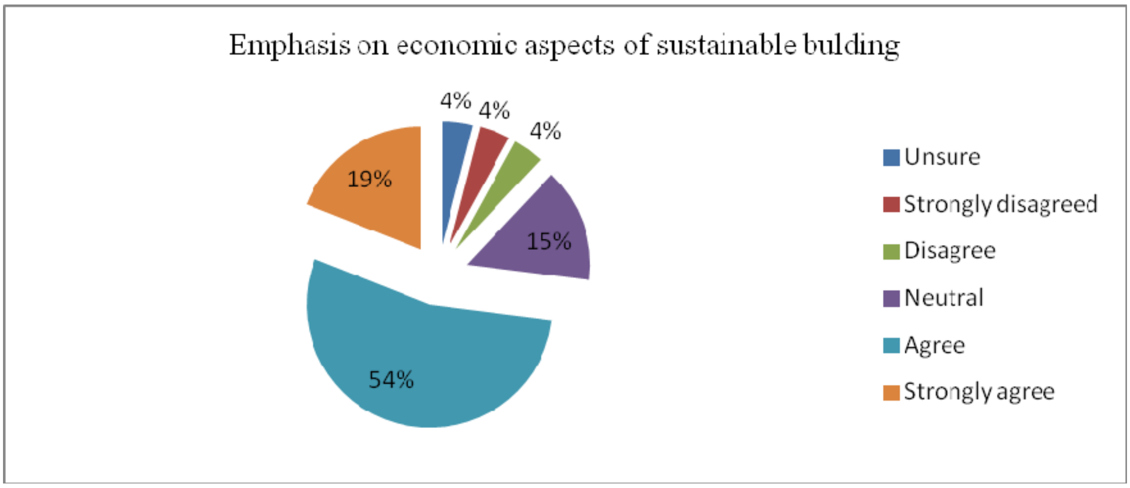

Figure 3: Respondents' perceptions of the emphasis on economic aspects of sustainable building

The results show that, most students agree that economic aspects of sustainable development are discussed in certain modules. This is because the specific curriculum under investigation has a specific Business and Construction Economics module which focuses on the economics topic within the built environment profession. The IT module in the built environment curriculum lacks a focus on climate change mitigation as can be seen from the perception of the respondents in Figure 4. The result of the study indicates that there is room for improvement in integrating the IT module with the climate change topic within the built environment curriculum.

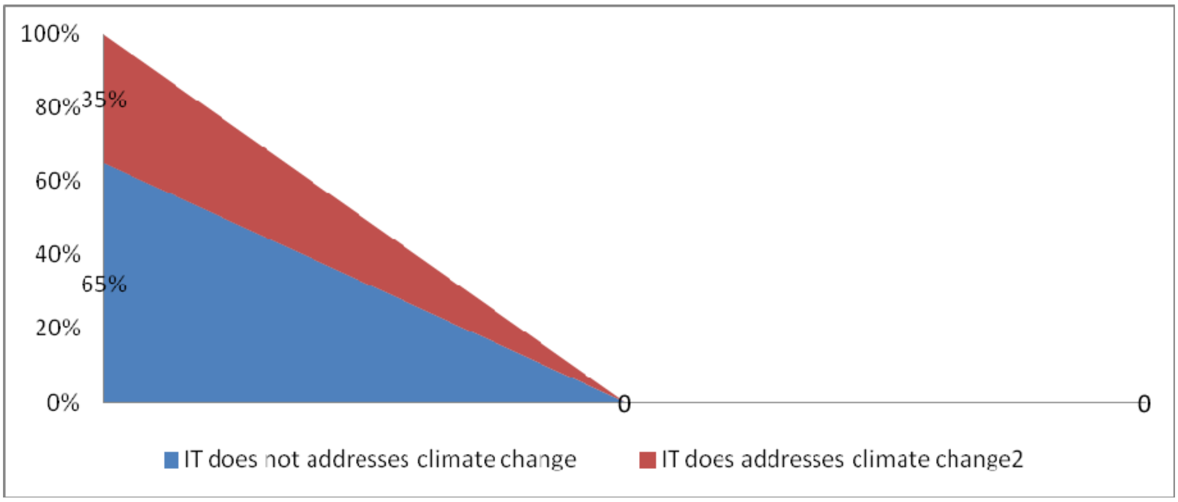

Figure 4: Students' perceptions of climate change being addressed by the IT module

The responses to the statement that 'lecturers discuss sustainable development challenges in classes' yielded the following results: none of the respondents were unsure, 8% strongly disagreed, 15% disagreed, 15% were neutral, 58% greed, and 4% strongly agreed. The results of the study show that most students agree that lecturers discuss sustainable development challenges in classes, but a more strategic approach is required as indicated by the lack of consensus from the results. When students were asked to respond to the statement that ‘elements of sustainable construction materials are included in some modules,’ the results indicated that Masters’ students generally agreed with this statement with a 52% affirmative response. Sustainable building requires a strategic approach from all role players more especially from top management. 50 % of the respondents indicated that a notable inclusion of the sustainable building topic was observed in the strategic management module. This confirms the earlier findings that strategic management module is inclusive of sustainability issues.

When students were asked to respond to the statement that ‘sustainable development is addressed in the Design Management module’, 12% of the respondents were unsure, none of the respondents strongly disagreed, 12% disagreed, 22% were neutral, 42% agreed, and 12% strongly agreed. The results show that most students agree that sustainable development is addressed in the design management module, but there could be more emphasis. In the study, respondents were asked to respond to the statement that ‘sustainable development is not mentioned at all in the programme.’ None of the respondents were unsure, 42% strongly disagreed, 27% disagreed, 15% were neutral, 12% agreed and none of the respondents strongly agreed. The results indicate that part of the curriculum addresses the sustainable building topic. However, no stand-alone module deals with this aspect, hence there is no consensus. The students who believe that sustainable building is mentioned in the programme could be referring to the research methodology module.

On the question whether sustainable development literature is recommended in modules, none of the respondents were unsure, 12% strongly disagreed, 12% disagreed, 22% were neutral, 35%greed, and 19% strongly agreed. These responses indicate that more sustainable development literature needs to be prescribed to students to advance SD education amongst MSc (Built Environment) students. Responses on the open-ended questions regarding how sustainable development concepts and topics can be addressed in the MSc (Built Environment) programme yielded great insight and alluded to the need to have a separate SD module within the programme.

CONCLUSIONS AND RECOMMENDATIONS

Sustainable development is considered a critical component of the future wellbeing of the human planet. While sustainable development cannot be realised only through the demand from the market, higher education in particular is seen as a focal point to help in promoting sophisticated, action-orientated teaching and learning regarding sustainability as well as creating sustainable solutions for climate change. Of the many human activities associated with climate change, the built environment offers the largest cost-effective potential for significant long-term reduction in greenhouse gas emission with substantial contribution to mitigating climate change. The inclusion of climatic behavioural factors in the design of buildings will significantly influence energy consumption in urban buildings and construction projects. In order to acquire the necessary skills in built environment, teaching and learning at tertiary level should incorporate sustainable development, green building, and environmental topics. The empirical results of this study show encouraging signs that MSc (Built Environment) students recognise the importance of appreciating sustainable development. Relevant tertiary institutions should develop a specific module to address sustainable development with emphasis on design, planning, construction, social impact, economic considerations and maintenance of buildings. There has to be an institutional drive and commitment to take part in sustainable development from the perspective of institutions of higher learning.

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PERCEPTIONS OF BUILT ENVIRONMENT STUDENTS TO THE ENVIRONMENT & SERVICES COURSE

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Abstract:

Students' perceptions of a subject matter's worth to their field of study is indelibly linked to the credit value awarded as opposed to its knowledge value, which has created various challenges in the presentation of the Environment and Services (E&S) course. In contrast, the subject matter covered is highly topical due to the increased attention to sustainable design and construction methodology known colloquially as 'green building'. Students from three built environment disciplines, namely Architecture, Construction Management, and Quantity Surveying completed a self-administered questionnaireat the inception of the presentation of the first-year of a course. Findings include: students do understand and appreciate the importance of knowledge of E&S to their disciplines, as well as the role of design; the impact of design and environmental factors on the built and natural environments, and the importance of knowledge of E&S in their studies. It is recommended that such research be conducted on an annual basis, and a preparatory lecture module on 'The role and importance of E&S' should be evolved for first year students.

Keywords: Built environment, Credit values, Environment & Services, Sustainable construction, Students

INTRODUCTION

The subject Building Science (Environment and Services) is a key course for three Built Environment disciplines, namely Construction Management, Quantity Surveying and Architecture. However, a perception had arisen among students that due to the low credit value for the course and the scheduling of only one double lecture a week along with four tutorials a semester, that the subject is not as important as other subjects in terms of their individual study disciplines.

In contrast, the subject matter of the course has become highly topical in the last five years, with greater interest being shown from both commercial entities and the general public towards sustainable design and construction which has manifested itself in what is collectively known as 'green' building. Since the release of the draft South African National Standard (SANS) 204 document in 2008 and the subsequent amendments to the national building

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regulations as a result of 10400-XA in October 2011, increased attention has been focused on the ability of students to understand not only the terms of reference, but also the scientific basis for the legislation and its impact on the design and construction of buildings.

Then, increasing demands 'for teaching excellence in higher education' (Nicholls, 2002) alongside a greater understanding of 'differences in the ways individual students experience learning' (Prosser and Trigwell, 1999), has led the department facilitating the delivery of the course to foster a culture for continuous research in lecturing and learning in order to better understand student perceptions relative to the course, and the relevance of its content to their future as built environment professionals. Furthermore, as the only course attended by all three disciplines and with the knowledge that there is a "need for innovative educational approaches that facilitate cross-disciplinary thinking" (Warburton, 2003), as highlighted in all three disciplines' professional registration councils accreditation reports, the research provided an opportunity to better understand the perceived importance placed on it by each of the student groups. In addition to this, the course lecturer desired to better inform the students of the particular environment and services challenges associated with each of their disciplines, thereby providing greater relevance to the lectures and a greater need to understand and appreciate the course material as opposed to simply passing the course.

The research reported on was undertaken due to the:

- Department presenting the subject 'Environment & Services' regularly undertaking 'lecturing and learning' related research to determine the impact of various interventions such as portfolio and integrated projects, industry oriented vacation work, and mediums of course delivery, and

- Various challenges that have been experienced relative to the subject 'Environment & Services': 'low' pass rates; low priority afforded to the subject by architectural students, and topicality of issues such as sustainability, including 'green' building, energy efficiency, and sustainability.

LITERATURE REVIEW

Student perceptions of a course's merit can be influenced by multiple factors, not only the weighting given the course by each of the departments under whose curricula it resides. In studies conducted across multiple disciplines, "engagement, perceived course value, and the use of deep learning strategies are believed to be integral to a student's positive learning experience" (Floyd *et al*., 2009). With positive learning experiences likely to lead to positive reinforcement of a course within the student body, relating the perception through deeper learning to the course content becomes a fundamental means to influencing that perception. "How the learning experience is perceived by the learner is probably the best source of intelligence on how education can be improved" (Edstrom, 2012).

The link between a positive learning experience and learning strategies being evident, creating a positive experience could also improve on the performance of students. "Motivation is an important factor in student learning" (Liu *et al*., 2012). Given that the presenting department is endeavouring to improve the overall academic performance of the students, in particular, the architecture students, being able to link the coursework with design related projects will, in itself, assist in impacting on the perceptions of the course within that grouping. Effective education for sustainability prompts students to reflect on their learning and leads to changes in values, attitudes and behaviours (Fien, 1997; Howard *et al*., 2000).

As has also been demonstrated, the students' perception of course value, in the form of personal relevance and meaningfulness of tasks, is a very important concept in enhancing and evaluating a student's learning experience (Floyd *et al*., 2009) and therefore "research looking at students' own descriptions of their experiences of the learning context has crucial implications for the teaching and learning in higher education" (Ramsden, 1997). The engagement of the department with the students through research surveys, both pre and post course, facilitates evaluation of, not only the perceptions of incoming students, but also influences the direction of the course through identifying areas of study that need enhanced attention.

Additional research has shown that "students' approaches to study and their motives are determined by a number of aspects of the higher education system, including their perception of the department" (Newstead and Hoskins, 2005), which can be greatly influenced by engagement with the student body and eliciting their input to improving the delivery of the subject matter. Furthermore, "The departmental context also plays a part, it would appear, in influencing students' attitudes towards studying – whether they feel that academic work is worthwhile" (Ramsden, 1997). Given that students are linked to three separate and generally divorced departments, getting the students to view the Department of Construction Management, who present the course, in a positive light, is an important aspect in influencing the students' perceptions of the course.

This is further heightened by the fact that architecture and construction management are inferred by students as being unrelated to one another "even the casual observer of higher education cannot fail to notice that the important differences in the context of learning are associated with different subject areas. It appears that there are systematic differences in students' perceptions of appropriate ways of learning in arts and science disciplines" (Ramsden, 1997). Theoretical concepts form an integral part of the architecture curriculum, and the design course is afforded a high weighting (50%), which means students focus thereon. "Students with a science background are more likely to emphasize operation learning while those coming from arts tend to emphasize comprehension learning (Warburton, 2003). Students, however, need an education 'that balances operation and comprehension learning.'

Added to this, the majority of the learning in the subject is focused towards concepts that have most resonance with the architecture discipline. As the approach of students to learning depends on their interest in the task and their previous experience of the area to which it relates (Ramsden, 1997), enabling quantity surveying students to understand relevance, and provide sufficient motivation to them can be challenging. This is exacerbated by the students generally not having experienced an environment where they can relate theory to practice, which has led to an increased need to engage with students on site visits as "curricula must support student learning and personal development through providing a meaningful and motivational context" (Edstrom, 2012). However, "self-motivation of students is a prime requirement for their active engagement" (Kamardeen, 2013), which means that the course content needs to stimulate interaction within the study sessions and also into other courses within each discipline's course structure. The influence of motivation theory on educational practice has been considerable (Kinman and Kinman, 2004) and aligned to that is the need for the students themselves to be convinced that the subject is worth investing their time outside of the lecture environment, which is compromised by the course weighting assigned. Common to many conceptualisations of motivation is an emphasis on the presence of stimuli to direct the individual: either an internal drive (intrinsic), or an environmental incentive (extrinsic) (Kinman & Kinman, 2004).

Unfortunately, with only tenuous links between the subject and the course work, mainly when the students have completed the undergraduate programme, there is little incentive to do any more than the basic minimum to pass the course. Extrinsic motivation to work is thus primarily in response to something apart from the work itself", being concerned with the material, social or symbolic rewards (Kinman and Kinman, 2004) with this reward all too often "a grade rather than understanding" (Kamardeen, 2013). Intrinsic motivation corresponds to personnel development, and extrinsic motivation corresponds to means to an end (Newstead and Hoskins, 2005). The implications are that students will only achieve the bare minimum for the course as "rewards are interpreted by recipients primarily as controllers of their behaviour" which will mean intrinsic motivation is likely to be undermined, whereas, if external goals are internalised and integrated with personal goals, intrinsic interest is unimpaired (Kinman and Kinman, 2004). Students with performance orientated goals are motivated primarily by obtaining good marks, while learning orientated students wish to actually learn something from their studies.

Performance goals are linked to a means to an end (and extrinsic motivation), while learning goals are linked with personal development (and intrinsic motivation) (Newstead and Hoskins, 2005). One of the ways to overcome this is to engender a deeper learning to the course. Interest and commitment to a subject area can be fostered by certain experiences of teaching and by perceived freedom in learning, and intrinsic interest is fundamentally related to a deep approach (Ramsden, 1997), while students that perceive higher course value and are more engaged will be more likely to use deep learning strategies (Floyd *et al*., 2009). Research has shown that deep learning is particularly crucial in the case of sustainability education (Warburton, 2003) as complementarities of different disciplinary paradigms is a desirable outcome of environmental education (Warburton, 2003). In addition, it has been shown that through deep learning, each of the disciplines will be able to increase knowledge and not simply pass the subject. Deep learning is internally motivated and is associated with an intention to understand rather than to simply pass an assessment task (Marton and Saljo, 1997). This would provide additional opportunities to engage with each of the discipline specific students and provide added motivation to foster extended relationships for personal gain following completion of the course content.

RESEARCH

Research method

'Lecturing and learning' related research has been undertaken in the Department presenting the subject 'Environment & Services' to determine the impact of various interventions such as portfolio and integrated projects, industry oriented vacation work, and mediums of course delivery. At the inception of a study year, first-year architectural, construction management, and quantity surveying students attending the first lecture were surveyed using a self-administered questionnaire consisting of five point likert scale type questions to determine their perceptions regarding:

- the importance of 'Environment & Services' to construction related disciplines;
- the impact of design, energy efficiency, and sustainability, and

- the subject ‘Environment & Services’.

Research findings

Table 1 indicates the respondents’ study discipline.

Table 1: Respondents’ study discipline

Discipline	No.	(%)
Architecture	50	43.9
Construction Management	32	28.1
Quantity Surveying	31	27.1
Not stated	1	0.9
Total	114	100.0

Table 2 indicates the response to various general non-course related questions. Less than half (42.1%) of respondents had studied geography at school. Geography as a subject addresses various environment related aspects such as climate, topography, and vegetation. Although only first year ‘Environment & Services’ registered students were surveyed, 19.3% responded that 2012 was not their first full year of university study, indicating that they may have repeated the subject. Most (80.5%) of respondents did not have any construction related work experience. Only 5.3% of respondents were a member of an environmental group e.g. WWF. Slightly more than half (53.2%) of respondents stated that they recycled. However, the nature and extent of recycling was not interrogated. Less than a third (29.8%) of respondents knew their monthly water and electricity usage amount, which is notable as these are primary sustainability issues.

Table 2: Response to various questions

Question	Response (%)	
	Yes	No
Geography part of school curriculum?	42.1	57.9
First full year of university study?	80.7	19.3
Construction related work experience?	18.6	80.5
Member of an environmental group e.g. WWF?	5.3	93.9
Do you recycle?	53.2	45.9
Do you know your monthly water & electricity usage amount?	29.8	70.2

Table 3 indicates the environment that respondents had grown up in. Urban (75.2%) predominates, followed distantly by the other forms.

Table 3: Environment that respondents had grown up in

Environment	Yes (%)
Urban	75.2
Rural	8.0
Peri-urban	4.4
Combination	12.4

Table 4 indicates the importance of knowledge of 'Environment & Services' to seven disciplines in construction on a scale of 1 (minor) to 5 (major), and a mean score (MS) between 1.00 and 5.00. It is notable that all the MSs are > 3.00, which indicates the respondents believe knowledge of 'Environment & Services' to be of major as opposed to minor importance. However, 4 / 7 (57.1%) of the MSs are > 4.20 ≤ 5.00, which indicates that the respondents believe knowledge of 'Environment & Services' to be of near major to major / major importance. It is notable that architects fall within this range. 2 / 7 (57.1%) of the MSs > 3.40 ≤ 4.20, which indicates that knowledge is between moderate to near major / near major importance. Although Construction Managers fall within this range, the related MS (4.16) falls marginally outside the upper range. The MS (3.23) of Quantity Surveyors is > 2.60 ≤ 3.40, which indicates that knowledge is between near minor to moderate / moderate importance. However, this MS is only 0.17 below the lower limit (3.40) of the upper range. Overall, the findings are notable in that the disciplines of architecture, construction management, and quantity surveying are represented by the respondents, and therefore the perceived importance of the subject to the three disciplines should be similar. Furthermore, Construction Managers manage the assembly of buildings and structures and Quantity Surveyors manage the costs thereof, and therefore an intimate knowledge of environment & services is important.

Table 4: Importance of knowledge of 'Environment & Services'

Discipline	**Response (%)**						**MS**	**Rank**
	Unsure	**Minor……………………………Major**						
		1	**2**	**3**	**4**	**5**		
Town & Regional Planners	5.4	1.8	1.8	5.4	15.2	70.5	4.59	1
Architects	2.7	0.0	1.8	10.6	30.1	54.9	4.42	2
Land Surveyors	2.7	2.7	3.5	7.1	21.2	62.8	4.42	3
Civil Engineers	4.5	0.0	1.8	19.6	20.5	53.6	4.32	4
Construction Managers	1.8	0.9	4.4	18.6	28.3	46.0	4.16	5
Mechanical and Electrical Engineers	6.3	6.3	9.8	24.1	25.9	27.7	3.63	6
Quantity Surveyors	3.6	10.7	17.9	28.6	17.0	22.3	3.23	7

Table 5 indicates the extent to which respondents believe various contentions in terms of percentage responses to a scale of 1 (minor) to 5 (major), and a MS between 1.00 and 5.00. Given that all the contentions are 'true', it is notable that all the MSs are > 3.00, which indicates the respondents believe the contentions more to a major than a minor extent. 6 / 14 (42.9%) MSs are > 4.20 ≤ 5.00, which indicates that the extent the respondents believe the contentions, is between a near major to major / major extent. The other 8 (57.1%) have MSs > 3.40 ≤ 4.20, which indicates the extent the respondents believe the contention is between some extent to a near major / near major extent. Clearly the respondents have an understanding and appreciation of: the influence of various factors: the relationships that exist between environments and buildings; the role of design, and the role of energy efficiency. The aforementioned is particularly notable given that they are first year students and that they were surveyed at the inception of the course.

Table 5: Extent to which respondents believe ……….

Contention	Response (%)						MS	Rank
	U	Minor…………………………....Major						
		1	2	3	4	5		
design will influence the internal environment of a building	1.8	0.0	2.6	11.4	28.1	56.1	4.40	1
the external environment will influence the construction methodology	3.5	0.0	0.9	10.6	35.4	49.6	4.39	2
sustainable design will impact on the cost of a project	4.4	0.0	0.9	11.4	35.1	48.2	4.37	3
sustainable environment and services design can impact on reducing the overall environmental impact of buildings including carbon emissions	3.5	0.0	4.4	13.2	21.9	57.0	4.36	4
climate change will affect building environment & services	0.9	0.9	6.1	6.1	31.6	54.4	4.34	5
the location of a building will impact on the environment and services design requirements	0.9	0.0	4.4	10.6	32.7	51.3	4.32	6
renewable energy can reduce building energy requirements	6.3	6.3	1.8	10.7	31.3	43.8	4.11	7
design will influence the services in a building	1.8	0.9	7.9	18.4	28.9	42.1	4.05	8
environment and services design can reduce water usage requirements	3.6	1.8	7.2	21.6	35.1	30.6	3.89	9
the energy efficiency of a building impacts on its rental rate	6.3	1.8	7.1	23.2	33.9	27.7	3.84	10
the energy efficiency of a building impacts on its resale value	9.8	0.0	10.7	30.4	22.3	26.8	3.72	11
legislation can change our perceptions of what constitutes sustainable building practices i.e. labelling on products	20.6	1.9	4.7	25.2	33.6	14.0	3.67	12
the internal environment will influence the construction methodology	7.1	3.5	3.5	36.3	29.2	20.4	3.64	13
perceived cost will influence the use of sustainable options	15.7	2.8	7.4	28.7	26.9	18.5	3.60	14

Table 6 indicates the extent to which respondents concur with statements in terms of percentage responses to a scale of strongly disagree to strongly agree, and a MS between 1.00 and 5.00. It is notable that with the exception of one, all the MSs are > 3.00, which indicates the respondents' generally agree as opposed to disagree with the various statements. The highest level of agreement (MS = 4.47) is relative to 'KES lectures will increase my awareness of environmental issues related to the built environment', which indicates the concurrence is between agree to strongly agree / strongly agree. This is followed by the level of agreement relative to 'KES knowledge will assist me in other modules' (MS = 4.17) and 'KES knowledge will assist me in everyday life' (MS = 4.04). Given that the two MSs are > 3.40 ≤ 4.20, the concurrence is between neutral to agree / agree. However, it should be noted that the two MSs are fall marginally outside the upper range of > 4.20 ≤ 5.00. 'Credits awarded for KES are disproportionally low to its knowledge value' achieved a MS > 2.60 ≤ 3.40, which indicates that the concurrence is between disagree to neutral / neutral. This is notable as anecdotal evidence from a number of students indicated the converse. Furthermore, the 32.7% 'unsure' response is notable.

Table 6: Degree of respondents' concurrence with various statements

Statement	Response (%)						MS
	Unsure	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
KES lectures will increase my awareness of environmental issues related to the built environment	1.8	0.0	0.9	5.4	38.7	53.2	4.47
KES knowledge will assist me in other modules	2.7	0.0	0.9	9.8	58.0	28.6	4.17
KES knowledge will assist me in everyday life	0.9	0.0	0.9	23.2	46.4	28.6	4.04
Credits awarded for KES are disproportionally low to its knowledge value	32.7	5.5	7.3	41.8	10.9	1.8	2.95

DISCUSSION

The respondents understand and appreciate the importance of knowledge of 'environment & services' to seven built environment disciplines, but to a lesser extent, mechanical and electrical engineers, for which the subject is equally important. The respondents understand and appreciate the: role of design, sustainable design, and renewable energy; the impact of the external and internal environment, climate change, buildings, energy efficiency, and legislation, and the influence of cost. The respondents understand and appreciate the importance of knowledge of environment & services in terms of their studies. Furthermore, anecdotal evidence to the effect that the current credit values accorded the subject are low was not validated by the study and therefore it can be concluded that such anecdotal evidence may be attributable to students that are not willing to dedicate the requisite time to the subject. Furthermore, the respondents can be deemed to be 'above average' in terms of their understanding and appreciation of the various issues pertaining to the subject 'Environment & Services', particularly given that they are first-year students.

CONCLUSIONS AND FURTHER RESEARCH

The Department presenting the subject 'Environment & Services' should undertake 'Lecturing and learning' related research on an annual basis and then in the form of a longitudinal study. There is a need to provide the students with a greater understanding of the relevance of the subject to their respective disciplines with the expectation that this will engender within the student body a greater level of interest and attendance of course lectures and site visits conducted in the course of the delivery process. Therefore, a preparatory lecture module: 'The role and importance of environment and services' should be evolved for presentation to first year students upon commencement of the subject. Consideration should be given to increasing the credit values accorded the subject at all three years of presentation and the possibility of an additional year of study at an honours level should also be considered that would include a research component to further evolve the areas of knowledge in the subject area particularly with respect to the future of sustainable construction. The study has also focused much needed attention on the importance of the subject in the context of the built environment professions at a time when sustainability has elevated the importance of those disciplines within the public domain.

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SUSTAINABLE BUILT ENVIRONMENT: A CASE STUDY OF SOME BUILDINGS OF CENTRAL UNIVERSITY OF TECHNOLOGY, FREE STATE

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Abstract:
The rising cost of energy consumption coupled with the depletion of scarce resources leading to compromising future use has led to a rethink of alternative energy sources. Passive designs which incorporate the use of renewable energy is now the focus for comfortable living. The study aims to assess the level of sustainability of our built environment using the passive design principles. Two methodologies were employed in this study, the questionnaire survey and case study. A total of thirteen (13) questionnaires, and three infrastructures on Central University of Technology, Free State in Bloemfontein campus (case study) were analysed for the study. Descriptive statistics statistical tool was used to analysis the data. Finding for the study include, designers have low consideration for passive design, as a result of dominance of high electricity consuming appliances, such as, water heater, skylight and high energy bulbs. The factors that mostly influence design and production of green environment are personal sense of environment responsibilities and rising energy cost. Employing the principles of passive design for procurement of designs, 21.5% achievement was attained of the facilities assessed. Recommendations include designers should at all stages of design consider designing passive. The government and the private sector should make the public more aware of our environmental responsibilities and benefits of renewable energy devices incorporation in facilities.

Keywords: Built environment, Facilities, Passive design, Sustainability

INTRODUCTION

Changes in climatic conditions appear to be inevitable, as a result of the emission of CO_2, is traceable to greenhouse gases. Global surface temperature has been on the rise since 1850 at 2-0-2.4°c per year. To keep temperature rise at this value, it is reported that greenhouse gas emission would have to be reduced by 50-85% by 2050 synthesis report (Rogner *et al.*, 2007). Based on this, it is important to employ sustainable development for our environment. The word sustainable could be defined as the ability to meet present need without compromising on the ability of meeting the needs of future generation in terms of use of materials or development (United Nations, 1987). Sustainable development and infrastructure has become an important topic as a result of scarce resources availability, and the needs of men that is increasing and complex in nature. Arguably, it could be said that the ability of a development to meet human needs both of the present and of the future does not lie with resources availability, but it is as a

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result of the shortcoming of human decision making. To develop sustainably, human needs must be top most within the Earth's environmental limits. Implying that sustainable development must not endanger the natural systems, that is supporting life on earth. This system are, water, atmosphere, and the soil. In the context of the build environment, it suggests, that sustainable development of the build space starts from the design of facilities. The concept of sustainable development should be integrated in the design right through the life cycle of a building. The construction phase should incorporate the principles of sustainable construction. The use phase, which is the most important phase, because it is at this stage that the natural resources, such as water, air and the need for light is being utilised. The phase of demolition should allow for the use of some components of the building, such as, the bricks, roofing materials, and so on.

Sustainable development affords reduction in exploitation of resources and improved technologies. This has led to the use of low energy appliances and machines, electrical fittings, and so on. This invariably has resulted in low cost of living, due to low energy consumption. The usage of low energy appliances has reduced accident risk and accident occurrences in firm, off fatality and death. It has also lead to the reduction in the emission of CO_2 that leads to global warming with its associated problems, and has foster international economic relations.

According to Dutil *et al.* (2011), in order to mitigate climate change, CO_2 emission must be reduced by 50% of the current level by 2050. To achieve this target, there ought to be criteria set from now to be followed, for realising this goal. It is based on this, that the study is initiated to assess the current situation, principles and policies promoted to achieve this goal in South Africa.

LITERATURE REVIEW

Fundamental principles of sustainability

There are principles which stipulates the practice of sustainability (Waas *et al.,* 2011); (Gibson 2000), and (Gibson *et al.,* 2005), they are:

- The normativity principle, which defines the kind of world we want to live in and would want to leave a legacy for future generations.
- The equity principle (or justice/fairness), a central principle of sustainable development, and can be subdivided into inter-generational equity, intra-generational equity, geographical equity, procedural equity, interspecies equity.
    - Inter-generational equity – is on the long term of furity aspects of sustainability. The concept is aimed at meeting present human needs and aspiration and right of future generations to meet their needs and aspiration, as we depend on natural resources to meet our needs and aspirations.
    - Intra-generational equity – refers to the right of every human being and the present to a decent quality of life.
    - Geographical equity or global responsibility refers to the need for cooperation worldwide that from the local to the global level responsibility must be taken to tackling sustainability issues.
    - Procedural equity – refers to democratic and participatory governance systems and decision making in tackling sustainability issues.
    - Interspecies equity – stands for the right that other species have equal rights as human beings for survival.

- Integration concept of sustainable development – that various tradition (socio-economic and institutional) should be integrated for sustainability.
- The dynamism principle – deals on directed- sustainability oriented – change and not a defined end-state. This implies that the society, environment and their interactions are subject to a continuous flow of change. Sustainable development is as on-going evolutionary process

Factors for consideration for passive design

In order to deal with the problem of climate change, and design enhancing sustainable development, the fundamental principles of sustainability must be incorporated in design. It can be argued that in dealing with problems of climatic change. It should begin with changes in our way of design to uphold sustainability. There are factors that must be considered for sustainable design. Several authors, Fiocchi *et al.* (2011) and Kientzel and Kok (2011) identify factors or parameters that should be considered during the process of designing sustainable infrastructure. Smart Living Handbook (2011) state that 70% reduction can be achieved of total household energy needs by means of simple design principles that reduce lighting, heating and cooling needs. This is known as passive solar design. Bearing in mind that natural resources are limited and the demand and human population is on the increase. They are: orientation of the building, skylight incorporation in design, and slope of sky light facing the north, type of flooring material, specification of insulation in walls, ceiling and roof, specification of bricks for walls in design, type of roof materials, well ventilated spaces, incorporation in design low electrical energy devices e.g water heaters, low energy efficient bulbs, design for solar (photovoltaic) panels on top of the roof to provide electricity to run low energy consumption appliances and design for reuse of waste water, rain water collection for use, and switching to green electrification of the building electrical system.

Factors influencing an organisations use of green design practices and procedures

There are factors that compel organisations to engage in green design practices (Rosen, 2013). These factors range from governmental and organisational policies, to clients demands. In the overall, the aim is to achieve a sustainable build environment, implying normal impact on natural resources, while putting into consideration the use of natural resource by future generations in not compromising their rights to the availability of these resources. These factors are, regulatory requirements, client demand, rising energy cost, ability to gain a market advantage, long-term returns on investment, personal sense of environmental responsibility, government/industry incentives, and none of the above.

Challenges of Sustainable Designs

Every system has its challenges in the running of it. There are challenges associated to sustainable design (Rosen, 2013). These include, economic cost, competitiveness, market forces and customer demand, corporate culture and commitment, inadequate incentives from government, short term focus relative to benefits, confidentiality, regulations and laws, lack of codes and standards for sustainable designs, and lack of laws to enhance the practice of sustainable design.

RESEARCH METHOD

Two methods were used in the study for data gathering, the questionnaire survey and case study. Regarding the questionnaire survey, a total of 55 questionnaires were administered and 13 were returned completed and included in the analysis of the data, which equates to a 23.6% response rate. The sample consisted of Architects mainly. The questionnaire was administered through the e-mail and retrieved through the same. The South African Institute of Architects Bloemfontein branch assisted in the distribution to their members. Based on the sample size which is below 100, the entire sample was surveyed. For the case study a check list was used to assess level of incorporation of passive design on building structures.

A brief description of the characteristics of the respondents surveyed is given as follow. Based on the academic and professional qualifications, years of experience and number of projects handled by the respondents, it can be inferred that the data obtained from the respondents can deemed reliable. 54% of the respondents were involved in private practice, and 46% in the public sector. Architects only were surveyed in terms of discipline. The average years of respondents experience is 14 years, and the average years of organisation existence is 32 years. Respondents within the years of 41-50 predominate (46.2%), next is 31-40 years age bracket (30.8%), and next is 26-30 years age bracket (15.4%) and over 50 years 7.6%. MSc / MTech level (61.5%) qualifications predominate in terms of qualifications followed by Honours (23.1%), and BSc (15.4%). Respondents have undertaken various types of projects: 84.6% of had undertaken residential projects, 69.2% of had undertaken commercial – office projects, 53.9% of had undertaken commercial - retail projects, 46.2% of had undertaken commercial - recreational projects, 30.8% of had undertaken hotel/motel projects, 23.1% of had undertaken parking garage projects, 58.9% of had undertaken industrial projects, 69.2% of had undertaken institutional - education projects, 23.1% of had undertaken institutional – health projects, and 38.5% of had undertaken institutional – other types of projects.

Data Presentation and Discussion of Results

This section is on data presentation and discussion of results. Table 1 presents extent of incorporation in design the principles of passive design, in terms of a mean score ranging between 1.00 and 5.00, based upon percentage response to a scale of 1(Minor) to 5(major). It is notable that 10/14 (71.4%) of the factors have MSs >2.5, which indicates that the factors have major influence on respondents design. The factor with the most influence is orientation of the longest side of the building to face the North (MS = 4.6). This is observed in order to allow into the building light and sunshine to lighten up the rooms and for sunshine to warm it, thereby reducing cost of keeping the building warm at cold season.

Next is specification of installation of ceiling insulating fibre (MS = 4.5). Ceiling insulation reduces the rate of escape of heat from building, resulting in energy saving relative to keeping the building warm using electricity. Next to installation of ceiling insulating fibre is ensuring of suitable ventilation for fresh air and cold breezes (MS = 4.4). Aeration of the building is important to prevent dampness and allow the diffusion of bad air from the building. Materials used for openings should be those that can prevent heat losses. Next to ensuring suitable ventilation for fresh air and cold breezes is specification of the insulation of walls in design (MS = 3.9). This is in an attempt to reduce heat losses from buildings particularly through walls. It is worth noting, that the difference in MSs between the first, second, third and fourth factors with the most influence relative to designing passive is 0.7, which is not significantly high. It can be inferred that these factors have major influence relative to Architects designing passive buildings.

Table 1: Extent incorporation in design the principles of passive design

Principles	Mean score	Rank
Orientation of the longest side of the building to face the North	4.6	1
The specification of installation of ceiling insulation fibre	4.5	2
Ensuring of suitable ventilation for fresh air & cool breezes	4.4	3
Specification of the insulation walls in design	3.9	4
Specifying in design low energy efficient bulbs	3.3	5
Floor design to be brick or concrete	3.2	6
Incorporation in design the channelisation of waste water and rain water for garden usage	3.0	7
Incorporation of option to switch to green electricity in the electrification of development	2.9	8
The specification of roof tiles (Clay) as roof covering / insulation of deep roofs	2.8	9
Incorporating in design solar water heater	2.8	9
Incorporation of skylight in design	2.3	11
Slope of skylight faces the North	2.3	11
Incorporation in design solar (photovoltaic) panels on roof tops for electricity generation to run low power consumption appliances	2.2	13
The specification of mud bricks instead of the conventional sharp sand or stone dust block for walls	1.9	14

The least factor that influence passive designing is specification of mud bricks instead of the conventional sharp sand or stone dust block walls (MS = 1.9). Although, mud bricks are excellent in preventing heat losses, it is considered no fashionable. Next to this factor is incorporation in design solar (photovoltaic) panels on roof top to run low power consumption appliances. The likely reason for this is based on low demand by clients and initial high capital installation cost.

Table 2 reveals the respondents rating of the factors that enhance the design and production of green environment, in terms of MS ranging between 1.00 and 5.00, based upon percentage responses to a scale of 1 (Minor) to 5 (Major). Personal sense of environmental responsibility (MS = 4.4) is the most factor that enhance the design and production of green environment. Resources are limited and the rate of their depletion should allow for future generation usage, this should reflect on designs. Next is rising energy costs (MS = 4.0). Rising energy cost has led to the development of alternative sources of energy with reference to renewable energy. This will afford the non-compromising of future generations usage of the limited resources. Long-term return on investment (MS = 3.3) is third in rating.

Table 2: Factors to enhance the design and production of green environment

Factors	**Mean score**	**Rank**
Personal sense of environmental responsibility	4.4	1
Rising energy costs	4.0	2
Long-term return on investment	3.3	3
Ability to gain market advantage	3.2	4
Regulation requirements	3.0	5
Client demand	2.9	6
Government / industry incentives	2.5	7
None of the above	1.2	8

The concept of green environment is new and clients are just beginning to enjoy the benefits that accrue from it. Greater awareness of the long-term benefits of low maintenance cost and high saving cost of a green environment will lead to higher demand of clients for green environment. Next to long-term return on investment is ability to gain market advantage (MS = 3.2). It is not all clients that are aware of the importance of green environment. The concept is new and just gaining increasing awareness. This influence the design and production of green environment. It is notable that all the factors that enhance the design and production of green environment except one, that have MSs equal to or >2.5, which suggest that with greater awareness our environment could be green in no distant time.

Table 3 presents the respondents perception with respect to the barriers and challenges to sustainable designs in terms of MS ranging between 1.00 and 5.00, based upon percentages responses to a scale of 1(Minor) to 5(Major). Economic cost (MS = 4.1) rated the main barrier and challenge to sustainable design. Client's consideration of the initial high installing cost of the various insulating materials and equipment for renewable energy, and lack of experts for maintenance of alternative sources devices. Next to economic cost is corporate culture and commitment (MS = 3.5). Organisation's believes and commitment could be a barrier to the promotion of sustainable designs. Organisations that are not committed to sustainable infrastructure designs are inclined towards active design. Based on this, there will be little done to promote sustainable designs.

Table 3: Barriers and challenges to sustainable designs

Barriers and challenges	**Mean score**	**Rank**
Economic cost	4.1	1
Corporate culture and commitment	3.5	2
Competitiveness	3.3	3
Market forces and customer demand	2.9	4
Lack of laws to enhance the practice of sustainable designs	2.9	4
Regulations and laws (policies to favour sustainability)	2.8	6
Lack of codes and standards for sustainable designs	2.6	7
Inadequate incentives from the government	2.3	8
Short term focus relative to benefits	2.1	9
Confidentiality (the hindering of sharing of knowledge to promote sustainable practices)	1.5	10

Next is competitiveness (MS = 3.3). Patronage with respect to sustainable design may greatly influence designer (Architects) regarding sustainable design. A low patronage could be a barrier to sustainable designing. The least factor relative to barriers and challenges to sustainable design is confidentiality (the hindering of sharing of knowledge to promote sustainable practice) (MS = 1.9). The fear of losing market (patronage) is not the reason for not sharing knowledge among designer about green designs. These suggest that the level of awareness of the public to green building may be one of the reasons for its low demand and practice.

Comparison of Factors Influencing Design (principles of passive design) with Factors that Enhance the Design and Production of Green Environment

From Table 1, it can be observed that the factors ranked into the 1-3 places are factors having relation to the methods of prevention of heat losses and the factors ranked into the 2 and 3 place on Table 2 are factors having relation also with methods of prevention of heat losses from a building, and this factors can only be in place via finance. Therefore, it can be inferred that the low practice of passive design and green environment is traceable to high cost. The initial installation cost may be high, but it does have long-term benefits.

Project Case Studies

Three main structures of the Central University of Technology, Free State were used for the case study. They are, ZR Mahabane, Faculty of Engineering and Information Technology (PHB Billiton Building), and the main Library. The criteria used for assessing the structures with respect to reduction of energy needs in structure are those listed on Table 1.

ZR Mahabane structure

The structure is I shaped. The longest side of it is oriented along the East-West axis that is the longest side is facing the North. The northern side of structure receives the most sun; this will afford the structure to be warm by sunlight. Based on the orientation of the structure, it can be deemed suitable for ventilation as the windows are positioned along the Northern and Southern faces. There are no window shutters incorporated on the windows, to keep the hot sun rays out during summer. There is no skylight provision in the roof. This suggests reliance on artificial lightening. The floor of this structure is made of concrete. It has the property of absorbing heat during the day from the sunlight and slowly reducing it at night, which will reduce the amount of artificial energy required to warm the structure. The walls of the structure are not insulated, which means that heat will quickly escape from the structure. The ceilings are made of gypsum board that has poor capacity for prevention of heat losses and gains. There are no solar (photovoltaic) panels installed on the structure to run low energy consumption appliances. Relative to re-use of water and harvesting of rain water, there are no provision for them on the structure; the same applies to switching to green electricity. There are thirteen factors that were used to assess the extent of energy efficiency of these structures. It was observed that, only four of these factors are incorporated in design and on this structure, which equates 4/13 X 70% = 21.5% of the 70% energy efficiency reduction level is achieved regarding this structure.

Faculty of Engineering and Information Technology Structure

The longest side of this structure is oriented along the East-West axis that is towards the North. This allows most part to receive sunshine, thereby keeping the structure warm. The windows on the structure are positioned on the Northern and Southern part with respect to orientation allowing West-East movement of air resulting in cross ventilation. Shutters are not incorporated on windows to keep hot sun rays away during summer. There are no provisions of skylight on the structure to reduce the use of artificial lighting. Floors are made of concrete which have good heat absorption property and slowly releasing it at night, hence keeping the structure warm reasonably. The walls of the structure are not insulated to reduce heat losses. This practice is only common at the coastal regions of the country. Generally, Gypsun ceiling boards are used. It has poor capacity for prevention of heat. There is no solar water heater installed in this structure, meaning that dependency will be high on artificial supply of electricity. This will increase energy cost. The same applies to the issue of provision of solar panels to run low electricity consumption appliances. Used water from this structure are not redirected for small scale agricultural purposes neither is rain water harvested to reduce usage of pipe borne waste and corresponding cost. Currently, there is no provision for switching to green electricity for use on the structure.

Main Library

The library is 'L' shaped, part of the structure is oriented towards the North and the other part towards the West or East. The part oriented towards the North receives sun rays to warm it up, implying much saving on provision of artificial electricity. While, the part oriented towards the West or East is disadvantaged. The part oriented towards the North has windows positioned along the North and South sides, allowing cross ventilation and sunlight during the day. The part oriented towards the West or East is disadvantaged with respect to the above. There are no provisions for skylight in this structure, implying heavy reliance on artificial lighting. Floors are made of concrete, which will keep the structure warm as sunrays are received and slowly releasing it at night. The walls are not insulated regarding prevention of heat losses. Heat will escape from the structure quickly as a result of this. It is noted that this structures have the same kind of ceiling materials. There is no installation of the following on the structure, solar water heater, solar panels to run low energy consuming appliances, the idea of reusing of water is not incorporated in design, nor harvesting of rain water, and there is no provision to switch to green electricity. These suggest heavy reliance on artificial supply of electricity and waste of water.

In summary, the three structures assessed are within the same locality, it can be inferred, that the principle of design applied on these structures are the same and not of passive design. Therefore, the same results were obtained of the factors used to assess the structures, Based on the earlier calculation, only 21.5% energy reduction of the 70% that can be achieved if the principles of passive design were employed at the design stages of these structures.

CONCLUSIONS AND RECOMMENDATIONS

There is low consideration of replacing high electricity consumption appliances to renewable sources of energy for powering these appliances/devices when designing. This is with respect to solar water heater for reduction in running cost. There is also low consideration for incorporation in building skylight and the specification of mud bricks for walls, which has excellent property regarding heat losses and gain. Personal sense of environmental responsibility and rising energy cost are the factors enhancing then design and production of green environment. Initial high economic cost of incorporation of renewable energy source is the main barrier to sustainable design. The lack of commitment by designers to production of sustainable design stands as a challenge to sustainable development. Assessment revealed that the infrastructure on Central University of Technology, Free State used as case study attained to 21.5% of the 70% of energy reduction that could be achieved employing passive design principles to procuring them.

With reference to the conclusions reached based on data analysis, the following recommendations were made:

- Designers should at all stages of design consider designing passive relative to incorporation of solar water heater, provision of skylight and insulation of ceiling and walls to mitigate high energy cost.
- Awareness should be increased of our environmental responsibilities by government and the industry. In order not to compromise future use and exploring renewable energy sources.
- Awareness should be increased of the benefits (long and short term) of renewable energy device incorporation in infrastructure by both the government and the private sector to mitigate rising economic cost relative energy use and lack of commitment by designers for passive designs.

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GREEN SUPPLY CHAIN MANAGEMENT IN DEVELOPING COUNTRIES

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Abstract:
The concept of Green Supply Chain Management (GSCM) is new and a promising paradigm shift in promoting environmental sustainability. Although supply chain management as a whole is a well-known process associated with most industries, the concept of going green in supply chain management is somehow new to the business world, corporate, and construction firms. As of today, literature documents are very few on GSCM. In most corporate, construction firms and businesses the emphasis now is to raise environmentally responsible consumption and production with a view of promoting environmental quality, reduce poverty and bring about economic growth, with additional improvements in health, working conditions, and sustainability. Green Supply Chain Management (GSCM) is an environmental management tool which integrates environmental thinking into supply chain management. It has gained prominence among academics and practitioners. The aim of this paper is to briefly review the recent literatures on GSCM and also to determine the new direction of this emerging field. The review focuses on gaining understanding on different GSCM practices in developing countries. It includes literature which is relevant to environmental and social sustainability in construction management practices found in the developing countries.

Keywords: Construction Industry, Developing Country, Supply Chain Management, Sustainability

INTRODUCTION

In recent time, most organizations are going green in their businesses as concerns to environmental sustainability. They must portray the environmentally friendly image of products, processes, systems and technologies (Vachon and Klassen, 2006). Environmental impact occurs at all stages of a product life cycle from resource extraction to manufacture, use, reuse, recycle and disposal (Zhu *et al*., 2007).

The increase of industrialization and globalization in developing countries creates more opportunities for manufacturing industries but concurrently increases environmental burden (Rao, 2002). The current changes in environmental requirements that influenced manufacturing activities have increased attention in developing Environmental Management (EM) strategies for the supply chain.

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Thus, the concept of GSCM arises as a new systematic approach and becoming an important factor for business activities today. Zhu *et al.* (2007) pointed GSCM as an environmental innovation. By integrating the green concepts to the supply chain concepts, whereby the supply chain will have a direct relation to the environment. Green Supply Chain Management (GSCM) emerges as a new systematic environmental approach in supply chain management and has been increasingly accepted and practiced by forward thinking organization. In most business and construction firms, the emphasis now is to raise environmental quality, reduce poverty and bring about economic growth with additional improvements in health, working conditions, and sustainability. The purpose of this paper is to review some of the green supply chain management practices, adoption and implementation in developing countries.

Research Framework

The research framework is presented in Figure 1. The research framework for this study will commence from the history and evolution of green supply chain management to extend the study about GSCM in more depth, to GSCM practice in developing countries, then narrow down to South Africa and a direction for research will be ascertained.

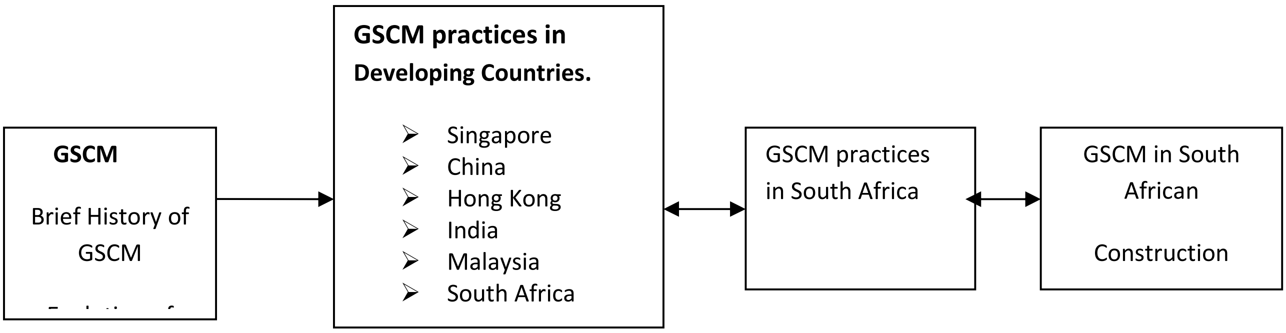

Figure 1: Research framework

HISTORY OF GREEN SUPPLY CHAIN MANAGEMENT

Managing supply chains gained notoriety in practice as evidenced by management and engineering literature in the early 20th century (Svensson, 2001). Some of the initial best practices of modern supply chains, such as lean and just-in-time (JIT) manufacturing can be traced to Henry Ford's efforts to vertically integrate the automotive supply chain and organizational practices. The concept of JIT and SCM at that time focused on enhancing operational efficiency and minimizing waste (Bornholt, 1913; Faurote, 1928). The purpose of the minimization of waste was not for environmental, but economic reasons. Waste means greater economic loss (Lai and Cheng, 2009). During these early periods, industrial pollution was not a major topic of investigation for management or economics scholars. In economics, the use of taxes for managing externalities such as industrial pollution was proposed (Pigou, 1920). However, the debate of taxing for environmental pollution caused by industrial activities was essentially the limit of the discussion at the time. Philosophical developments during this period were occurring with discussion on whether the natural environment deserved its own rights and had its own intrinsic value (Leopold, 1933).

Some of the earliest work that can be tied to today's greening of the supply chain, occurring even before the formation of the United States Environmental Protection Agency, can be traced to Ayres and Kneese (1969). This work presented some of the earliest issues related to reconciling industrial metabolism and material balancing as well as the roles of production and consumption in the supply chain. Although, their work focused on a linear relationship from extraction to disposal, some loops were incorporated into the evaluation and there were concerns about the possibility of integrating 'residuals' back into the system. Interestingly, not only were solid and water pollution waste included in the discussion, but warnings of global climate change due to carbon and other greenhouse gas emissions was also prevalent in the argumentation on evaluating the roles of inter-organizational relationships. Further refinement of the industrial metabolism and material flow balance ideas occurred throughout the 1970's (Ayres, 1978).

Discussion on how to utilize the mass balance for organizational and governmental decision making was also introduced in the early 1970's through "a process-chain evaluation model estimates the cumulative costs (direct and hidden) of various processes or steps that form 'chains' leading from a set of raw material inputs to a marketable output such as semi-finished or consumer products" (Stern *et al.*, 1973). Also, concurrently, the further refinement of the industrial eco-systems philosophy (Jelinski *et al.*, 1992) and further acknowledgement of the supply chain concept as a strategic competitive weapon was occurring (Bhote, 1989).

Evolution of Green Supply Chain Management

The environmental movement in the United States was catalysed in the late 1960s due to the increased consumer concern about degradation resulting in the formation of the environmental protection Agency in the early 1970s, with the directives of enforcing regulations covering industrial manufacturing of all firms along supply chain (Sarkis, 2012). These resulted in an increasing need for the application of environmentally-sound decisions in supply chain management (SCM), shifting planning from reactive to proactive. Consequently, environmental performance standards have become increasingly incorporated into contracts guidelines for supply chain partners (Simpson and Samson, 2007). A firm's response to the environmental requirements of external stakeholders is directly influenced by their level of commitment related to both environmental awareness and performance. In such environmentally – based scenarios the supplier customer relationship is impacted by both existing transaction cost requirements as well as environmental commitment of both entities. Responding to growing needs for environmental compliance, GSCM evolved, reflecting an integration of environmental thinking. GSCM entails a comprehensive perspective, including product design, material sourcing and selection, manufacturing processes, delivery of final products to the consumers, as well as end-of-life management of the products (Strivastava, 2007). According to the Strivastava and Lu *et al.*, 2007, GSCM is growing in importance and driven by increasing environmental degradation, diminishing natural resources and rising pollution level.

GREEN BUILDINGS

In most countries, buildings are the largest driver for both energy use and CO2 emissions. Europe's buildings use over 40%, the continent's energy and are responsible for 40% of its carbon emissions (BPIE, 2011). Among developing countries, the share of the building in total energy use and emissions is much lower with china buildings for example, representing a 10% share of that nation's energy use. But rapid economic growth and industrialization in these countries is pushing a booming construction sector. As a result, by 2030, Asian countries are expected to contribute a third of worldwide GHG emissions. Consequently, the challenge to reduce the energy and GHG footprint of new existing buildings is a very serious one.

Sustainability management in buildings consist of construction, lifetime use and decommissioning. Throughout these stages, the main objective is to be efficient in the use of resources of the occupants' health and well-being and reducing the negative impacts, such as waste and pollution.

ROLE OF SCM TO THE CLIENT

SCM is a philosophy that describes how companies should manage their supply chains to achieve strategic competitive advantages. Its objective is to synchronize the client requirements with the materials and information flows along the supply chain, until reaching a balance between client satisfaction and cost. It refers to the coordination of the activities of all the participants of the supply chain, to knowing the production requirements with the purpose of satisfying the client, to delivering products of higher value and to reducing the cost of the firm that apply these principles (Serpell and Heredia, 2006).

Though the construction process is different from production processes in factories, SCM can be useful and effective in construction (O'Brien, 1999). When working effectively and efficiently modern supply chains allow goods to be produced and delivered in the right quantities, to the right places, at the right time and in a cost effective manner (Christopher and Peck, 2004).

PAST RESEARCH ON GSCM IN DEVELOPING COUNTRIES

According to the United Nations (UN), a developing country is a country with a relatively low standard of living, undeveloped industrial base, and moderate to low Human Development Index (HDI) (Education pathways international, 2010). Several studies have been conducted on GSCM in developing countries. Some of the studies will be reviewed in this section.

Lee (1994) undertook an audit of practices on construction sites in Singapore, to assess the use of Environmental Management System (EMS), approaches towards energy conservation, and the use of `harmful or non-recyclable materials. She found that a high level of awareness of, and commitment of contractors to the need to protect the environment. She found that inefficiencies in the usage of materials were common, leading to high wastage levels, even on sites run by construction firms implementing ISO 9002 in which materials management is enshrined. She suggested that the government should provide leadership by increasing awareness of environmental protection as it had done for quality, and encouraging firms to adopt elective materials management and utilize the ISO 14000 EMS. Her suggested measures include education to enhance environmental awareness at all levels; introduction of voluntary standards; offering of financial incentives; demonstration projects on sustainable buildings; a product certification scheme for building materials, and eco-labelling; encouraging innovative technology; and developing a building assessment system for Singapore.

Zhu and Sarkis (2004) in their study on Chinese manufacturing industry discovered the following:

- GSCM practices tended to have win-win relationship in terms of environmental and economic performance.
- Quality management was a positive moderator in that quality programs along with GSCM practices performed better especially with respect to external GSCM and internal management programs, organizations seriously considering implementing GSCM practices could benefit greatly with introduction of quality management practices.
- JIT programs with internal environment management practices may cause further degradation of environmental performance and came from environmental perspectives, care should be taken when implementing GSCM programmes in manufacturing organization with JIT philosophies in place.

Ofori (2000) in his study on greening the construction in Singapore concluded that SCM should be implemented in the Singapore construction industry, embracing all the parties involved in a project to realize its full potential. Environmental purchasing should be an integral element of the form of SCM which is applied in Singapore.

Eleven barriers to implement GSCM in Indian automobile industry were identified by Luthra *et al*. (2011). Market Competition and Uncertainty; Lack of Implementing Green Practices; Cost Implications; Unawareness of Customers and Supplier Reluctance to Change Towards GSCM was identified as dependent variables. Lack of Government Support Systems; Lack of Top Management Commitment and Lack of IT Implementation have been identified as the driver variables. Resistance to Technology Advancement Adoption; Lack of Organization Encouragement and Poor Quality of Human Resources have been identified as the linkage variables. No barrier has been identified as autonomous variable. Market competition and uncertainty; lack of implementing green practices; cost implications; unawareness of customers have been identified as top level barriers and lack of government support systems as most important bottom level barrier. Removal of these barriers will help in implementing GSCM in Indian automobile industry.

Zhu in 2006 studied GSCM: pressures, practices and performance within the Chinese automobile industry in which they observed that increasing pressures from a variety of directions have caused the Chinese automobile supply chain managers to consider and initiate implementation of GSCM practices to improve both their economic and environmental performance. Expanding on some earlier work investigating general GSCM practices in China, authors explores the GSCM pressures / drivers (motivators), initiatives and performance of the automotive supply chain using an empirical analysis of 89 automotive enterprises within China.

Hsu in 2008 studied the green supply chain management in the electronic industry in which they mentioned that there are various approaches for implementing green supply chain management practices that has been proposed and recognized in previous literatures. According to the author, there is yet no investigation that identified the reliability and validity of such approaches particularly in the electronic industry. The author employed the fuzzy analytic hierarchy process method to prioritize the relative importance of four dimensions and twenty approaches among nine enterprises in the electronic industry. The findings indicate that these enterprises would emphasize on supplier management performance in the crucial role of implementing green supply chain management.

Zhou in 2009 study on the implementation of GSCM in textile enterprises in which according to the author, the green supply chain management is a sort of modern management mode which could comprehensively consider the environmental influence and resource utilization efficiency in the whole supply chain. In another study, Ninlawan *et al*. (2010) worked on the implementation of green supply chain management practices in electronics industry in which they aimed to survey current green activities in computer parts' manufacturers in Thailand to evaluate green supply chain management and they conducted survey on current green activities in computer parts' manufacturers in Thailand, 11 manufacturers were used as case studies who provided in depth responses to the interviews about green procurement, green manufacturing, green distribution, and / or reverse logistics. To evaluate green supply chain management, the questionnaire related to investigate the GSCM practices, measure GSCM performance, and explore GSCM pressure / driver within the Thai electronics industry was used to obtain the survey results. Also Seman *et al*. (2012) in their study concluded that there are still little research about GSCM implementation and adoption in developing countries especially Malaysia and recommended further study for more understanding toward the adoption and implementation of GSCM and also the organization awareness level on environmental problems that are caused by their business operations.

Zelani *et al*. (2012) results proved that sustainable supply chain management practices have a positive effect on sustainable supply chain performance, particularly from the economic and social perspective. Firms need to collaborate in advocating sustainable supply chain management practices as a route for firm's commercial success rather than as a moral obligation. Also, Wu *et al*. (2010) findings revealed that firm should realize the effect of short term costs and benefits on knowledge transfer in order to enhance green management performance.

REVIEW ON GSCM PRACTICES IN SOUTH AFRICA

South Africa's logistics sector has much to contribute as the country focuses more internally on issues of sustainability. Supply chains hold substantial potential to contribute to the achievement of vision 2025 which aims to improve South Africa energy mix by having 30 percentage of clean energy by 2025 (Annual Performance plan 2012 / 2013). The case study on Green Supply Chains is highly attractive, by addressing the problem of Carbon emission and environmental pollution; companies not only limit carbon footprint and waste, but strive to optimise supply chain performance.

The country's top green organisations and individuals were honoured for their committed efforts at the 4th annual Green Supply Chain Awards – the only awards in South Africa dedicated to greening the supply chain. It's a joint initiative of the Chartered Institute of Logistics and Transport: South Africa (CILTSA) and the Consumer Goods Council of South Africa (CGCSA). Presently GSCM practices are adopted in Transport, automobile and Consumer goods in South Africa (Ittman and King, 2010).

Woolworths, for example are offering environmentally-friendly products, and are charging premium prices for them. They are also able to charge higher prices for organic food, since people are willing to pay for organically grown food. Sustainability can offer a company a distinct competitive advantage. Creating a sustainable supply chain creates an opportunity to save a lot of money that would have been spent on disposing of waste materials and harmful by-products. It decreases the amount spent on scrap by making money out of it, and not having to waste resources spent on obeying regulations. Companies have begun to generate money from the by-products they used to throw out. They use sustainability as a tool to increase their competitive advantage (Mazumder, 2010).

FINDINGS AND DISCUSSION

The findings from this study revealed that GSCM is now gaining momentum in developing countries. Although, GSCM approaches are still relatively new in developing countries, it has been implemented in manufacturing firms and few construction firms. The findings revealed that not much literature are available in GSCM of the construction industry, but there are several literature review in manufacturing firms, the strategy used can be adopted to get results in construction firms. Also, the author identified that GSCM is not new in transport and food industry in South Africa, but the practice is relatively young in South African construction firms.

CONCLUSIONS AND FURTHER RESEARCH

This paper looked at the genesis of GSCM, how it began and transcended to developing countries. It was found that GSCM is mostly practiced in manufacturing industries and few in the construction industries. GSCM has been tested in some developing countries like Singapore, India, China, Hong Kong, Malaysia and South Africa. However, construction companies in South Africa are still chasing behind in the adoption of Green Supply Chain Management (GSCM). In conclusion, this has given a path for adoption of GSCM in South Africa construction industry because GSCM is a process of using environmentally friendly inputs and transforming these inputs into outputs that can be reclaimed and re-used at the end of life cycle thus creating a sustainable supply chain. As a well-known fact, materials are made from nature, thus needs to be 'environmentally friendly'. Hence, there is a need for campaign awareness in the construction industry, which is a major issue the authors are addressing in their current research study.

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PSYCHOTHERAPEUTIC AND TEAM BUILDING INITIATIVE OF GREENING CONSTRUCTION SITES – THE CASE STUDY OF AN 'OASIS IN THE DESERT'

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Abstract:

The temporary nature of the contract, uncertainties and the inherent danger involved in construction work, extremities of temperatures, and the lack of natural synthesis and the symbiotic support of natural ecosystem or healing contact with nature, are psychotraumatic factors on construction sites. These issues exacerbate the stress of the constant threat that fatalities and injuries have on the health, well-being and performance of workers. The psychosocial stress inherent in these factors in turn presents an unavoidable challenge to effective communication and beneficial interaction among construction workers that could compromise health and safety (H&S) issues. A therapeutic and beneficent biophilic workplace environment could be a necessary catharsis for sustainable and spontaneous interaction that could spur community and team building initiatives with a significant impact on improved performance and productivity of workers on the project. The case study of a psychotherapeutic garden design on a construction site in the Northern Cape Province of South Africa exemplifies these findings. An exploratory field survey conducted on the site includes a focus group study of both workers and management regarding the 'green' initiative on the construction site aptly dubbed 'an oasis in the desert'. Deductions from the findings indicate that the originality of the innovative strategy of a biophilic workplace design adds value to ergonomics for human factors and sustainable sites initiative in construction and enhances communication, interpersonal relationship, and team building initiatives.

Keywords: Biophilic design, Communication, Construction performance, Team building, Health and well-being

INTRODUCTION

Literature exposes the construction workplace as an environment in dire need of the psychotherapeutic intervention of a biophilic design concept (Smallwood, 2003; 2006). The range of psychosocial risk factors involved in construction work begins with the disregard of the psychosocial value and natural aspects of the workplace environment (GSA, 2003; Heerwagen, 2006; EU-OSHA, 2012). The blatant disregard for the aesthetics and social benefit of human interaction with nature on construction sites could have untold emotional impact on the health, wellbeing and performance of workers (GSA, 2003; Heerwagen, 2006; Miyake, 2003). The inherent danger and demand of construction work could be likened to the stress of hospital and health facilities with the constant background threat of fatal consequences that could be a

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constant source of irritability and nervous reactions (Berman *et al.,* 2008; Prins *et al.,* 2011). The mood thus generated could be dampening on the ability of employees to communicate effectively, interact and socialise with one another (Kellert, 2005; Heerwagen, 2006; Prins *et al.,* 2011; Kim *et al.,* 2012). By implication, communication becomes a severe challenge that could compromise mutual trust and understanding among workers (King, 2000; Bartlett, 2011; Kim *et al.,* 2012). According to research findings the hospital and health facilities have long since adopted the biophilic design concept of incorporating therapeutic garden designs in various forms within and around its facilities with proven benefit overtime (Kellert, 2005; Heerwagen, 2006; Berman *et al.*, 2008). The question is: could therapeutic garden design have the same sustainable impact on construction sites? If so, how could it be effectively implemented and sustained?

The objective of the study is to determine the impact of a green construction site on the health, wellbeing communication and team building initiative of employees in construction. The objective envisions a construction workplace environment that is healthy and spiritually conducive to effective communication, beneficial interpersonal relationships, community, and team building initiatives which could be of mutual benefit to H&S, performance, and well-being issues in construction. It represents an effort that employs the proven benefit of the Biophilic Construction Site Model (BCSM) (Smallwood 2003; 2006; Obiozo, 2012; Obiozo & Smallwood, 2012; 2013; Smallwood & Obiozo, 2013). The methodology involves a survey of an existing construction site in the Northern Cape Region of South Africa that includes a focus group study of both management and workers. It involves an exploratory study of the innovative H&S strategy of 'greening construction sites' that is spontaneously implemented in the construction workplace as a form of psychotherapeutic measure by the H&S management team. Findings expose the beneficial and interactive nature of a communicative and aesthetic biophilic construction workplace environment derived from nature towards enhanced health, performance and wellbeing of all stakeholders in construction. The BCSM is hereby considered a silent team mate that binds, sustains and supports communication, relationship building blocks and the H&S strategy in construction. This research therefore proposes the procurement and provision for the BCSM in construction workplace designs and tender bids as a cost effective team building initiative and environmental sustenance factor in construction projects.

The BCSM, Green Performance indicator, Communication, wellbeing and worker performance

The BCSM is a spatial and psychosocial 'green performance' index that involves the greening of construction sites (Bartlett, 2011; Obiozo, 2012; Obiozo & Smallwood, 2012; 2013; Smallwood & Obiozo, 2013). It is a derivative of biophilic workplace design, which is a factor that derives its substance from the theory of biophilia (Kellert & Wilson, 1993; Kellert, 2005; Heerwagen, 2006). Biophilia is a theory that authenticates the symbiosis of ecosystem support and emotional sensitivities that address the innate natural affiliation of humankind to nature and all living organisms (Wilson, 1984). Kellert & Wilson (1993) have developed the biophilia hypothesis in collaboration with findings from a number of researchers across the professions that validate the health, safety, performance, and wellbeing benefits of a restorative natural environment or biophilic environment (Miyake, 2003; GSA, 2003; Berman *et al.,* 2008; Heerwagen, 2006; Dul & Ceylan, 2011). The significance of these findings have shown the necessity of developing a biomemetic interaction with nature in all aspects of human endeavour that could yield a wholesome and all inclusive health, well-being and performance of all stakeholders involved (GSA, 2003; Berman *et al.,* 2008).

Respect, performance and integrity are interactive factors that are the natural consequence of a healthy and safe workplace environment (King, 2000; Prins *et al.,* 2011; Kim *et al.,* 2012). Interaction with nature is a spiritual factor that silently communicates what is needed to heal and soothe frayed nerves, and by so doing, trigger the wellbeing benefits that could ameliorate irritability and restiveness among workers (Cohen 2010, Corbett & Milton 2011). A range of research findings indicate that the restful, aesthetic psychotherapeutic benefits so derived could lead to spontaneous communication and interaction, that would yield mutual trust, fraternity and team work among the workers (GSA, 2003; Heerwagen, 2006; Prins *et al.,* 2011).

Dul & Ceylan (2011) advocate the use of the ecosystem as the interface between technology and the workplace environment in construction. This is regarded as an effort that combines the basic principles of ecology and engineering known as ecological engineering (Mitsch & Jorgensen, 2004). The findings indicate that the result could yield economic benefits derived from the synergy of natural science and ecological design. Through this effort, a life sustaining environment with increased access to open spaces, improved air quality, reduction in the urban heat island (UHI), as well as reduction of waste and increased biodiversity is developed and sustained (Mitsch & Jorgensen, 2004; Petersen & Holness, 2013).

Ergonomics, sustainability and interpersonal relationships in construction

Research findings linked to ergonomics for human factors involving worker health, well-being, and productivity support the findings that satisfaction, retention and productivity in business concerns such as in the construction industry are linked to the physical features of the workplace environment (Haslam & Waterson, 2013; GSA, 2003). An overview of evidence from studies regarding ergonomics approach in sustainable construction workplaces indicate that when a workplace is designed, built and maintained for sustainability less money is needed to accommodate work practices, and organisational change and productivity is also maintained (Haslam & Waterson, 2013; GSA, 2003). Findings from Smallwood (2003; 2006) and Heerwagen (2006) assert that substantial evidence has shown that the benefits of sustainability extend beyond air quality to a wide range of environmental components and features that have functional, psychological and social benefits. Ergonomic discipline focuses on design, technology and management of human compatibility systems which include social networks, communication and interpersonal relationships (Smallwood, 2003; 2006; GSA, 2003; Prins *et al.,* 2011).

Interpersonal relationships are defined as social phenomena formed through interaction between participants and dynamic systems that change over time (Prins *et al.,* 2011). Bar-On & Parker (2000) (cited in Prins *et al.,* 2011) have also defined interpersonal relationships as the ability to establish and maintain mutually satisfying relationships characterised by emotional closeness, intimacy and giving and receiving affection. Research findings indicate that these relationships cannot exist outside of the participants involved, and most importantly, are created, maintained and altered through communication (Sias & Batoo, 2007, cited in Prins *et al.,* 2011).

Interpersonal relationships, team building and green performance indicators in construction

The WHO (2007) defines team building as two or more people working interdependently towards a common goal. The objective could serve as a 'green performance indicator' if given a 'green' incentive as its norm and formative core (Bartlett *et al.,* 2011). It goes further to explain that getting a group of people together does not make a 'team'. A team is seen to develop products that are the result of the team's collective effort which involve synergy; defined as a property where the whole is greater than its parts (WHO, 2007). Team building, thereby, describes a process of gathering the right people and getting them to work together for the benefit of projects such as construction projects. The WHO (2007) determined that a team manager in the construction management team is expected to play a key role in pointing out the right motivational direction to a group of individuals who work as a unit. Findings indicate that an effective team is result-oriented and committed to project objectives, goals, and strategies. A role is a factor described by the WHO (2007) as a unit of defined responsibilities that may be assumed by one or more individuals that constitute a group. The 'norms' guiding a group is regarded as an acceptable standard of behaviour within a group that is shared by group members, which usually indicates the appropriate performance oriented responses and behaviour in any given workplace environment (WHO, 2007; King, 2000; Kim, 2012; Bartlett *et al.,* 2011). One of the most relevant aspects that determine the ability of a team to achieve desired goals is shared vision and goals that are clearly stated. Various research findings (WHO, 2007; King 2000; Kim, 2012; Bartlett *et al.,* 2011) have shown that the goals of a team could be developed through a group process of team interaction and agreement that enables and encourages team members to bond and work effectively in-order to achieve a common objective such as the BCSM.

Communication and developing interpersonal relationships

Bergh (2007, cited in Prins *et al.,* 2011) states that work environments such as the construction workplace comprise a complex system of relationship with the importance of a good relationship clearly self-evident. Effective organisational functioning depends, to a large extent on positive interpersonal relationships between individuals and groups within a group (WHO, 2007, King 2000, Kim *et al.,* 2012, Bartlett, 2011). Prins *et al.* (2011) cite a number of research findings (Bar-On & Parker, 2000; Bergh & Theron, 2007; Prins 2010) as indicating that a favourable emotional climate existing in an organisation would yield the following benefits; high level of job satisfaction; improved work engagement; increased work performance; a positive orientation, and a greater sense of well-being. A durable social network and mutually gratifying relationship enriches lives by offering valuable support (Prins *et al.,* 2011). In a social environment where compassion and assistance is accepted and offered, individuals experience a sense of belonging and stability (Bergh, 2007 cited in Prins *et al.,* 2011).

RESEARCH METHODOLOGY:
Wessel's mine case study – 'Murray and Roberts (M&R) Construction Site'

The research methodology involves a case study and survey of an existing construction site in the Northern Cape Region of South Africa. The applied technique used for data collection and analysis of the case study involved the focus group study of workers and management which included interviews, photographs, and personal observations. The survey was part of a larger study conducted during the hot arid summer season of the Northern Cape region.

Description and background of study

By virtue of its climatic condition and geographical location the construction site is known to be very hot in summer, and extremely cold in winter. Geologically it is very arid and of a semi-desert nature, with more than 21km of sand atop a dense manganese core according to a BHP

Billiton Geological Survey Report for 2013. Wessel's mine is located at a lonely place in Hotazel (Hot as hell) near the Kalahari Desert about 86km and one hour's drive from the nearest town, Kuruman. The 'rose garden courtyard with water fountain' concept was developed as part of the Health, Safety and Environment (HSE) performance enhancing programme for the M&R staff consisting of both management and workers of diverse construction trades.

Description of study population and respondents

The four construction companies involved in the Central Block Project as shown in Table 1 include: M&R Cementation as the main contractor directly involved in the construction of the ventilation shafts and who share the same construction site office premises (CS-1) with the Synntech Project Management (PM) team; Bashewa Construction contracted to build the new ventilation fan substation and Motor Control Centre (MCC) Building that will energise the three ventilation fans for the shaft and share site office premises (CS-2) with Olivier construction involved in the civil works construction. The sample population for CS-1 is 119 and 28 for CS-2. The representation of the target respondents cut across various trades in the construction industry including the management and administrative staff. CS-2 and CS-1are interlinked. CS-1 is located closer to the entrance to the Wessel's mine Central Block Premises such that the staff and management with office premises located at CS-2 have to pass through CS-1 to get to the offices and project site. CS-2 is located next to the project site such that the staff and management with office premises located at CS-1 have to pass by CS-2 to get to the project site or Vent-shaft.

Table 1: Details of number of employees and respondents from each company

<table>
<tr><th>Construction Site</th><th>Construction Company</th><th>Project</th><th>No. of employees</th><th>No. at the time of survey</th><th>No. of respondents</th></tr>
<tr><td rowspan="3">CS-1</td><td>M&R Cementation</td><td>Vent shaft construction</td><td>204</td><td>109</td><td>109</td></tr>
<tr><td>Synntech PM</td><td>Project management</td><td>10</td><td>10</td><td>10</td></tr>
<tr><td>Total</td><td></td><td>214</td><td>119</td><td>119</td></tr>
<tr><td rowspan="3">CS-2</td><td>Bashewa Construction</td><td>Electrical substation and MCC Building</td><td>10</td><td>10</td><td>10</td></tr>
<tr><td>Olivier Construction</td><td>Civil works</td><td>40</td><td>18</td><td>18</td></tr>
<tr><td>Total</td><td></td><td>50</td><td>28</td><td>28</td></tr>
</table>

(Source: Field Survey)

Single Element Study: The Rose Garden Courtyard with the Giant Water Jug Fountain – An 'Oasis in the Desert'

M&R Cementation established a green construction site which includes a 'rose garden courtyard with a water fountain in a giant concrete pot' as its focal point and foundation stone of their Wessel's Mine Construction Site in the latter half of 2008 (Photos 1, 2, 3, and 4). A greening construction site survey was conducted at CS-1 involving a single biophilic element study of the 'rose garden courtyard with water jug fountain' fondly dubbed 'an oasis in the desert' (Photos 1 and 2).

Photos 1, 2, 3, and 4: Rose garden courtyard in its early stages in 2008; its full grown stage in 2013; site entrance location adjacent to the rose garden; view of the construction site through the rose garden courtyard within the site office premises; source: field survey

Photos 5, 6, 7 and 8: The giant water jug fountain in the courtyard before the trees and rose garden were planted in 2008; the nature devoid construction site; the tree planting exercise as an all staff initiative; the green grass verge in the workers' changing room courtyard extension (courtesy of M&R Cementation)

Key Biophilic Design Features – Nature based concept of the BCSM

Four cardinal trees of the Hydrangea Macrophylia specie were originally established as cardinal points in the rose garden courtyard for organisational effectiveness, namely, Tree of Endurance, Tree of Loyalty, Tree of Respect and Tree of Just (Photos 1 and 2). Other trees were subsequently planted at various locations around the courtyard with the original four as focal points on the right side of the entrance to the construction site (Photo 3). The gigantic water jug fountain (Photos 1, 2 and 4), was located in the middle of the courtyard with rose bushes surrounding it signifying life and growth according to research findings (Kellert, 2005; Heerwagen, 2006). As well as being a water feature, it also represents a life like sculpture made out of clay which is of earth material and appeals to the sense of life, order and harmony with nature in accordance with the eco-psychology study of Cohen (2010), nature-psychophysiological study of Miyake (2003), and restorative environment study of Berman *et al.,* (2008). An additional water feature is the water vent located around the garden on the eves of the roofs of the surrounding site office containers, which not only constantly sprays the garden with water, but also humidifies the air. The M&R construction site was initially devoid of natural vegetation and plants (Photos 5 and 6).

RESULTS AND ANALYSIS OF THE FINDINGS

The deductions from observations and interviews with management and workers include the following:

1. *Community building and team spirit:* The planting of the garden was a collective effort of both management and workers from the highest to the lowest cadre across the staff hierarchy as shown in Photo 7. The M&R construction management team admitted that as a result of many years of experience it has identified this all-inclusive strategy as a means of positively

impacting the organisation effectively each time. This signifies the need for staff involvement in-order to achieve a holistic and personalised result (Bartlett, 2011);

2. *Evidence of Wellbeing and psychotherapeutic benefits:* According to the team; the rose garden courtyard serves as an ‘oasis in the desert’ to enhance the psychosocial value of the construction site, health, wellbeing and performance of all staff. In both design and concept it has significantly created a pleasant environment with a beneficial micro climate within the construction site offices; providing fresh, clean, oxygenated and moist air, which keeps the staff active, attentive, relaxed and upbeat or in high spirits constantly, as their various duties constantly take them round and about the courtyard or garden;

3. *Personalisation and psychosocial benefit:* The rose garden courtyard has become an aspect of personalisation as each member of staff identifies with it in their own personal way as an ‘icon of life’ at the site. This view was expressed by the H&S management and supported by both workers and management during the focus group interviews. It is considered an enduring source of sustenance during the day, and a succour and healing presence at the end of a stressful work day;

4. *Social interaction and team building initiative:* The presence of the garden has helped to relieve stress, fatigue, and boredom among the staff. The H&S manager further stated that the presence of the rose garden courtyard has, by a large margin, enhanced the social network and team building initiatives of the organization. A testimony to this fact is that the focus group interview and interaction with the workers was conducted within the courtyard by their own suggestion not at the conference room as was originally planned;

5. *Nature-psychophysiology and improved communication:* The rose garden courtyard provides a cool restful environment for spontaneous dialogue, informal meetings and interaction among the staff. The H&S team of M&R Cementation concurred and noted that this situation of communion and interaction among the staff would not have been possible in a physically repulsive environment devoid of nature. The lack of a beneficent view and environment would have naturally kept most people within the confines of the offices most of the time to avoid the stark, arid, and uninviting reality of such a workplace environment;

6. *Attachment to the organization:* A visible sense of attachment to the organisation, to one another and the worksite environment clearly exists among the employees. It is notable that a particular group of workers whose offices were located in the new construction site extension began to voluntarily green their portion of the site, according to M&R’s H&S management report and interview with the workers (Photo 8). They collected grass sods from the other green areas to plant on the bare patch of their own section of the construction site, until it was fully covered with green grass, and

7. *Green performance index:* The sense of appreciation and commitment to management’s ‘green’ effort is of such value that their portion of the site has remained green even with the prevailing reticulation problem on the construction site. It represents a unanimous and collective factor of team work because the workers have maintained the grass in that area

‘green’ with waste water from their changing room all through the harsh arid summer season of the hot dry climate of the Northern Cape region of its location.

Discussion from Research Findings and link with existing literature
Research indicates that shared values, concepts, attitude, and healthy and safe behaviour on the part of workers contribute to H&S culture (King, 2000; Bartlett, 2011; Kim *et al.,* 2012). Workers’ perspectives regarding H&S, well-being, and performance are interdependent and not isolated (King 2000; Bartlett 2011; Kim *et al.,* 2012) and are intrinsically related to an organisational structure that fosters shared concepts among workers in an environment imbued with physical and cognitive wellbeing (GSA, 2003). Goodwill built on interpersonal trust is an attitude that is encouraged within a pleasant and psychotherapeutic communal environment where emotional support is offered in the form of the BCSM (Prins *et al.,* 2011). Findings indicate that the BCSM draws on nature’s principles to build an empathetic, understanding and love filled environment by employing the biophilic amenity of emotional human cognitive affiliation to nature (Wilson, 1984; Berman *et al.,* 2008; Prins *et al.,* 2011, Bartlett, 2011; Obiozo, 2012; Obiozo & Smallwood 2012; 2013; Smallwood & Obiozo, 2013).

CONCLUSIONS AND FURTHER RESEARCH

From the focus group study it is clear that the rose garden courtyard is clearly regarded and viewed as an aspect of health and wellbeing among the staff by both workers and management. It has also encouraged communication and interaction among employees, building fraternal spirit among them that is beneficial to the organisation’s H&S initiative. The effect has been rejuvenating and therapeutic in relieving psychosocial stress among the workers. The BCSM is therefore recommended as a community and team building initiative on construction sites in furtherance of an optimum H&S culture and wellbeing that is ultimately psychotherapeutic. In furtherance of positive research in construction, organisations should employ the BCSM as an H&S team building block and enabling environment that becomes a silent partner in which to share common values of benefit to individual workers and the organisation (WHO 2007; King, 2000; Bartlett, 2011; Prinset al., 2011; Kim *et al.,* 2012).

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ARE ENVIRONMENTAL CONDITIONS IN SOUTH AFRICAN CLASSROOMS CONDUCIVE FOR LEARNING?

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Abstract:
Environmental factors have been shown to have a significant impact on quality of education. This exploratory study investigates environmental conditions in a case study classroom at a South African secondary school. It undertakes field measurements within a classroom over a typical school day in summer. Measurement data from the study is analysed and interpreted in relation to indoor environmental condition standards developed by American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) and South African Bureau of Standards (SABS). The study indicates that environmental conditions in the case study classroom do not achieve the environmental standards defined by ASHRAE and SABS. This suggests that the classroom does not provide an environment that promotes productivity and comfort for particular summer conditions, and therefore is unlikely to be conducive for learning. The paper draws a number of conclusions from the study and makes recommendations for further research.

Keywords: Assessment, Environmental Conditions, Schools

INTRODUCTION

Existing studies show a direct link between physical environment in which learners are taught, learning effectiveness and student learning outcomes (Schneider 2002; Seppänen *et al*., 2006) Poor learning environments have been found to contribute to irregular student attendance and dropping out of school and teachers' absenteeism and ability to engage in the teaching and learning process (Haverinen-Shaughnessy *et al*., 2011). Indoor Environmental Quality (IEQ) factors such as extreme thermal conditions have been found to increase irritability and reduce students' attention span and mental efficiency. This results in an increased rate of students' errors, teacher fatigue and deterioration in work patterns (Jago and Tanner 1999; Schneider 2002). Good lighting has been found to improve students' ability to perceive visual stimuli and their ability to concentrate on instruction (Schneider 2002).

This paper describes an exploratory study of environment conditions within a case study classroom in order to establish whether environment conditions in classrooms are conducive to comfort, productivity and learning. The main research question addressed by the study is "*do*

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South African school classrooms' indoor environments, as represented by the case study, achieve indoor environmental quality standards as outlined by legislation and good practice standards"?

This question is answered by addressing the following sub-questions:

- What standards define acceptable, or minimum, environment conditions in class rooms?
- How does a case study classroom perform in relation to minimum and good practice indoor environmental control standards in learning environments?

The paper describes an exploratory study of environmental conditions in a class room as a pilot for a larger-scale assessment process. It is acknowledged that a larger-scale survey is required in order to increase the validity and significance of findings for this type of study.

Minimum Environmental Conditions

There are a range of different standards that can be used to define acceptable, or minimum, environmental conditions for classroom, such as those developed by the World Health Organisation. In this exploratory study environmental conditions assessed will be restricted to lighting, indoor air quality and temperature. Reference standards for these aspects are drawn from South African building regulations for lighting requirements and the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) standards, for thermal and indoor air quality requirements. These are outlined in Table 1.

Table 1: Minimum environmental conditions

Aspect	**Reference**	**Acceptable / minimum standards**
Light	National Building Regulation and Building Standards (South Africa)	Above 200 lux on working surfaces.
Indoor air quality	Upper control limit concentration (Caution Level) based on 400ppm ambient and ANSI/ASHRAE Standard 62.1-2007: Ventilation for Acceptable Indoor Air Quality in Low-Rise Residential Buildings ASHRAE (ASHRAE 2007, Lawrence 2007)	CO_2 concentrations below 942 ppm.
Temperature	ANSI/ASHRAE Standard 55-2004 Thermal Environmental Conditions for Human Occupancy (ASHRAE 2004).	25.0°C to 28.0°C (at 0.5 Clo, 20% RH)

Case Study

The classroom selected is representative of standard classrooms in public schools in South Africa. The building is approximately 20 years old and is located in Attridgeville, a township in Pretoria, South Africa (latitude -25.7733, longitude 28.0713). The physical properties and occupation of the classroom is described below.

Physical properties
The case study classroom has the following physical characteristics:

- The classroom is within in a linear, single storey block consisting of 4 classrooms.
- The building envelope is composed of face brick walls with fenestration on North and South walls and double pitched corrugated steel roof with a plasterboard ceiling.
- The internal walls of classrooms are composed of face brick from the floor level to 1100mm above finished floor level. Above this walls are finished in plaster and paint to the ceiling.
- The North side of the block is characterised by centre pivot steel windows school at 1568mm above finished floor level. The open able area of one window is 0.84m^2.
- The South facing side of classroom block is characterised by a row of 1303mm x 1445 mm steel school window, with top and bottom open able areas with the top window pivot having an open able area of 1.17 m2 (1303mmx978mm) and bottom hung window with an open able area of 0.6 m2 (1303mmx467mm). The lower sections of these windows are all painted with dark green paint, to limit views and therefore distractions.
- The classroom area size is 52.78 m^2 (7440 mm x 7560mm).
- A plan of the classroom and furniture layouts is provided in figures 1 and 2. Plans are orientated with North to the top of the page.

Occupation
The occupation schedule of the classroom is as follows:

- The classroom was occupied by 44 learners throughout the morning. An educator was present for most of the morning.
- Classes within the space are scheduled 08:00 to 13:30 with a 30 minutes break from 11:00-11:30.

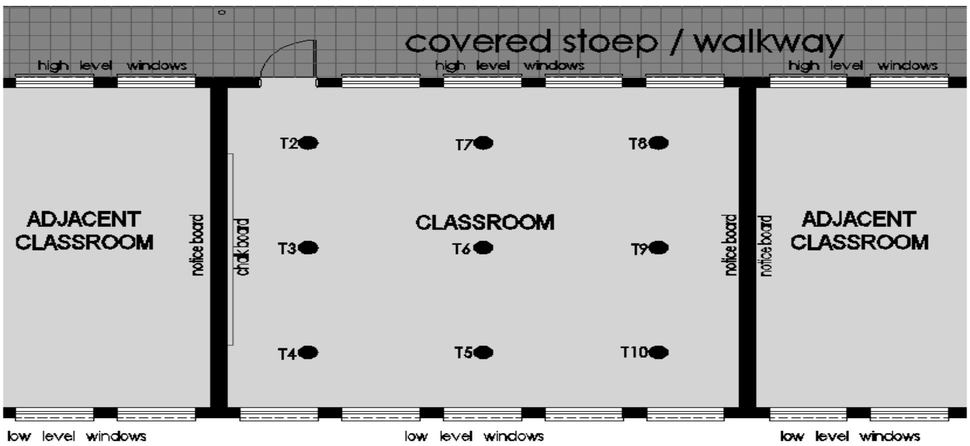

Figure 1: The location of category T2-T10 measurement locations (T1 is taken externally in the quad/assembly area)

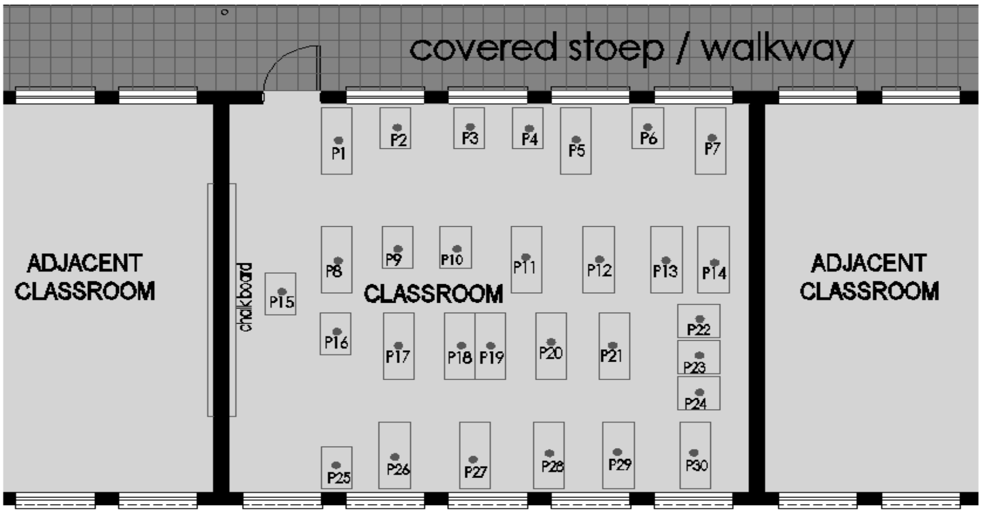

Figure 2: The location of category P1-P30 measurement locations

METHODOLOGY

In order to obtain data on both the performance of the building and the experience of occupants, two types of measurements were taken. Type 'T' measurements are designed to reflect building performance and are measurements of environmental conditions at uniform locations within the classroom, as indicated in Figure 1. The external T measurement (T1) was measured at the centre of the external quad/assembly area and the internal T points (T2-T10) are positioned 1200mm away from the 4 internal classroom walls and +/- 2581mm away from each other. T measurements were taken every hour from 8:30 - 13:15, with measurements being completed within a 15 minute period. 'T' locations were marked on the floor of the classroom to ensure consistent measurement locations. Type 'P' measurements are designed to reflect the actual experience of occupants in the classroom. These measurements were taken at the desk locations of occupants as indicated by locations 'P' in figure 2. There are 30 desks in the classroom and 28 of these were occupied. The number of occupants at each desk varies from 1 to 4 students. The desks are marked and tagged P1 – P30 and measurements were taken once, at 13:30, within a period of 15 minutes.

Instrumentation used including a digital lux meter, a CO2 meter and a digital thermocouple (Sentry ST 303 multi meter). Measurement processes aligned with ASHRAE protocols and included the following aspects (ASHRAE 2004).

- Lighting was measured at 730mm above finished floor level at the marked locations.
- Carbon dioxide was measured at 1100mm above finished floor level at the marked locations.
- Temperature was measured at 1100mm above finished floor level at the marked locations.

FINDINGS

Lighting

Figure 3 below shows lighting levels in the classroom for different T locations over the morning (08:30 – 13:30).

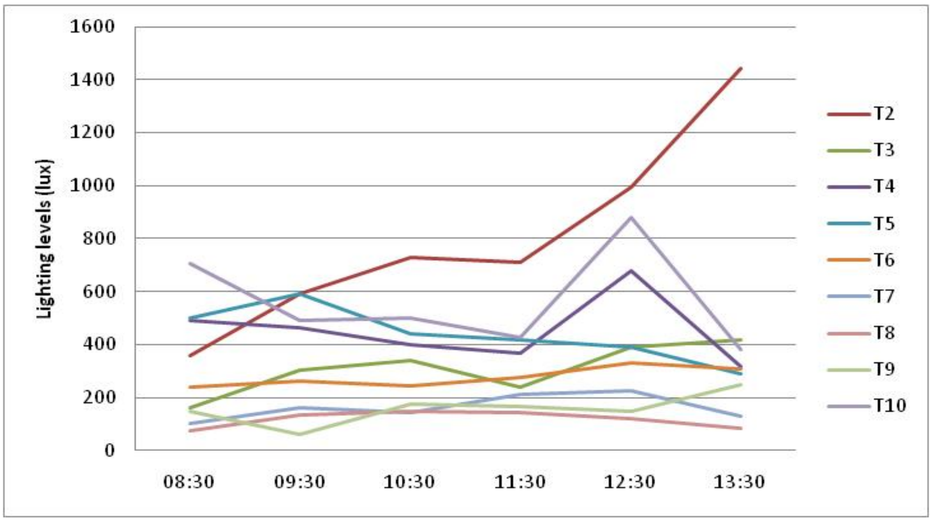

Figure 3: Lighting levels for different T locations in the classroom over a morning

Lighting levels for most locations reduce after 12.30. This is probably due to reduced external lighting levels as a result of cloud cover. The figure shows that a number of locations (T2, T7, T4, T5) had consistent lighting levels of above 400 lux, other locations (T6, T3) were just above the minimum requirement of 200lux. It also shows that a number of locations (T8, T9, T10) where consistently below the minimum requirement of 200lux.

Figure 4 below shows lighting levels in the classroom for different desk (P) at 13:15.

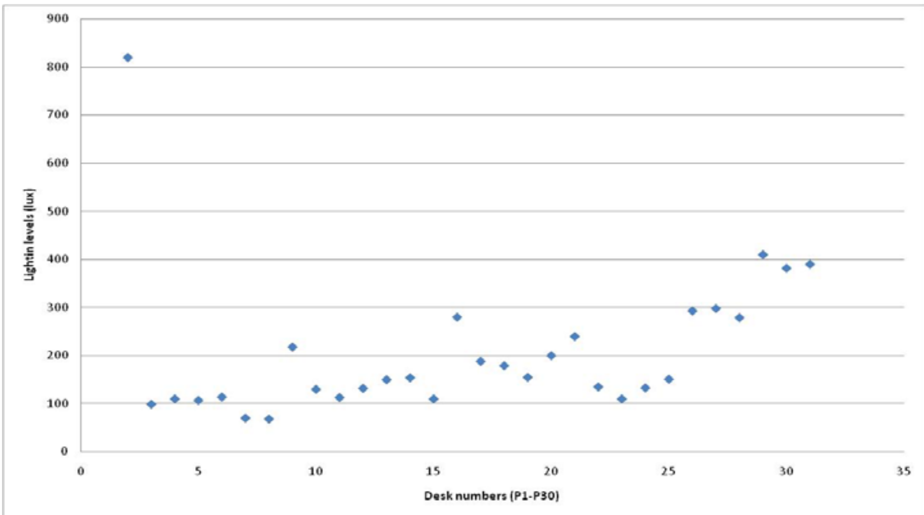

Figure 4: Lighting levels for different desks (P) at 13:15

Figure 4 shows that 19 desks (63%) have lighting levels less than 200lux and 11 desks (39%) have lighting levels of above 200lux. This shows that 63% of desk light levels that are below the minimum lighting standard of 200lux. The figure also shows that only one row of desks in the classroom (row P25-P30) receive above 200lux. These desks are adjacent to the low levels windows. Desks adjacent to the high level windows (P2 –P7) all receive less than 200lux. Desks in the centre of the classroom (P8 – P24) also appear to generally have less than 200lux. Desk locations P9 and P16 have higher lighting levels than the rest of the desks in the centre of the classroom. This is probably due to light from the door. Desk location P1 has very high light levels (800lux) as this is beside the open door. There are number of interesting findings in relation to lighting in the classroom that can be discussed.

Lighting levels: The results show that lighting levels in some areas of the classroom are below the minimum of 200lux. As good lighting levels are required to write and read, it is possible that poor lighting levels are negatively affecting the quality of learning and should be addressed immediately.

Lighting levels near the door: Figure 17 and 18 shows that lighting levels near the door (T2) are lower than lighting levels near windows early in the morning. They then rise above lighting levels near windows and carry on rising even after lighting levels near windows appear to drop due to cloud cover. This can probably be explained by the fact that lighting near the door has a higher reflected component received from lighting reflected from the walkway. This reflected component is proportionally lower in the early morning when sun angles are low and appears to be only marginally affected by reduced sunlight intensity later in day.

This suggests the following further investigations should be carried out.

Is there the potential to improve day lighting, both in intensity and consistency in classrooms through greater use of reflected light?

- *Can surfaces, such as light coloured walkways adjacent to classroom be used to reflect light into classrooms?*
- *Would a light shelf connected to walkway columns be effective in increasing reflected light into the classroom through high level windows?*

Lighting levels and the location and size of windows: Figure 3 and 4 show that the high level windows do not contribute to lighting in the classrooms. This is probably due to the fact that these are located where they receive limited light from the sky as they are immediately underneath the roof so are shaded and receive limited reflected light from the walkway. The low level windows on the North provide light to desks immediately beside them, but are not effective at distributing light further into the classroom. This suggests the following further investigations should be carried out.

- *Can lighting in classrooms be improved by providing lower level windows on the North façade of classrooms?*
- *Would locating walkways on the South side of classrooms improve lighting by reducing the extent to which North light is reduced by the roof?*

Air quality

Figure 5 below shows carbon dioxide levels in the classroom relative to external carbon dioxide levels over a morning (08:30 – 13:30). T1 indicates external lighting levels and T2-T10 indicate lighting levels within the classroom.

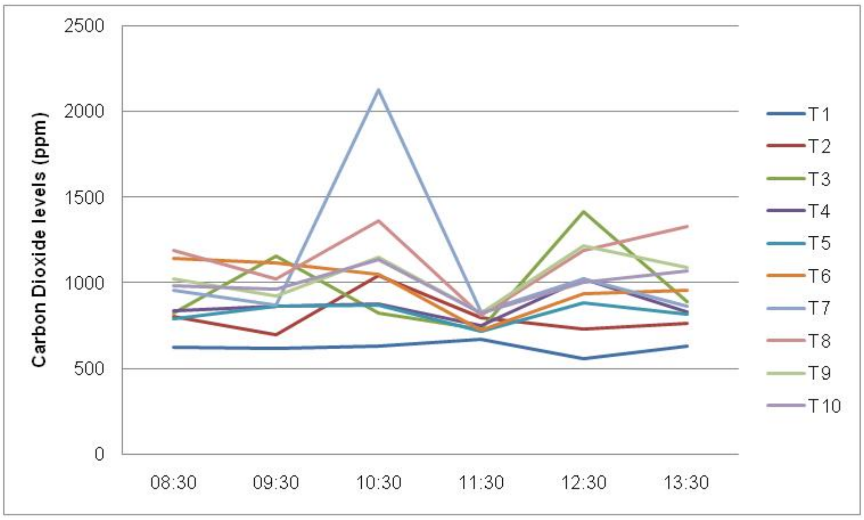

Figure 5: Carbon dioxide levels for different locations (T2-T10) in the classroom over a morning relative external carbon dioxide levels (T1)

Figure 5 shows that carbon dioxide levels in the classroom generally remain at the same level over the morning, within a band of about 750-1250ppm. Carbon dioxide levels at all locations in the classroom drop at 11.30 in the morning. This is likely to be due to break-time when most learners leave the classroom. One location (T7) experiences significantly higher carbon dioxide levels at 10:30 than other points in the classroom. This location is near the high level windows and has a high density of learners. The higher levels experienced are probably due to poor airflow and the higher learner density at that particular location.

Figure 6 below shows carbon dioxide levels in the classroom for different desks at 13.15.

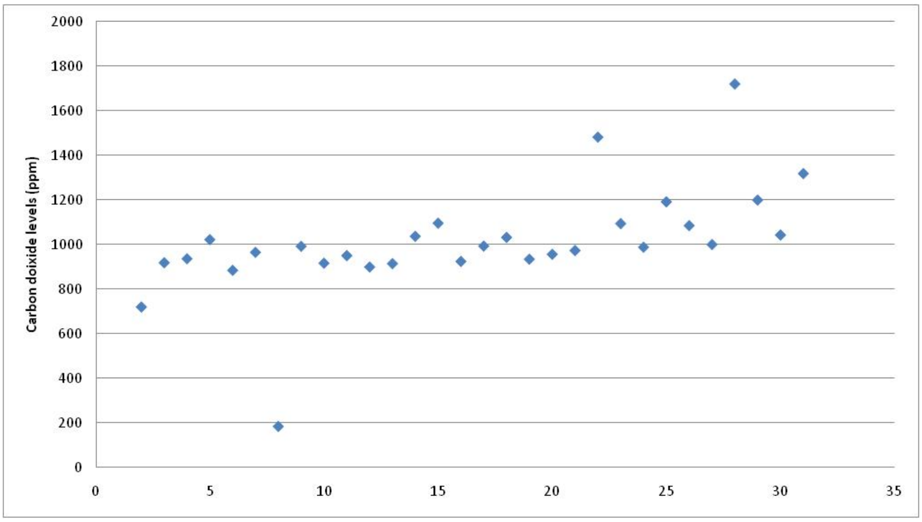

Figure 6: Carbon dioxide levels for different desks at 13:15

Figure 6 show that most locations in the classroom at 13:15 have carbon dioxide levels of about 1000ppm. There are however locations where levels are over 1500ppm, which is well in excess of the limits suggested by the Standard (ASHRAE 2007). There are number of interesting findings in relation to carbon dioxide levels in the classroom that can be discussed.

Carbon dioxide levels: Carbon dioxide levels do not increase over the morning despite the high density of learners in the classroom. This suggests that levels of ventilation and infiltration in the classroom allow some dilution of carbon dioxide levels above concentrations of about 1250ppm.

Breaks: Carbon dioxide levels in all locations in the classroom dropped over the break period when most learners left the classroom. This indicates that ventilation at this time helped to flush the classroom with fresh air and reduce background carbon dioxide levels.

This suggests the following further investigations should be carried out.

- *Do breaks play a significant role in reducing carbon dioxide levels in classrooms?*
- *Would it be better for learners to move between classrooms for different lessons enabling stale air to be flushed out of classrooms during this movement and the 5-10 minute unoccupied period?*

Temperature

Figure 7 below shows air temperature in the classroom relative to external temperatures over a morning (08:30 – 13:30). T1 indicates external temperature levels and T2-T10 indicate classroom temperatures within the classroom.

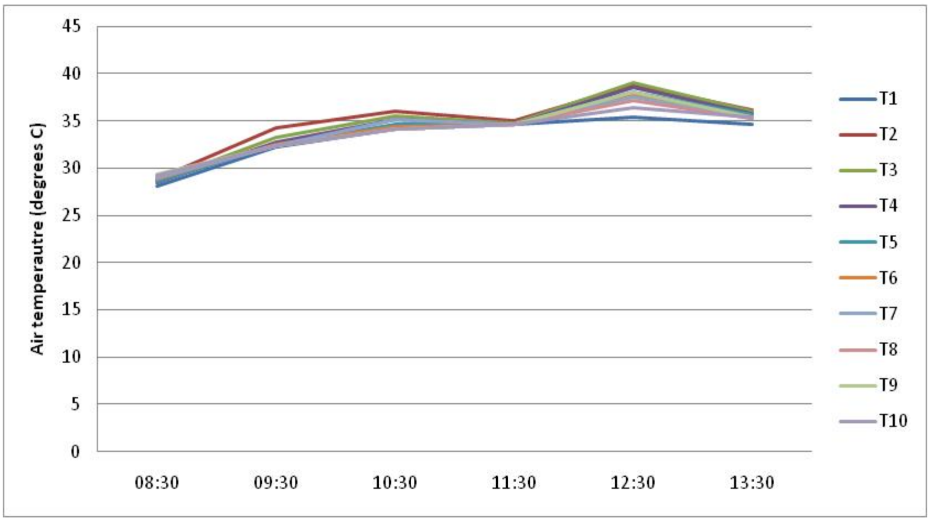

Figure 7: Air temperatures at different locations (T2-T10) in the classroom over a morning

The figure shows that there is very little difference between external air temperatures (T1) and internal classroom temperatures (T2-T10). Figure 7 shows that temperatures increase over the morning from about 28 degrees C to a peak of 38 degrees C at 12:30 with temperatures dropping to about 35 degrees at 13:30. This shows that temperatures were well over the maximum temperature of 28 degrees C for entire morning. Temperature increases level off at 11:30. This may be due to the break period when most learners leave the classroom and therefore reduce the heat load. Temperatures drop again at about 12:30 which may be due to cloud cover and reduced heat conduction through the roof.

Figure 8 below shows air temperatures for different desks at 13:15.

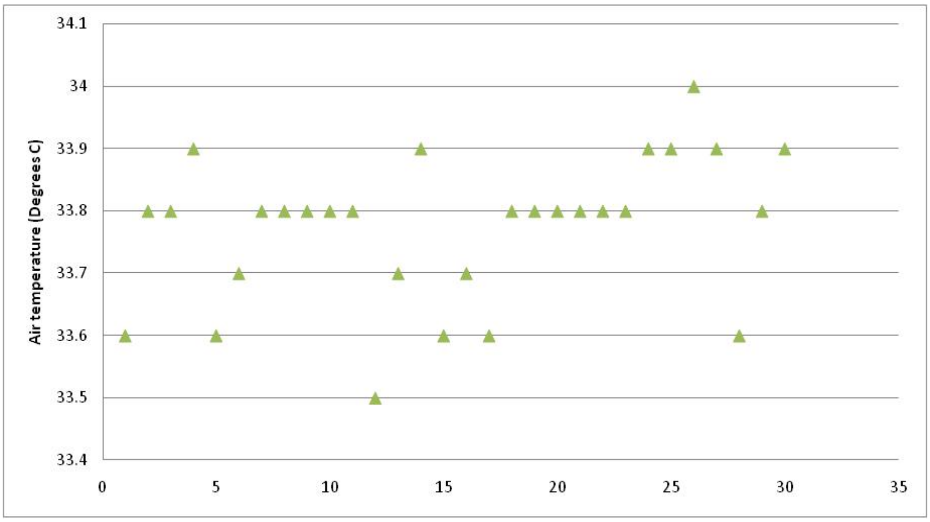

Figure 8: Air temperatures at desks at 13:15

Figure 8 shows that temperatures at desks are between 33.5 and 34 degrees C. This indicates that all desk locations experience temperatures in excess of the maximum air temperature detailed in the ASHRAE standard for thermal environmental conditions (ASHRAE 2004).

There are number of interesting findings in relation to temperature in the classroom that can be discussed.

Environment control: The results show that the classroom is ineffective at thermal environmental control. Indoor air temperature track ambient air temperatures closely and the building envelope appears to play no role in making thermal environments within the class room more comfortable.

Temperature increases: Air temperature increases in the classroom are probably due to a combination of warmer air entering the classroom from outside, solar heat gain through the roof and the heat load from occupants. This finding is confirmed by the air temperature drop experienced at about 11:30 when cloud cover results in reduced solar heat gain and a break reduces heat loads from occupants. This suggests the following further investigations should be carried out.

- *Insulation in the roof could help reduce temperature increases in the classroom by reducing heat being conducted through the roof.*
- *Temperature increases from occupants could be reduced by having regular breaks between lessons to enable classrooms to be vacated of learners and be flushed with fresh cooler air.*
- *It may be possible to use diurnal range to keep classrooms cool. This would require increased thermal mass in the classroom which would be exposed to cool night air to cool down. Cooled thermal mass would then act as a heat sink during the day limiting increases in internal temperatures.*

CONCLUSIONS AND RECOMMENDATIONS

The study shows that internal environmental conditions in the case study classroom do not comply with SABS and ASHRAE standards for occupant comfort and productivity. Therefore, the paper concludes that the case study classroom building does not provide environmental conditions conducive for learning in particular summer conditions.

Further research should be carried out to establish how prevalent these types of conditions are in classrooms and how representative the case study classroom is of other classroom buildings in South Africa. This research should take into account local variations in climate and teaching practice. In addition, research should be undertaken to identify, and test, interventions that can be used to improve environmental conditions in classrooms and ensure that these are compliant with SABS and ASHRAE standards. Recommended areas for investigation include:

- **Roof insulation:** Data from the case study indicates that internal temperature increases may be due in part from heat gain through the corrugated metal roof. Roof insulation could counter this heat gain to reduce internal air temperatures. Roof insulation and the roof colour may therefore be valuable factors to investigate.
- **Management:** Data from the case study indicates that the break when students left the classroom may have resulted in increased fresh air within the classroom. This may help to reduce carbon dioxide levels and reduce air temperatures. Therefore class timetabling and space scheduling may be a valuable non-capital intensive avenue to explore in improving environmental conditions.
- **Windows and light shelves:** Lighting data indicates that light shelves and / or larger windows on the north face of the building are likely to improve internal lighting conditions. These interventions could be modelled with lighting software as a means of improving lighting levels in a classroom.

Finally, it is recommended that research in this area inform the development of school classroom design guidelines. In particular, these should ensure that design fundamentals such as building form and orientation, the location of corridor access, envelope insulation values, fenestration location and size and ventilation opening size respond to local climates and school management schedules to create conducive environments for learning.

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SUSTAINABILITY, A WORLDVIEW SELDOM PRACTICED IN CHOOSING ROOF COVERINGS FOR HOUSES

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Abstract:
Sustainable development was introduced globally by the Bruntland Report in 1987. The concept of development and sustainability went through a process of acceptance and are today buzz words in a political correct world. The relationship between the definition of sustainability and the world of man which includes values, theories and practice will be addressed with the focus on the effect of sustainability in the choice of building materials. Embodied energy for products gives an indication of the total energy used to produce it as well as for its transport and installation. By calculating the embodied energy of the different materials, it is also clear that thatched roofs are the best choice on behalf of environmental impact assessment. The findings are that in terms of a monetary a thatch roofs costs 3.66 times more than sheet metal roofing and 2.24 times more than concrete tiles per m³ floor area. And in terms of embodied energy a thatch roof uses 398 million joules, a concrete tile roof 9 478 million joules and a galvanised sheet roof 26 790 million joules. It is the responsibility of the consultants working in the building industry to make clients aware of the sustainability of building materials. By using scientific knowledge and analyses the client should be persuaded to use sustainable material in order to reduce the negative effect on the environment and take up their responsibility towards the environment.

Keywords: Construction, Housing, Roofing, Sustainability

INTRODUCTION

Sustainable development is a relative new term as it was only introduced globally by the Bruntland Report in 1987. The definition of sustainable development is "*development that meets the needs of the present without compromising the ability of future generation to meet their own needs*" (United Nations, 1987: 43). The relationship between this definition and the world of man which includes values, theories and practice will be addressed from the perspective of a white, middle class Calvinists trying to explain it in terms of material choices by parties involved in the building industry for roofs of houses as an example.

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The concept of development and sustainability went through a process of acceptance and are today buzz words in a political correct world. Development of this process in the western world is driven by value systems. Goudappel (1985) comes up with a solution to have practise, theory and values in the world of thinking in line with each other. Each person should live up to their own value system in all walks of life. This also include that normative choices is made even when choosing building materials in order to reduce their carbon footprint. Part of literature review will be looking at the choice of roofing materials and its ecological footprint as well as energy needed to produce these material, thus to see the effect on the sustainability by the choice of building materials.

By comparing thatched roofs to other conventional types of roof coverings used in housing in the northern suburbs of Bloemfontein, this theory is tested in practise. The findings are that although the initial construction cost of thatched roofs are much higher than other conventional roofs and their insurance are also higher, if sustainability is taken into account, the environmental cost of thatched roofs are a fraction in comparison to the other types of roof coverings. Thus architects and quantity surveyors should bring these facts to the attention of their clients to thereby take up their responsibility towards the environment.

DEVELOPMENT, SUSTAINABILITY AND MAN'S WORLDVIEW

The Concise Oxford Dictionary (1991) describes develop as "*make or become bigger or fuller or more elaborate or systematic" and development as "the act or an instance of developing, the process of being developed*". They also defined sustainable as to "*maintain or keep going continuously".*

What most of the western world see as development, is in most cases just the increase of material wealth. Nijkamp (1980: 13) stated that western communities since the period of the Enlightenment most frequently used the progress ideal as an ideological motif (also religious tinted). The modern cathedrals are not the bank buildings of the 1970's but the malls, the casino's and the waterfronts where through Disney-like Imagineering you can find Mexico, Tuscany or Japan a few minutes away from each other and cultures are reduced to a few products and signs of their past.

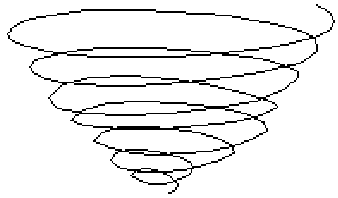
Rist (1997: 181-183) found that the Bruntland Report dealt in a very simplistic way with the term sustainable development even if it is not short on good intentions "*it merely expresses a hope that the necessary will become possible*". Today "*'sustainable development' has become part of the language of every developer*" (Rist, 1997: 192). Unfortunately the new interpretation is that development should be kept up, meaning economic growth should be sustained and it fits in with the neo-liberal politics in which poor countries should use global economic growth as a means to get out of hardship. Thus sustainable development ends up as a belief in a goal that will solve the economic problems of the world.

THE INFLUENCE OF VALUES ON MANKIND

The Dutch philosophy of Dooyeweerd and the Philosophy of the Cosmonomic Idea (Wysbegeerte van die Wetsidee), developed a scientific philosophical approach within which modern man can practice science and be a Christian at the same time (Stellingwerff, 2006). This approach to science dealt with the fact that scientific research is not value free but mostly has either science or humanism as a religious base (Van der Vennen, 1975). The same argument is true of other fields of science as the neo Marxists proved in their critique of the capitalist system in most scientific fields.

Every philosophy or worldview will deal with the meaning of life, with what are man and his society as well as with his relation with the environment. These issues are interrelated as they are the product of a religious outlook. Four main stream philosophical-anthropological approaches are found in the West namely a Christian, an idealistic rationalistic, a naturalistic and a Marxist view of man (Nijkamp, 1980). We now know that western man's vision on earth could theoretically be one of the above four visions but what is man in reality? Science could as yet not totally fathom 'what is man', while philosophy and theology it has been debated for more than two thousand years whether man is body, mind or soul (Goudappel, 1989, Van Praag, 1990). Christians know that the Bible teaches that your heart could either be orientated to a heavenly vision of life or to an earthly vision of life. The choice is to become more spiritual like or more animal like (Figure 1).

Becoming more human and more spiritual



Becoming less human and more earthly

Figure 1: Human choice is a spiral upwards or downwards

In the world of thinking, modernism was followed by post-modernism and replaced by deconstrutivism. According to the ecologist David Orr (Papaneck, 1998:11) deconstuctivism is an anti-world view that "*deconstructs or eliminates the ingredients necessary for a world view, such as God, self, purpose, meaning, real world, and truth as correspondence...This type of postmodern, deconstructive thought results in relativism even nihilism*". Man has the choice which worldview he wants to support.

A SUSTAINABLE FUTURE FOR MAN

For future scenario building Goudappel (1986:11) uses urbanities to analyse how the different ways of reflection can be included into a model. Goudappel (1986) argue that a choice in scenarios is a choice between a quantitative and a qualitative future. Three choices are shown in Figure 2, namely:

- the economic technical approach (the growth model);
- the ecological harmony approach (the equilibrium model – zero growth), and
- the moral generating approach (reparation of man and ecology model).

Each choice, however, has an effect in the third dimension which is the policy (superstructure) that guides implementation of the superstructure choice. Most people have lost the meaning in life. The development of science has pulled the rug from under most of western man's beliefs. When Galileo discovered that the earth was not the centre of the universe, man still was the crownpiece of creation. When Darwin's evolution theory stated that mankind is a side effect of a selection process, man still was a reasonable creature to be reckoned with. Unfortunately Freud's psychological theory which describes man as a beast driven by instinct and not reason took away the special meaning of man as steward of the creation for most people who could not combine their values with theory and practice. Modern man is now been reduced to a consumer with "*no choice other than the choice to consume if, of course, you have the resources to do so*" (Miles & Miles, 2004: 172).

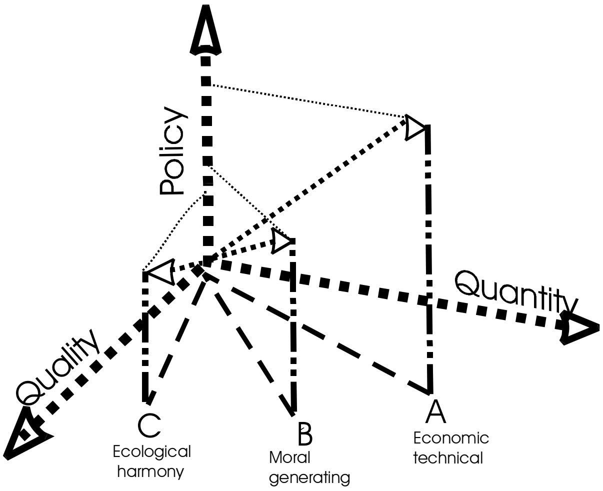


Figure 2: Scenario space for different policies (Goudappel, 1986: 20)

As a functional view for a Christian approach to spatial planning, it must create conditions, set norms and enrich the mind (Nijkamp, 1980: 14-150). Retief (2002: 191-192) came to the conclusion that the social, economic and biological systems could be managed responsibly from a Christian perspective if the approach is from an attitude to "*serve, share and stewardship*". Zwart (cited in Goudappel and Ter Horst, 1991: 99) asked the question "*when are we going to polish our souls instead of our cars?*" Taking up our responsibility would mean learning about how to connect a Christian value system to the scientific and practical world.

The conclusion is that modern man, be the poor or rich, might endorse the modern day buzz word of sustainability but few practice it. Once people learn to be "satisficed"[1] and take up personal responsibility for their own household, the use of energy and the environment within their control a first step towards a more sustainable environment is made.

SUSTAINABILITY AND THE CHOICE OF BUILDING MATERIALS

The biggest and the longest lasting investment man is making in life is the building or buying of an own home. In this section the focus will be on the effect of sustainability in the choice of building materials. Haas and Schmid (1990) in a book on bio-logical building and living spend a whole chapter on the choice of materials. They use the word bio-logical as it combines the biology with logic, meaning that someone who is concerned about nature (biology) in development should approach any solutions logically. In the first instance it starts with the choice of building materials.

Four main biological aspects groups are distinguished in building materials namely genuine natural products (stone), cultivated natural products (sawn wood), processed natural products (mineral wool) and synthetic products (plastic) Haas and Schmid (1990). Not only the

[1] Herbert A. Simon said that people and organizations should "'satisfice' (i.e. look for a course of action that is satisfactory or good enough) rather than maximize" (Banfield, 1973:147).

origin of the material, but also the type of transformation or processing it underwent will influence the material itself but also its impact on the environment (Haas and Schmid, 1990). The following matrix (Figure 3) shows how these two aspects could help in the choice of materials.

origin / **processing**	unchanged	lightly changed	severely changed	transformed
mineral metal				
vegetable matter				
animal matter				
combined matter				

Figure 3: Origin and processing of materials (Source: Haas and Schmid, 1990: 50)

For Burnham (1998), the choice of natural material alone is not enough to be sustainable. The added value that natural products get amongst others through processing or transport cost can make the use of a material not profitable. Wackernagel and Rees (1998) developed the term "ecological footprint" to explain the influence of man on his environment. Snell (2004) uses the term embodied energy for products to give an indication of the total energy used to produce it as well as for its transport and installation. It is normally measured in terms of energy used for a certain mass of a product (in joules per kilogram) or in terms of energy necessary for the production of a certain volume of material (joules per cubic meter) (Table 1).

Table 1: Embodied energy of material

MATERIAL	**Million joules/kg**	**Million joules/m³**
Concrete roof tiles	2	2 780
Galvanised sheet metal	51	371 280
Thatched roofs	0.2	31

(Source: Snell, 2004: 42)

According to Papanek (1995), there are six factors that are important in the choice for designing safe products and reducing pollution namely:

- the choice of materials;
- the manufacturing process;
- packaging the product;
- the finished product;
- transporting the product, and
- waste, after the useful product life is over (demolition of building).

THE MEANING FOR THE PRESENT

To a large extent, modern man is materialistically driven and individually orientated with little thought of the consequences of his behaviour. Although all people believe in something few practice what they preach because they never learned that values, theory and practice is one whole as Sorokin puts it:

> *"If the groups of an individual are in conflict; if they urge him to contradictory actions, duties, thoughts, convictions; if, for instance, the state demands what is disapproved by the church or the family, then the respective egos will be mutually antagonistic. The individual will be a house divided against himself, split by the inner conflicts. There will be no peace of mind, no unclouded conscience, no real happiness, no consistency in such an individual. He will be like a ball pushed in opposite directions by several forces"* (Van den Berg, 1963: 9).

Each person should thus live up to their own value system in all walks of life. This also include that normative choices is made even when choosing building materials in order to reduce their carbon footprint.

RESEARCH METHODOLOGY

With a normative approach it was decided to test three different roofing materials in terms of their origin and the processing done to it. The most natural product is thatched roofing and that was compared to the cost of concrete roof tiles and galvanized sheet metal which is the products of choice in Bloemfontein for houses. A standard house plan was used and quotations were requested from different contractors to supply and erect the three types of roofs. The construction cost of each roofing type was then adjusted to the environmental cost of that product to be used in Bloemfontein. A survey in the two of northern suburbs of Bloemfontein, Dan Pienaar and Waverley showed that only 13 thatched houses were found amongst the 1 800 houses in that area. Lapas were not taken into consideration. The sample area represents a middle class and higher middle class neighbourhood where more expensive roofing is more easily used. A questionnaire was handed out to the owners of the thatched houses to find out what their experience in terms of cost, maintenance and insurance of thatched roofs are. This being much higher than the other types of roofing led to the question of what will be the choice of roofing for their next house and why that choice.

FINDINGS AND DISCUSSION

In this section the construction cost of the thatched, sheet metal and concrete roof tiles as construction material for a standard house will be used in conjunction with the embodied energy cost of these materials. This includes all the wood for trusses and purlins as well as the roofing material.

Cost of erection

By using the quotations for different roof types received from construction companies, the following conclusion as shown in table 2 could be made.

Table 2: Comparison of the different erection costs of roof coverings based on case study

TYPE	**DESCRIPTION**	**SIZE**	**TOTAL COST (incl. VAT)**	**COST PER M² FLOOR AREA**
Thatched roofs	With SABS fire treatment, anti-rot treatment and necessary lighting-conductor. Labour included.	80m²	R 82 200.00	R1 027.50/m²
IBR galvanized sheet metal	Labour cost* and material.	80m²	R 22 450.51	R280.63/m²
Concrete roof tiles	Labour cost** and material.	80m²	R 36 597.33	R457.47/m²

*Labour cost of construction R70/m², Labour cost of roof covering IBR R30/m²

** Labour cost of construction R70/m², Labour cost of roof covering tiles R50/m²

Note that there is no extra cost for insulation at thatch roofs as by IBR and tiles, as it is not needed.

Environmental cost

By using Haas and Schmid (1990: 50) matrix (Figure 4) and looking at galvanised steel (G), thatched (T) and concrete tile roof covering (C), it can be concluded that thatch is the most environmental friendly. By calculating the embodied energy of the different materials, it is also clear that thatched roofs are the best choice on behalf of environmental impact assessment. By using the same material as in table 2 for table 3 and applying it to Snell (2004: 24) embodied energy factors the following calculations and findings was made from the case study. The embodied energy of the materials in the case study was measured in terms of the energy needed to produce a certain weight of each of the materials (in joules per kilogram).

origin \ processing	unchanged	lightly changed	severely changed	transformed
mineral metal			**C**	**G**
vegetable matter	**T**			
animal matter				
combined matter				

Figure 4: Application of matrix: Origin and processing of materials (Source: Haas and Schmid, 1990: 50)

Table 3: Calculation of material needed in roof coverings of case study

MATERIAL for $80m^2$ house	m^2 roof	kg/m^2	m^3 per m^2	total kg	total m^3
Concrete roof tiles	103.03	46	0.01738044	**4739.38**	**1.790706733**
Galvanised sheet metal	110.73	4.744	0.00535	**525.30312**	**0.5924055**
Thatched roofs	99.638	20	0.15	**1992.76**	**14.9457**

(Source: Burger, 2011: online; Botes, 2011: online)

Table 4: Calculation of embodied energy

MATERIAL		Million joules/kg	
Concrete roof tiles	4739.38 kg	2	**9478.76 million joules**
Galvanised sheet metal	525.30312 kg	51	**26790.46 million joules**
Thatched roofs	1992.76 kg	0.2	**398.55 million joules**

The different amounts of energy needed for the materials of the case study are calculated in Table 4. The findings are that where only 398.55 million joules are needed for thatched roofs, galvanised sheet metal needs 26 790.46 million joules and concrete tiles needs 9 478.76 million joules.

Liveability

The findings of the questionnaires to the residents of the different houses about the liveability of thatched roofs were in favour of thatched roofs. Even though the construction costs, insurance and risk for fires is higher in thatched houses, 78% of the respondents still chose thatched roofs over conventional roof coverings and that they would buy a thatched house again.

CONCLUSION AND FURTHER RESEARCH

The word sustainable became a political correct buzzword after the Brundland Report. It is now normally used in conjunction with the word development. Now sustainable in the sense to sustain economic growth which is in line with neo-liberal economics where the market determines most decisions. Modern man is now been reduced to a consumer with "*no choice other than the choice to consume if, of course, you have the resources to do so*" (Miles & Miles 2004: 172). According to Jackson (Papaneck, 1998: 11) our society is the first to have created '*do-it-yourself extinction*'. For Christians who see themselves as stewards, Retief (2002: 191-192) concluded that the social, economic and biological systems could be managed responsibly from a Christian perspective, if the approach is from an attitude to "*serve, share*" as stewards in this world. Taking up our responsibility would mean learning about how to connect a Christian value system to the scientific and practical world even in the field of quantity surveying and the built environment.

When calculating the construction cost of different roofing materials for a house, it is not only the marginal cost that should be taken in account, but also the environmental cost. When calculating the different amounts of embodied energy needed for the roofing materials, it was found that in terms of a monetary a thatch roofs costs 3.66 times more than sheet metal roofing and 2.24 times more than concrete tiles per m³ floor area. And in terms of embodied energy a thatch roof uses 398 million joules, a concrete tile roof 9 478 million joules and a galvanised sheet roof 26 790 million joules.

The initial monetary cost of thatch roofing is thus much higher than the other materials, but if energy cost is taken into account thatch cost is a fraction of the others (1:24:66).

Despite higher construction cost, higher maintenance cost and higher insurance nearly 80% of present owners of thatched houses in the northern suburbs will buy a thatched roof house again, showing users satisfaction.

It is the responsibility of the consultants working in the building industry to make clients aware of the sustainability of building materials. By using scientific knowledge and analyses the client should be persuaded to use sustainable material in order to reduce the negative effect on the environment. It is thus the consultants responsibility to advice his client on the preferable use of thatched roofs. Further research should be done as to why thatched roofs are not more popular in construction and why it is not marketed as a sustainable solution for the building trade.

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CAUSAL LAYERED ANALYSES FOR AFRICA'S BUILT ENVIRONMENT TOWARDS 2050

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Abstract:

The primary objective of this research was to perform Causal Layered Analyses (CLA) for Africa's built environment over the next forty years. The secondary objective of this study was to not only offer what is already known and knowable about what is happening right now at the intersections of Africa and its built environment development, but also to explain the many ways in which environmental scanning and development could co-involve – both push and inhibit each other – in Africa's built environment future. Then to begin to examine what possible paths may imply for Africa's poor and vulnerable population with regards to built environment demands. Furthermore, this research will attempt to indicate how different approaches to or solutions provided by the CLA process, will lead to different outcomes. This research will not attempt to predict the future, but rather to illustrate the plausible futures taking into account the current prevailing and future forces and factors, both external and internal that will make an impact on Africa's built environment. Future research indicates that too many forces work against the possibility of obtaining the right balance.

Keywords: Built Environment, Causal Layered Analyses, Environmental Scanning, Sustainable Development

INTRODUCTION

There are important questions to ask as to where these future properties will be built, who will construct them, what will they be like and whether the built environment will meet the needs of future generations towards 2050 (Worthington, 2004; UNDP, 2011). The question of the existing built environment stock and its capacity to meet future needs poses a major key issue toward 2050 (UNDP, 2011; Worldwork, 2011). The above mentioned issues are regarded as a unique driver for change in the world, as the seven billionth living people was born around the 31st October 2011. While it took an initial 250 000 years for the planet to play host to a billion inhabitants (circa 1800), each successive billion has taken substantially shorter periods. More than a century passed to reach two billion in 1927. The billion after that took only a third of the time (1927-1960) and the next billion half as long. The most recent additional billion took just 12 years, and the previous only13 years (Haldenwang, 2011). By 2050 the planet's population will have risen to a record 9.1 billion (UN, 2011). Put more starkly, the global population has risen by almost four billion people since 1950 and will grow by another two billion in the next 40 years (Haldenwang, 2011; Silke, 2011).

It is notable that population growth continues to be concentrated in some of the most populous countries. An astonishing 70% of the world's population growth between now and

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2050 will occur in 24 countries, each classified by the World Bank (2011) as low- or middle-income with an average per capita income of under $3 855 (Silke, 2011). During 2010-2050, nine countries are expected to account for half of the world's projected population increase namely India, Pakistan, Nigeria, Ethiopia, the United States, the Democratic Republic of Congo, the United Republic of Tanzania, China and Bangladesh, listed according to the size of their contribution to global population growth (Haldenwang, 2011; UNDP, 2011; Silke, 2011).Beyond the economic, social change and the ways the future populations are composed, living arrangements, housing, the built environment and its demands coupled with the troublesome issues of urban development will dominate this new demographic induced debate (Haldenwang, 2011; UNDP, 2011).

As population pressures increase in the medium term, built environment professionals will feel the environmental pressure in everything from cradle to the grave (UNDP, 2011).As most of the world's population is now living in urban areas, it is in these areas that the main economic, social and environmental processes that affect human societies take place. Urbanisation is now commonly regarded as one of the most important social processes, also having enormous impact on the environment at local, regional and global scales (Turner *et al.*, 1990). In general, it is presently recognised that, in order to respond to the idea of sustainability, urban areas have to maintain an internal equilibrium balance between economic activity, population growth, infrastructure and service, pollution, waste, noise etc. in such a way that the urban system and its dynamics evolve in harmony, internally limiting, as much as is possible, impacts on the natural environment (Barredo, Demicheli, Lavalle, Kasanko & McCormick, 2004).

The aim of this research was to provide practical inputs for government officials, academics, public policy makers and built environment specialists as well as land-use development governance practitioners who are involved with the development of current and future government strategic policies thereby ensuring plausible, good governed built environment frameworks. As part of CLA, this will be delivered through:

- Analysing the nature of built environment progress and failure in the African context;
- Analysing of the extent to which plausible future concepts are recognised and understood amongst decision makers and built environment professionals;
- Analyses of factors that impede the implementation of a plausible built environment future for Africa, and
- Generation of recommendations and guidelines of how to achieve the desired future state for Africa's built environment.

LITERATURE REVIEW

The term built environment refers to the human-made surroundings that provide the setting for human activity, ranging in scale from personal shelter and buildings to neighbourhoods and cities that can often include their supporting infrastructure, such as water supply or energy networks. The built environment is a material, spatial and cultural product of human labour that combines physical elements and energy in forms necessary for living, working and playing. In practice, the term is typically used to describe the interdisciplinary field which addresses the design, construction, management and use of these man-made surroundings as an interrelated whole as well as their relationship to human activities over time (rather than a particular element in isolation or at a single moment in time). The field is generally regarded as a new academic discipline in its own right, instead drawing upon areas such as economics, law, public policy, management, design, technology, and environmental sustainability (O'Brien, 2009).

In architecture and environmental psychology, the phrase is a useful acknowledgment that the majority of urban environments already exist, that the fractions of buildings constructed annually, even in the industrialised world, are designed by architects, and that users of the built environment encounter issues that cross the traditional professional boundaries between urban planners, infrastructure engineers, zoning authorities, architects, interior designers, and industrial designers. In urban planning, the phrase connotes the idea that a large percentage of the human environment is man-made, and these artificial surroundings are so extensive and cohesive that they function as organisms in the consumption of resources, disposal of wastes, and facilitation of productive enterprise within its bounds. Recently there has also been considerable dialogue and research into the built environment's impact on population health (Lee and Rubin, 2007).

Urban sprawl reveals that information and existing tools for urban policy are insufficient in providing an adequate understanding of urban systems. Questions on the sustainability of large regions surrounding the metropolitan areas are sometimes posed in global terms. How mankind anticipate, recognise, measure and interpret urban problems and how mankind respond to them will determine the overall sustainability of the urban system (Barredo *et al*., 2004). As half the world's population now live in cities and the number of urban dwellers is constantly growing, undeniably, the 21st century is being recognised as the 'century of cities' (Krawczyk & Ratcliffe, 2010). Cities are placed centre stage in the modern world; the world that is shaped by rapid technological developments, expanding globalisation, profound cultural shifts and new economic trends. In this very complex and well-connected world, cities function as the nucleus of human activity, frontiers of progress and engines of economic growth (UNDP, 2011). Cities are seen as a key factor that will shape the future of the world (UN, 2011; Krawczyk *et al*., 2010; Silke, 2011).

There is, therefore, an on-going endeavour to ensure their prosperous and sustainable development alongside the provision of good living conditions for all their inhabitants (UNDP, 2011).Land-use development increases complexity even further and makes it even more difficult for urban planners and policy makers to understand the internal and external interdependencies of such urban systems (Krawczyk *et al*., 2010). Contemporary cities struggle with a whole range of problems that are predominantly the result of an inability to deal effectively with the consequences of recent trends and events (Worldwork, 2011). The main problematic areas include economic growth, urban finance, social development, environmental quality, and governance. Continuous structural changes in manufacturing and built environment services sectors combined with global competition put major strains on the economies of countries and cities (Krawczyk*et al*., 2010). Many urban regions also struggle with high sectoral unemployment and lack of financial resources for the development of necessary infrastructure and for tackling social and environmental difficulties. The lack of sufficient financial resources is usually a result of a combination of a weak economy and inappropriate management of existing built environment resources (Silke, 2011).

Lack of sufficient funds is an important limitation for the development of necessary infrastructure, such as transport and communication facilities, environmental protection services, the general built environment and social amenities (Krawczyk*et al*., 2010).

The economic, social, and environmental problems characteristics for cities are difficult challenges for their built environment leaders and administrators be they at local, regional or national level. On one side, the demands placed on cities and their governments are increasing;

on the other, many urban regions are faced by the failure of local democracy, citizens' apathy and conflicting political interests (Krawczyk*et al*., 2010). Present urban management approaches and mechanisms often fail to deal effectively with these challenges (Ratcliff, 2001; Krawczyk*et al*., 2010; UN, 2011). It is increasingly becoming apparent that new approaches and mechanisms are needed to address these built environment problems in a more effective and comprehensive manner (UNDP, 2011).

Most of these built environment difficulties are the result of an inability to cope effectively with the consequences of both global and local change and the extreme complexity of urban and regional systems (Worldwork, 2010). It is ever more being recognised that urban planners, architects, built environment specialists and policy-makers lack an effective future-orientated approach that would enable them to anticipate future transformations; efficiently prepare for ensuing consequences and tackle the inherent complexity (Ratcliffe, Krawczyk & Kelly, 2006). There is a growing need for planners and decision-makers to become 'visionary' in: building environment, community support and creating alliances; taking a long-term view and cultivating best practices; embracing both diversity and authenticity; committing to social equity and community pride; and in planning for liveability and espousing sustainability on land-use development (UNDP, 2011).

Above mentioned challenges can be addressed by adopting and further developing approaches and methods from the Futures Studies field developed over the past five decades. The Futures Studies field has generated an extensive body of knowledge on trends and forces creating the future (Roux, 2010). Future Studies embraces a whole range of methods and techniques that enable the exploration of what lies ahead in a systematic, rigorous and holistic way. But, even more so, Futures Studies offers a different way of thinking and acting about the future (Krawczyk, 2006). This paper have been undertaken in order to address the existing need for an effective future orientated approach in land use development, city planning as well as how future thinking and methodologies can be used to fulfil Africa's built environment needs. Thinking about the future has been present in human history virtually from its beginning. What is important today, for all areas of life, is a growing realisation that recognition that the future is not predetermined and human actions can influence its course (Ratcliffe, 2002a). These realisations underline development of the Futures Studies field – a rigorous discipline, the purposes of which are to "discover or invent, examine and evaluate, and propose possible, probable and preferable futures" (Bell, 2003; Roux, 2010).

The capability to explore the future has come to the force in times of increasing levels of uncertainty due to the accelerating pace of change and growing complexity (World Trends Research, 2008). Systematic exploration of the future can help all decision makers, including corporate managers, urban planners or government ministers to: identify possibilities which lie ahead, be they positive or negative, as they may consequently indicate new opportunities or hold warnings; determine areas, in which the future can be shaped, as well as the areas that are very difficult to influence as decision-makers have little control over them, and evaluate planes, define ways in which these plans can be realised an anticipate their likely outcomes (Krawczyk*et al*., 2010; Coates, Mahaffie & Hines, 1996; UN, 2011; Worldwork, 2010; UNDP, 2011). Examination of the future also helps to establish what are the main continuities and major trends and to understand how change occurs. It helps to identify the critical problems, the new factors that will gain importance and the sources of motivation and hope (Ratcliffe 2002a; Roux, 2010; Krawczyk, 2010). An understanding of how the future can unfold, however important, is only a part of the process for creating desired futures. The images of these desired futures should be developed building upon the values and wishes of people, whom they concern, and they should guide the actions of all actors responsible for policy and decision-making (Krawczyk & Ratcliffe, 2005).

RESEARCH METHODOLOGY

The Futures Studies field has developed a whole range of methods and techniques to enable the study of the future in a systematic, rigorous and holistic manner. Futures concepts, methods and techniques have been extensively applied in many areas, such as business, military, environmental studies, education, health and national and regional developmental studies (Assukal, 2003). Over the past 15 years, the use of futures methods has begun to influence urban planning processes. A number of cities, such as Lyon, Barcelona, Bilbao, Vancouver, have efficiently applied futures methods in order to guide their development (Krawczyk *et al*., 2010). By doing so, these cities have proved that there is a need for change in a way of thinking about the future of cities and a requirement for a new innovative future-orientated research that could assist urban planners, architects, built environment specialists and decisions makers alike. Glenn (2004) described "Future Studies as any exploration of what might happen and what might become" (Glenn, 2004), "Futures Research as the use of methods to identify systematically the consequences of policy options and to identify alternative futures with policy implications for the decision makers" (Glenn, 2004) and "Prospective as the study of the future to develop a strategic attitude of the mind with a long-range view of creating a desirable future" (Glenn, 2004; Krawczyk, 2008). For Ratcliffe (2001), the terms Futures Studies, Futures Research, Foresight and Prospective describe various methodologies.

Causal Layered Analysis, or CLA, is a future oriented methodology created by Sohail Inayatullah. This methodology is post-structural in so far as it seeks to problematize existing future oriented thinking; exploring the assumptions, ideologies, worldviews, episteme, myths and metaphors that already are embedded in images, statements or policy oriented research about the future. It has also developed as a way of opening up spaces for alternative futures. These alternative futures are not based on extrapolating trends or tweaking the assumptions in a systems model, as is common in scenario building, but through deconstructing / reconstructing critical assumption about the way we constitute the world. The articulation of alternatives is a product of this method, not a primary focus of the method. While the theoretical underpinning of CLA is based on post-structuralism, the approach is layered, that is, it is a method of analysis which is inclusive of accounting for various streams of causality operating in unison upon an issue. CLA is a way of 'integrating levels of reality, science, social science, philosophy and religion, if you will'. Only then can researchers see and act beyond our idiosyncratic notions and traditions, creating truly alternative futures.

Inayatullah (2005: 2) places causal layered analysis within what is considered critical futures research. Inayatullah (2005: 2) writes: "*This tradition is less concerned with the disinterested pursuit of knowledge, as in the empirical, or with creating mutual understanding, as in the interpretive, but with creating distance from current categories. This distance allows researchers to see current social practices as fragile, as particular, and not as universal categories of thought. They are seen as discourse, a term similar to paradigm but inclusive of epistemological assumptions*."

Through establishing distance and introducing different ways of knowing, the problem can be redefined. Redefining the problem allows for the exploration of new and alternative possibilities, ideas and solutions whilst testing their validity against the norms and values of society (Inayatullah, 2005). CLA therefore starts with two key presuppositions; the way in which we define the problem determines the potential solutions and stakeholders, which are determined through our view or layer under consideration, be it deep, shallow or wide, of the past, present and the future (Inayatullah, 2005: 3-5). Causal layered analysis consists of four layers, each a step change deeper than the previous. The first or the “litany” layer is concerned with obvious trends, the second explores social causes, the third drills into the discourse or worldviews and the fourth the hidden stories or myths or metaphors (Inayatullah, 2005: 5). The “litany” layer is characterised by quantitative trends and problems, exploited by politicians and the media creating high visibility for these trends (Inayatullah, 2005: 5). Due to its political nature these trends or problems also tend to quickly fall out of fashion as they are replaced by some new hot topic. Little to no analysis is done and trends and data are accepted as fact. The second layer is also characterised by quantitative trends and data like economic, political and historical factors. Unlike the “litany” level, the second level explores the trends and data in an effort to develop an understanding through interpretation rather than blind acceptance.

This layer is characterised by the application of technical techniques and models built on a strong academic foundation (Inayatullah, 2005:5). Going even deeper, the third layer endeavours to explore the worldviews underlying the trends and problem definitions in the second layer. This layer allows for the opportunity to redefine the problem in the “litany” layer through not only understanding how the different discourses cause and sustain the trends but also legitimise and reinforce them. This level is less about the technical analysis but rather about how factors like culture, political views and religion influence our views about the world. This layer, unlike the second layer with strong technical grounding, uses language as a key for unlocking the meanings and different ways of knowing (Inayatullah, 2005: 5). The fourth layer explores what is termed the myth or metaphor layer. This layer is about discovery of the deeply rooted, unarticulated, highly emotional and unconscious stories behind the story. This layer attempts to deconstruct the worldview into images which can transcend into other structures of interpretation. Images become the key to this layer due to the limitations of language (Inayatullah, 2005: 5). The richness that causal layered analysis brings follows from moving up and down and within layers providing different perspectives on the problem, even challenging whether or not the right question or problem is being considered and who owns the problem, opening up a multitude of alternative solutions.

FINDINGS AND DISCUSSION

Casual Layered Analyses identified that Africa’s planning process should be fragmented and uncoordinated among various sectors, including land use, infrastructure, transport, and housing and built environment planning (NDP, 2011; Situma, 2007; World Bank, 2013). As the built environment and city plans often lack detail and integration across sectors, Africa therefore requires macro-level planning that sets an overall strategy to create a cohesive vision for channelling future built environment growth. Issues that must be addressed at a larger scale include ‘smart growth’ and sustainability principles such as integration of land use and infrastructure development, coordination of various transport systems, resource conservation and environmentally sensitive urban design. It would be most valuable to empower a common, central authority to administer the overall, inclusive African built environment planning process such as the United States, African Union or the World Bank (Thomas, 2003; Westendorff, 2002).

In most large African cities, urban development takes place without core built environment improvements (UNEP, 2006). In many instances, expansion of built environment systems is considered after the built environment development has occurred, when it is starts exerting additional pressure on existing systems. This results in chaotic built environment development patterns and environmental hazards adversely affecting the long-term quality of urbanized areas (Williams, 2000). The key indicators that should trigger an extension of infrastructure are therefore not clearly defined. As African cities experience continued growth, infrastructure capacities are not able to keep pace with the scale of urbanization (McKinsey, 2010; McCarney, Blanco, Carmin & Colley, 2011). Efficiencies in implementing built environment infrastructure projects in Africa must therefore be improved at all stages, including awarding projects according to plan targets, securing financial closure, and executing projects within cost and on time (Potts, 2008). Data from African governments and industry suggest that, on average, each project suffers from 20-25% time and cost over-runs (UN, 2012; World Bank, 2013). The inter-disciplinary and collaborative urban planning process that is required would be further supported by integrated city information databases (Williams, 2000; Gudes, 2010).

Great strides should be made to enhance the quality of life in the African built environment. The African built environment plan calls for housing programmes to eliminate slums that will fast track construction of new housing with secure land tenure (Global Economic Transition, 2007). An African built environmental management strategy also calls for measures to be taken to mitigate heavily polluted water courses and mismanaged dumping sites, which both have negative impacts on human health. The main health issues in the African continent are all linked to the environment and include HIV/AIDS, tuberculosis and diarrhoea. A cohesive, long-term master built environment plan for Africa's integrating sectoral plans for land use, transport, infrastructure, and built environment planning at regional-, state- and city level should be prepared for the cities of Africa towards 2050. Progress in micro-level planning also needs to be incorporated and complemented with comparable innovation and detail in macro-level planning in Africa. The objective is to overcome problems caused by current built environment planning practices that are disjointed that result in unorganized urban growth and built environment development (Aduwo, 2011; Tan, 2011).

Parks and open spaces are the backbone of sustainable built environment cities, facilitating healthy living and fostering a sense of belonging for the residents (UNICRI, 2011). The benefits for Africa will include preservation of native plant and wildlife habitat and conservation of conservation of critical ecosystems. A balance between protection and recreational use of land should be established in African countries by implementing sustainable built environment strategies that allocate areas to be preserved as open spaces when new built environment development occurs (Government of Ireland, 2009). For each African country's city, a parks and open space plan will determine the per capita norms for green space. It will identify a range of parks, recreational facilities, passive open space recreation areas, street landscape corridors, and open space buffer areas at city, community, and neighbourhood-level. Type, location, and size of parks at all levels in Africa's will be defined to provide access within walking distance from any starting point in the city (UN-HABITAT, 2012).

Private sector role players should work with the governments to guarantee that Africa's resources are optimally utilised and should shape a African built environment society where solidarity between people is central, and everyone participates freely (EPP Group, 2001). Creating work for the youth, disadvantaged and the poor is a vital challenge for the proposed built environment vision, a role that can be best played by an effective and organised private sector. The challenge, therefore, is to formulate suitable built environment structures to ensure that the private sector continues to develop and grow (Williams, 2009; Global Risks, 2012). To advance best practice in a sustainable built environment urban planning, Africa should set up a program to establish collaboration among various cities, government agencies, and knowledge partners (Cisco IBSG, 2010). Knowledge partners may include industry leaders, experts, consulting groups, real estate developers and builders, and academic institutions. The program should therefore encourage peer to peer learning by facilitating knowledge exchange (BU Strategic Plan, 2012).

The governments of Africa and various bodies within it are very aware of the importance of energy conservation (Winkler, 2007). While enormous investment is directed toward meeting anticipated electricity demand, policy makers also recognize the urgency of action on climate change, sustainable built environment and the importance of energy security. They are encouraging both energy conservation and renewable energy generation at state level. However, this awareness does not appear to be widespread among the businesses and general community. Implementation of a wide ranging public awareness and action campaign will provide long-term foundations for other energy efficiency solutions (McKinsey, 2010; UNCSD, 2012).

An effective institutional and policy framework is key to delivering transitional built environment and reconstruction programmes and projects (USAID, 2011). Central to this is the built environment development of a strategic plan for the built environment sector which sets out the objectives of assistance, the respective responsibilities of governments and the humanitarian and built environment agencies and relevant laws and standards. The strategic plan is the responsibility of the particular African government and the mandated coordinator. Sufficient resources must be dedicated to contributing to the built environment development of the particular African countries' strategic plan and this should form the basis of individual agencies' programmes and projects to ensure their response is appropriate, coordinated and meets the needs of the entire affected population

CONCLUSION AND FURTHER RESEARCH

Currently, Africa is extremely dependant on donor aid and support, as a large percentage of government expenditures and relief efforts are funded from external partners either as loans or grant aids. Proposed African built environment visions should aim at making Africa less reliant on donor support (Fraser & Whitfield, 2008). Nevertheless, at present, the continent will require the assistance and goodwill of the international community in supporting any African built environment vision. Governments will need to guarantee that built environment development partners are fully conscious of the strategic forces of the possible, probable and preferable proposed African built environment visions, and are kept up to date on the status of implementation (IFAD, 2009). Implementing agencies are accountable to beneficiaries, donors and particular African governments.

A key challenge is satisfying the requirements of all parties as to how funds will be spent. Significant funding constraints include the total amount of money available, the timescales over which it can be spent, and other donor requirements (DFID, 2007). Typically, funds raised through emergency appeals must be spent within the first nine to twelve months after a built environment disaster (DFID, 2012). This generally precludes reconstruction and places greater emphasis on emergency and transitional built environment options (Lee & Flemming, 2012). Assistance should be provided equitably, and the needs of the most vulnerable must be met. It is therefore critical to agree a clear policy on eligibility and responses across all agencies. The selection of individual beneficiaries should involve the whole community in a transparent process, and beneficiary lists should be coordinated and approved by local governments to avoid duplication. This can be a time consuming and resource-intensive process involving village leaders and local African governments. The decision to work in several districts or sub-districts may also impact on mobilisation costs and programme (European Commission, 2011; UNDP, 2011).

There are many different ways in which built environment assistance can be provided to support reconstruction. Selection of an appropriate method of assistance depends both on the needs of the affected communities and on the type of assistance a particular agency is best placed to provide (UNEP, 2009). The latter is based on the agency's capacity, institutional knowledge and available resources and includes how reconstruction may overlap with other sectoral capacities within the organisation. Different methods of assistance should be combined to create specific programmes tailored to the needs of the affected communities and individual households (UIW, 1996). It is highly unlikely that a single agency will be able to deliver all aspects of an African transitional built environment or reconstruction programmes themselves. Aspects which fall outside their remit or core strengths will require partnerships with local governments, other agencies or local organisations (THP, 2013). It is essential that the responsibility of each partner in contributing to the common goal of a sustainable African built environment and reconstruction is clearly defined and communicated (World Bank, 2008; World Bank, 2013).

By 2050, above mentioned gradual exogenous built environment changes will have transformed the opportunities and challenges facing Africa in at least six dimensions. Urbanization will accelerate. Migration will increase (Wordpress, 2012). Agriculture may well decline, both in relative and absolute importance. Natural resources will remain an important part of the built environment development picture and a major African built environment development challenge. Some African economies may have learned to compete globally, and conflicts will continue to diminish, but not wholly disappear (African Development Bank, 2011). How individual economies in Africa respond to these challenges will depend on the choices made, individually and collectively. Broadly, countries in the African region need to respond by investing in their cities, managing migration, transforming agriculture, managing their natural resources better and making concerted efforts to break in at the bottom of the global market in goods and services (Rural Poverty Report, 2011). Collective action by Africans, themselves, in the form of deeper regional integration, and by the international community in the form of improved performance on trade and aid must support the efforts of individual countries in Africa towards 2050.

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ARCHITECTS' PERCEPTIONS OF BIODIVERSITY AND ENERGY EFFICIENCY IN THE CITY OF CAPE TOWN, SOUTH AFRICA

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Abstract:

Taking into consideration the documented challenges concerning the loss of biodiversity and energy efficiency, it is imperative for the construction industry to examine its contributions to sustainable developments in major cities in sub-Sahara Africa. Focusing on biodiversity and energy use, the study was undertaken with the overall intention of shedding more light on the extent that built environment developments in Cape Town were sustainability compliant. A survey with the aid of a structured questionnaire, which relied on issues that were identified in the literature reviewed, was conducted among Architects that were practicing in the City of Cape Town. The purposive sampling of Architects led to the generation of the primary data. In order to deepen the insights provided by the primary data, additional interviews were conducted among professional that were not survey. The research findings show that biodiversity in the City of Cape Town is being threatened by urban sprawl and development; and innovative designs could improve the pace of sustainable development in the city. The study also suggests that the construction industry could reduce energy use through energy efficient designs, although cost constitutes a significant barrier. To overcome these challenges, there is much to be done by the City of Cape Town and the construction industry. Such intervention should include the recognition of the importance of protecting biodiversity and construction energy efficient buildings.

Keywords: Biodiversity, Construction industry, Energy, Sustainable development,

INTRODUCTION

The Brundtland Report defined sustainable development as that which meets the needs of the present generation without compromising the ability of future generations to meet their own needs (United Nations, 1987). Although there have been many definitions of sustainable

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development over the years, this is the most commonly embraced definition (Shelbourn *et al.*, 2006). Sustainable development is the programme that will integrate various spheres of human activities that were initially seen as separate (Kibert, 2008). That is, sustainable development as a concept focuses on three aspects, namely, economic, environmental, and social. In other words, the concept of sustainable development is contrary to traditional development that is founded on a programme of economic growth (Pawlowski, 2008).

A recent Construction Industry Development Board (CIDB) report concludes that the operation of non-residential and residential building sectors account for around 23% of total Greenhouse Gas (GHG) emissions in South Africa (CIDB, 2011). Of this percentage, the non-residential sector accounts for around 10% of the total emissions; the urban and rural high-medium income residential sectors account for around 8%; while the manufacture of building materials accounts for around 5% of the total emissions. Thus, the commercial and the high-medium income residential sectors, together with the materials manufacturing sector, are obviously the sectors that require specific focus in terms of energy efficiency and the reduction of GHG emissions. The historical trends and the seemingly low levels of the uptake of sustainable building construction, and the confusion about what sustainable development means in sub-Sahara Africa, is a cause for concern given the amount of built environment development that can be reasonably expected to happen in the continent in the coming decades (Du Plessis, 2005). In this sense, the main objective of the paper is to evaluate the awareness of Architects regarding sustainable development; and to evolve recommendations that can begin to address identified problems in terms of biodiversity and energy use in the City of Cape Town. In the context of sustainability, biodiversity implies the existence of solutions to changes in future makeup of an environment whereas energy efficiency implies that resources should be optimally utilized in a production setting.

BIODIVERSITY IN THE BUILT ENVIRONMENT

Atkinson, Dietz and Neumayer (2007) indicate that environmental space is known as a sphere of the planet and its resources. This is where human beings can utilise renewable resources without depriving future generations from meeting their own needs (Atkison *et al.*, 2007). Surendran and Sekar (2010) state that biodiversity is a valuable and yet a poorly understood natural resource that is on the decline due to human activities. Ketola (2008) indicates that biodiversity is essential for preserving life on the Earth since it helps species and ecosystems to adapt to climate change. Ayoo (2008) also mentions that biodiversity provides important benefits to society as it provides humans with the necessities of life and forms the basis for the economy. The aforesaid comments describe biodiversity through its usefulness for the preservation of resources that are vital for the continued existence of the planet.

According to Ayoo (2008), biodiversity is vital to life as living organisms are supported by the interactions within ecosystems. In the South African context, Glazewski (2005) mentions that the *South Africa Biodiversity Act* was made public in June 2004. The purpose of the Act is to manage and conserve South Africa's biodiversity and its components; to protect species and ecosystems that warrant national protection; to engender sustainable use of indigenous resources; to achieve fair and equitable sharing of benefits arising from bio prospecting including indigenous biological resources, and to establish a South African National Biodiversity Institute. The South Energy Africa (SEA) and AMATHEMBA (2007) observe that the advantages of biodiversity in the City of Town, *inter-alia*, include:

- The natural biodiversity cleans water and air, preventing flooding and holding the soil in place;
- Biodiversity provides the complex genetic pool that provides us with food and medicines, and
- A spectacular natural environment supports the tourism industry providing livelihoods to many. That is, livelihoods are provided by the harvesting of flowers such as proteas, medical plants such as buch and the production of clean spring water.

These advantages are accessible in Cape Town despite the presence of threats to biodiversity in the form of urban sprawl and development; human population growth; spread of invasive alien species; litter, dumping and pollution; frequent human induced wildfires, and overprotection from fire in some areas (SEA and AMATHEMBA, 2007). Thus SEA and AMATHEMBA (2007) advocated for a strategy to manage, restore and protect the biodiversity of the City of Cape Town. Such interventions include:

- Primary biodiversity – to establish a network of conservation areas and biodiversity nodes that are actively managed;
- Secondary biodiversity – this involves open spaces such as rivers, areas forming part of storm water management, parkways, parks, road verges, servitudes and transport routes which play an important secondary role;
- Conservation of biodiversity in freshwater aquatic systems – this is the integrated management of rivers, wetlands and vleis that provide important green ‘corridors’ between the mountains and coastlines. This will be done in recognition of the importance of the freshwater systems;
- Biodiversity legislation and enforcement – legislation, innovative law enforcement and committed governance will be used to enhance a “no nonsense” approach to biodiversity, and
- Biodiversity education and awareness – this is to empower citizens of Cape Town on biodiversity issues in order to effectively share, own and take collective responsibility for the City’s exceptional biodiversity resources.

ENERGY SUPPLY IN SOUTH AFRICA

Talukhaba, Lenkwe and Aduda (2009) suggest that rapid industrialization and the mass electrification programme have led to demand exceeding supply by early 2008 in South Africa. They pointed out that it is this power crisis that has led to accelerated recognition of the need to diversify energy production, from coal and nuclear power to renewable energy sources. Eskom, which is the state energy company, has been involved in a massive programme to upgrade and expand the country’s electricity infrastructure and focus on the need to diversify the energy production. Stephen (2009) also contends that the energy generation shortage in South Africa is a result of the lack of timely investment in generation capacity in the late 1990’s. Secondly, the tariff increases allowed by the regulator did not take into consideration the future generation capacity costs as they were very low considering the costs of procuring the generation plant. That is, the tariff increases assist in preventing large increases when the generation plant is being procured. The energy crisis therefore provided a platform for major cities in the country to start to evaluate renewable sources of energy.

SEA and AMATHEMBA (2007) stated that the City of Cape Town was the first Su-Sahara African city to develop an energy and climate change strategy in 2005. This strategy sets out a vision for the delivery and consumption of sustainable environmentally sound energy for the population of the city. The key targets for this strategy include:

- 10% of all households to have solar water heaters by 2010;
- 30% of all households to use compact fluorescent lighting by 2010 and 90% by 2020;
- All the new subsidized houses to have ceiling from 2005, and
- Renewable energy to comprise 10% of total city energy consumed by 2020.

RESEARCH METHODOLOGY

The collection of required data, which comprised of the design and administration of closed-ended questionnaires, was conducted among purposive (non-random) selected Architects that are practicing in the City of Cape Town. The data were collected by means of a quantitative survey initially. A purposeful sampling was adopted in order to reach known practices that have designed landmark projects in the city. The sample size constitutes twenty (20) Architectural practices in the city. At the end of the survey period that spanned over eight (8) weeks, only 14 validly completed questionnaires were returned, which equates to a 70% response rate. In order to deepen the insights provided by the Architects that responded to the survey, 10 separate built environment professionals were approached for interview purposes. However, only 4 of them agreed to be interviewed. Those that were interviewed include 2 public works officials, 1 consultant and 1 building contractor. Although a total number of 24 questions were asked in the course of each interview session, only responses that further illuminate the perceptions of the Architects are herein presented.

RESULTS

Tables 1, 2, and 3 indicate the respondents' perceptions' related to the contributions of the construction industry to biodiversity and the use of energy in the City of Cape Town in terms of response percentages to a scale of 1 (strongly disagree) to 5 (strongly agree), and a mean score (MS) ranging between 1.00 and 5.00. Table 1 indicates that with the exception of two, all the MSs are above the midpoint of 3.00, which indicate that the respondents can be deemed to agree as opposed to disagree with 5 biodiversity related statements.

The results indicate that 71.4% of the respondents strongly agreed that design can play a significant role in protecting biodiversity in the City of Cape Town; 50.0% strongly agree that the construction industry should protect the biodiversity in the city; and 28.6% strongly agree that alien vegetation threatens indigenous vegetation in the city. Thus, the role of design with respect to biodiversity is ranked 1st on the table based on the MS.

Table 2 shows that all the MSs are above the midpoint of 3.00, which indicate that the respondents can be deemed to agree with the statements. With 85.7% of the respondents strongly agreeing, and 14.3% of the respondents agreeing, it can be observed that designs can promote the construction of energy efficient buildings in the city. Perhaps, this is because the respondents perceive that constructed buildings / facilities in the city are not energy efficient, while the city is experiencing energy shortages. Although they are ranked 4th and 5th respectively, the MSs related to 'the construction industry consume significant amount of energy and the city council promotes energy efficient buildings' are equally significant.

Table 1 Biodiversity in the City of Cape Town

• Scale				
1 = Strongly Disagree	2 = Disagree	3 = Neutral	4 = Agree	5 = Strongly Agree

Biodiversity in the City of Cape Town	**1**	**2**	**3**	**4**	**5**	**MS**	**Rank**
Design can play a significant role in protecting biodiversity in the city	0.0	0.0	7.1	21.4	71.4	4.64	1
The construction industry should protect the biodiversity in the city	0.0	0.0	7.1	42.9	50.0	4.43	2
Alien vegetation threatens indigenous vegetation in the city	7.1	21.4	7.1	35.7	28.6	3.57	3
The city has policies that could enforce protection of biodiversity	7.1	7.1	21.4	57.1	7.1	3.50	4
Biodiversity in the city is under threat	7.1	7.1	35.7	35.7	14.3	3.43	5
Enforcement of the protection of the biodiversity is adequate in the city	7.1	57.1	21.4	14.3	0.0	2.43	6
The construction industry protects the biodiversity in the city	35.7	28.6	35.7	0.0	0.0	2.00	7

Table 2 Energy efficiency in the City of Cape Town

• Scale				
1 = Strongly Disagree	2 = Disagree	3 = Neutral	4 = Agree	5 = Strongly Agree

Energy Efficiency in the City Of Cape Town	**1**	**2**	**3**	**4**	**5**	**MS**	**Rank**
Designs can promote the construction of energy efficient buildings	0.0	0.0	0.0	14.3	85.7	4.86	1
Constructed buildings / facilities in the city are not energy efficient	0.0	0.0	0.0	42.9	57.1	4.57	2
The city is experiencing energy shortages	0.0	7.1	28.6	35.7	28.6	3.86	3
The construction industry consumes significant amount of energy	7.1	0.0	7.1	71.4	14.3	3.86	4
The city council promotes energy efficient buildings	7.1	14.3	14.3	50.0	14.3	3.50	5

Table 3 indicates that 35.1% of the respondents perceive that efficient use of electricity by contractors when executing projects is 'never', while 50.0% of them perceive it to be 'rarely'. In effect, the majority among the respondents opine that contractors rarely or never make use of energy efficiently when executing projects. In addition, 42.9% of the respondents observed that the use of renewable sources of energy for project execution in the City of Cape Town is ‘never’, while a further 50.0% are of the opinion that the use is ‘rarely.’

Table 3 Energy efficiency related practice in the City of Cape Town

• Scale				
1 = Never	2 = Rarely	3 = Sometimes	4 = Often	5 = Always

Practice	1	2	3	4	5	MS	Rank
Efficient use of electricity by contractors when executing projects	35.7	50.0	14.3	0.0	0.0	1.79	1
Use of renewable sources of energy for project execution	42.9	50.0	7.1	0.0	0.0	1.64	2

The need to add depth to the insights gained through the quantitative method led to the inclusion of a qualitative approach in the study. As aforesaid, 4 built environment professionals were interviewed separately in the city of Cape Town. Certain findings corroborate the perceptions of the surveyed Architects. Such findings, which are presented verbatim, include:

1. *Are there any policies for conservation of biodiversity in the City of Cape Town?*

The 4 respondents agreed that there are policies for conserving biodiversity in the City of Cape Town. However, there was a view that these policies are not strongly enforced; hence they are not adhered to by the majority of the stakeholders in the construction industry.

2. *Are there contributions made by the construction industry to the loss of biodiversity?*

When asked if there are contributions made by the construction industry to the loss of biodiversity in the city, all respondents answered in the affirmative. The 4 respondents were of the opinion that the construction industry pays more attention to getting maximum benefit from the land because of economic considerations, a situation that seemingly drives considerations related to the environment to the background in the scheme of things.

3. *Are there any initiatives conducted by the construction industry to mitigate the loss of biodiversity?*

Two of the respondents indicated that the construction industry has done nothing to mitigate the loss of biodiversity due to two reasons. Their first argument was that the law protecting biodiversity is very weak, so the construction industry does not adhere to it. Secondly, the construction industry is mainly concerned about the structure of the building withstanding the test of time, that is, structure versus soil. On the other hand, the other two respondents indicated that the construction industry is doing something to mitigate the loss of biodiversity. They opined that policies related to environmental impact assessment (EIA) are assisting in mitigating the loss of biodiversity.

4. *Are you aware of any initiatives made by the City of Cape Town on protecting our biodiversity?*

All the respondents were aware of the initiatives made by the City of Cape Town for the protection of biodiversity. But they said these initiatives are not publicly stated so that the majority of the population might be aware of them. They also contend that the City of Cape Town is also very slow to act as they only come when the damage has already occurred hence the construction industry project stakeholders do not adhere to them.

5. *Are you aware of alien invasion on our vegetation contributed by the construction industry?*

In addition, only one respondent is aware of alien invasion related to vegetation. The other three respondents said they are not aware of it.

6. *Is there anything that could be done by the construction industry to enhance our environment?*

All the respondents indicated that there is something that should be done by the construction industry. Firstly, they opined that all concerned should adhere strictly to laws related to protecting biodiversity. Secondly, the City of Cape Town should issue heavy fines on the individuals that do not adhere to these laws. Thirdly, the protection of the environment should be the major focus of clients, consultants, and contractors in the construction industry, that is, building structures that are environmentally friendly should be emphasised. Lastly, they observed that the addition of an environmental specialist to the design team in construction projects is also a possible way forward.

7. *Are you aware of what is known as ecological design?*

The 4 respondents concurred that they are aware of ecological design, although they pointed out that it is not a compulsory practice in the industry.

8. *Do you know anything about energy efficiency?*

The 4 respondents indicated that they are aware of energy efficiency and have seen some of the energy efficient buildings, even though they have not been involved in such projects.

9. *What is the City of Cape Town's energy efficient strategy?*

All the respondents said that they are not aware of any energy efficient strategy conducted by the City of Cape Town.

10. *Do you know any government's initiatives to promote energy efficiency?*

All the respondents indicated that they are aware of the government's initiatives related to the promotion of energy efficiency.

11. *Do you know anything about passive design?*

All the respondents indicated that they are aware of passive design but have not been involved in such projects.

12. *Is there anything that has been done by the construction industry to ensure energy efficient projects?*

The 3 of the respondents believed that the construction industry is doing something through environmentally friendly buildings to promote energy efficient projects. But they also indicated that the construction industry is slow in promoting passive design as it is a voluntary practice. However, one of the respondents indicated that nothing is done by the construction industry to ensure energy efficient projects even though the City of Cape Town is still faced with energy crises.

13. *Do you know anything about renewable sources that are used as producers of energy or have you seen any projects that use renewable sources to produce energy?*

Three of the respondents have seen renewable sources of energy since people are starting to be more conscious about their use of energy. However, one of the respondents has not seen any renewable sources of energy.

14. *What has the energy crises in South Africa changed in your everyday life?*

All the respondents indicated that they have become more conscious about energy usage.

15. *Do you know anything about energy audits and their benefits in the building?*

All the respondents did not know anything about energy audits. However, they indicated that benefits to buildings would be to educate the users about their energy usage and that would assist them to be more energy efficient.

16. *Do you know what retrofitting is and its advantages on energy efficiency?*

Only one of the respondents knew what retrofitting is all about, while the other three respondents said they have limited knowledge about retrofitting. However, they all agreed that retrofitting could assist in reducing energy usage within a building, but it can also be an expensive exercise and should be done only if it is practical and cost effective.

DISCUSSION

Given that the climate change agenda have yet again placed the construction industry under pressure as not only is the industry expected to deliver value for money for clients while providing profits for the supply chain, but also sustainable construction processes and buildings are also expected, the findings of this study provide an insight into the awareness level of Architects in terms of biodiversity in the city. However, introducing sustainable construction practices into the construction sector in region will require an approach that takes into account the regional needs and priorities, and that draws on local initiatives (Du Plessis, 2005).

According to the CIDB (2011), major opportunities for energy efficiency in the building sector in South Africa tend to focus on solar-water heating, geyser blankets, energy-efficient lighting, thermal design, and behavioural changes, among others. Since climate change is already impacting biodiversity in many regions of the world that include the Arabia (Asem and Roy, 2010), and possibly Africa, sustainable construction (development) should be encouraged in the construction industry. This is because changing temperature as well as water levels has serious ramifications for ecosystems, and also threatens the survival of species and habitats that are unable to adapt. In other words, the losses in biodiversity affects the livelihood of many people that are dependent on natural resources so much so that implementing nature conservation actions could reduce the threats of environmental disruptions to species and habitats, and also improve their adaptive capacity (Asem and Roy, 2010).

CONCLUSIONS AND RECOMMENDATIONS

The study points to the need to address biodiversity and energy usage in buildings in the city of Cape Town. Though limited by the sample size, the findings nevertheless call for the evaluation of the awareness of the professionals in terms of the sustainable development of the built environment. The evaluation is needed as the respondents to this study perceive that currently the construction industry does not protect biodiversity in the City of Cape Town; the construction industry consumes a significant amount of energy through its constructed buildings / facilities that are not energy efficient; and the construction industry rarely practice efficient use of electricity by contractors when executing projects. In particular, innovative designs that could lead to environmentally friendly buildings were advocated by the respondents. Therefore, it can be suggested that through formal and informal channels:

- The city should promote sustainable development more vigorously;
- The professionals (such as Architects) must acknowledge their role and ability to drive sustainable developments in the sector, and
- Sustainable construction should be viewed in terms of the larger 'picture' of sustainability: it should form an aspect of the planning and development of cities.

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WATER FOR THE BUILT ENVIRONMENT IN THE FACE OF CLIMATE CHANGE: A SOUTH AFRICAN PERSPECTIVE

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Abstract:
There is plentiful evidence that Earth is warming. Water sources are particularly vulnerable to the warming of the planet. Little is known about the potential impact of climate change on southern Africa, particularly South Africa. A meta-analysis was conducted to obtain insight into temperature and precipitation change, using data from three South African weather stations located near Cape Town, Bloemfontein and Johannesburg, all at different latitudes and altitudes. Daily temperatures and precipitation readings were obtained from the WeatherSpark Beta database, while the annual temperatures and precipitations were obtained from the TuTiempo.net database. Annual temperature and precipitation data were partitioned into two groups, one containing the older values and the other containing the more recent values. These groups were tested for significant differences. The t-tests revealed significant changes in temperature for Bloemfontein ($p = 0.007$), while all other temperature and precipitation tests were not significant ($p = \geq 0.05$). In contrast, daily temperatures demonstrated increasing extreme values, although the yearly daily mean low and mean high temperatures did not show identifiable change from 1949 till 2012 for Cape Town and Bloemfontein, and from 1956 to 2012 for Johannesburg. Similarly, precipitation showed increases in the severity of precipitation events. Recent single downpour events continued for more hours than in the past. These changes could affect the country in various ways; by bringing about changed patterns of disease, increased risk of malaria, hindering food production and severe shortages of safe water.

Keywords: Climate change, Meta-analysis, Precipitation, Temperature, Weather stations

INTRODUCTION

Observational records and climate projections have provided plentiful evidence that the world's freshwater resources are vulnerable and have the potential to be strongly impacted by climate change, with wide-ranging consequences for human societies and ecosystems (Bates *et al.* 2008). For example, warming over several decades has been linked to changes such as: increasing atmospheric water vapour content; changing precipitation patterns, intensity and extremes; reduced snow cover and widespread melting of ice; and changes in soil moisture and runoff.

Precipitation has demonstrated substantial changes in variability mostly increasing over land in high northern latitudes, while decreasing mostly from 10°S to 30°N since the 1970s

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(Bates *et al.,* 2008). Globally, dry areas have doubled and water stores in mountain glaciers in the Northern Hemisphere have decreased substantially. Increased water temperatures and changes in extremes including flooding and droughts, are expected to affect water quality and worsen many forms of water pollution (Bates *et al.,* 2008).

Most of Africa, including South Africa relies on rain-fed agriculture. As a result, it is highly vulnerable to changes in climate variability, seasonal shifts, and precipitation patterns. It is projected that agriculture will be severely compromised by climate variability and change (WWF South Africa, n. d.). Migration of human settlements, particularly in coastal regions is expected. In the built-up environments aging and newly constructed buildings are also not adequately constructed to endure changing deterioration processes brought about by a changing environment, particularly driving thunderstorms (Nielsen *et al.,* 2007).

Little is known about the African climate, its drivers and their links to global warming (Africa Partnership Forum, 2008). With increasing evidence that Africa is warming faster than the global average and is likely to continue (Africa Partnership Forum, 2008), the question arises, is Africa preparing for the inevitable? In the light of the paucity of information about Africa and South Africa's changing environment (Africa Partnership Forum, 2008), a meta-analysis was conducted using historical climate data to obtain insight, albeit preliminary, into the changes in temperature and precipitation at three South African weather stations. These stations, located at Cape Town, Bloemfontein and Johannesburg, are at different latitudes and altitudes. The available mean annual temperature recorded at the Bloemfontein weather station demonstrated significant change over the years studied. The daily temperatures revealed substantial changes in extreme temperatures for all three weather stations. Also, the length of precipitation events have increased and become more severe over the years at all three weather stations.

IMPACT OF A CHANGING ENVIRONMENT

Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all (WHO, 2006). Billions of people are living without access to safe water and sanitation. Every year many children die from preventable water-related diseases (Gleick, 2008). One of the Millennium Development Goals states that the international community is committed to halving the proportion of people without access to safe water by 2015 (UNDP, 2003). Efforts to achieve the Millennium Development Goal, which is aiming for 75% by the year 2015, will fall short by nearly half a billion people (WHO, 2006).

'Almost half the world population (47%) will be living under severe water stress by 2030' (OECD, 2008). This means people suffering water stress in 2030 will increase by more than a billion, from 2.8 billion to nearly 4 billion. Most of these people will be living in developing countries. In Africa, one of the major challenges is the ability for both rural and urban Africans to access clean water (Lewis, n. d.). As the temperature on Earth warms, water on the surface evaporates more quickly. When the water condenses in the atmosphere, it can lead to more severe storms that produce large volumes of rains. Consequently, this leads to flooding, soil erosion and property destruction (USGCRP, 2009). Africa is one of the most vulnerable continents to climate variability and change because of multiple existing stresses and low adaptive capacity (Boko *et al.,* 2007). Existing stresses include poverty, political conflicts, and ecosystem degradation. The rapid evaporation will inevitably result in more droughts in some places on the planet, which will compromise agricultural production, impacting food production, including access to food in many African countries and regions (World Bank, n.d.).

Human health is also at risk. For example, malaria threatens health in southern Africa and the East African highlands (Boko *et al.,* 2007). Pollutants can cause illness such as asthma and increased risks for insect-related diseases as insects find the warmer temperatures more conducive to their growth (World Bank, n. d.). Water availability and quality is particularly of concern in semi-arid countries such as South Africa. Droughts and floods are often catalysts for wide-ranging health problems, including an increase in diarrhoea among children, cholera, skin problems and acute under-nutrition. Negative impacts of climate change could create a new set of refugees, who may migrate into new settlements, seek new livelihoods and place additional demands on infrastructure (Africa Partnership Forum, 2008).

DATA COLLECTION AND ANALYSIS

A meta-analysis was conducted in an attempt to identify patterns in historical climate data that could provide insights into the role of climate change on water quality. To understand the climate change's role from a South African perspective, a prerequisite for this study was to find historical data of three weather stations that spanned at least 50 years. The WeatherSpark Beta data base that contains daily temperature and precipitation data for weather stations across the world including South Africa from as early as 1949 was selected. The TuTiempo.net data base was used to supplement the WeatherSpark Beta data with annual temperature and precipitation data, because the WeatherSpark Beta data base does not contain annual temperature and precipitation data. Three weather stations were selected based upon the size of the TuTiempo.net annual temperature and precipitation data available, because this data base was not as extensive as the WeatherSpark Beta data base. The data of the three weather stations, near Cape Town (coastal), Bloemfontein (central) and Johannesburg (northern) were selected, which represented areas at different latitudes and altitudes.

The investigation followed three steps. In the first step that annual data were used to ascertain whether the available annual data could indicate changes in the patterns of annual temperature and precipitation. The data on temperature and precipitation of each of the weather stations were partitioned into two equal groups depicting *older* and *younger* data. These groups were then tested for significant differences using a two- tailed *t*-Test with an alpha of 0.05. In step two the daily temperatures were compared over the years using the years, 1949, 1980 and 2012 for Cape Town; and Bloemfontein; and 1956, 1980 and 2012 for Johannesburg as representative of the early, midterm and recent years. Step three was similar to step two, using precipitation data. These findings were then used to propose potential effects that climate change might have on water quality destined for human settlements.

FINDINGS AND DISCUSSION

A comparison between the *old* and *young* mean annual temperatures and mean precipitation volume for the three weather stations did not reveal any substantial climate change indications, except for the significant difference ($p \leq 0.01$) in the annual temperatures at Bloemfontein over the study period (Table 1).

Table 1: Demographic Data and *t*-Test Results for Annual Temperatures and Precipitation

Variables	Weather Station		
	688160 (FACT) Cape Town	**684420 (FABL) Bloemfontein**	**683680 (FAJS) Johannesburg**
Latitude	-33.96	-29.1	-26.15
Longitude	18.6	26.3	28.23
Altitude	42	1354	1694
Temp. data collection	1977 - 2012	1977 - 2012	1977 - 2012
Temp. mean	16.75	16.55	16.07
Temp. Standard deviation	0.33	0.69	0.63
Temp. Standard error	0.08	0.16	0.15
Temp. *t*-Test *p*	0.631	**0.007**	0.264
Precip. data collection	1979 - 2011	1977 - 2006	1977 - 2009
Precip. Mean	556.41	596.67	782.93
Precip. Standard deviation	97.10	213.78	152.53
Precip. Standard error	28.03	59.29	40.77
Precip. *t*-Test *p*	0.312	0.811	0.328

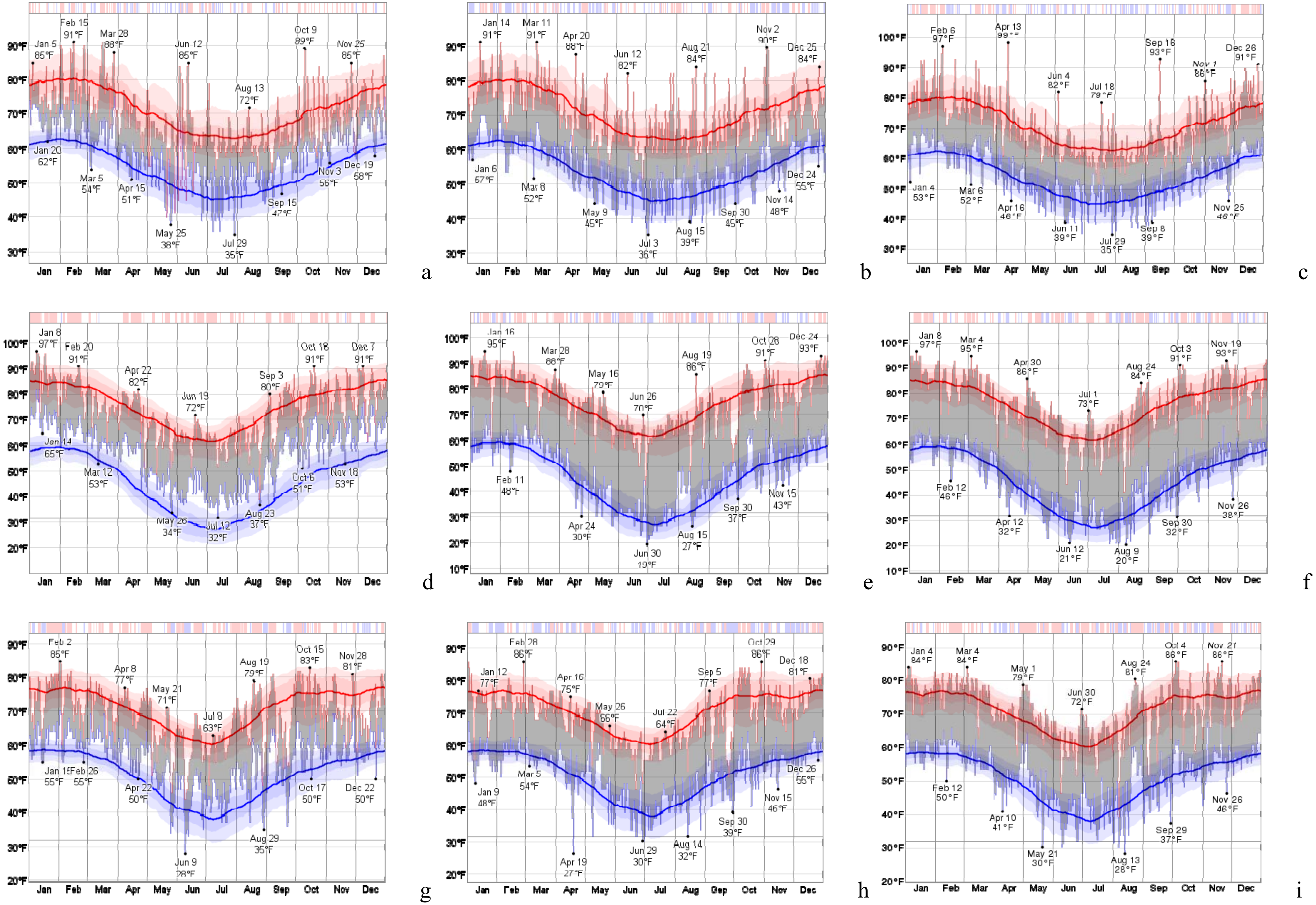
Temp = temperature; precip = precipitation; bolded *p* value = highly significant

In contrast, the yearly daily high and low temperatures demonstrated indications of the impact of climate change. The averages high and low daily temperatures for Cape Town remained more or less unchanged from 1949 to 2012. However, the extreme temperature values beyond the 10 and 90% percentiles superimposed over the high and low averages, demonstrated increasing extreme values as shown by the graphs for 1949 (Figure 1a), 1980 (Figure 1b), and 2012 (Figure 1c). The extreme lows for the daily high readings and the extreme highs for the daily low readings resulted in the smoothing out of the band between the two average lines. Similar results could be demonstrated at Bloemfontein for 1949, 1980 and 2012 (Figure 1d, e, and f) and at Johannesburg for 1956, 1980 and 2012 (Figure 1g, h, and i). The extreme highs of the daily high temperatures became more extreme over the years, similarly for the extreme lows of the daily low temperatures. The smoothing out of the band between the two average lines also became more pronounced for these two weather stations compared to Cape Town. It should also be pointed out that the increasing extremes were more pronounced for Bloemfontein and Johannesburg in comparison with Cape Town.

Although the TuTiempo.net mean annual precipitation data did not demonstrate significant changes over the years studied, the yearly daily precipitation did show substantial changes for the years 1949 to 2012 for Cape Town and Bloemfontein and from 1956 to 2012 for Johannesburg. When comparing how long precipitation occurred, the data showed that a single precipitation events became longer and longer over the years. In 1949 the length of all precipitation events at Cape Town never passed the 5 h mark (Figure 2a). This was also true for Bloemfontein in 1949 (Figure 3a) and Johannesburg in 1956 (Figure 4a). When viewing the length of precipitation events in later years, the data revealed a steady increase in the how long it rained at all three stations. During 1980 precipitation events reached 7 h in Cape Town (Figure 2b) and 6 h in Bloemfontein (Figure 3b) and Johannesburg (Figure 4b). This trend continued to recent times as the 2012 data showed, where the longest precipitation event in Cape Town (Figure 2c) was for 15 h, for Bloemfontein 14 h (Figure 3c) and for Johannesburg 16 h (Figure 4c). When looking at the type of precipitation events that occurred, thunderstorms were rare in the earlier years when compared to recent times at all three station.

CONCLUSION AND FURTHER RESEARCH

Looking forward, it is clear that changes in temperature and precipitation patterns will continue. With the ever growing population, more and more people will be subjected to the impacts of climate change. Weakened and old infrastructural water supply networks will not be able to cope with the demand for clean and safe water (DWA, 2011). The envisaged increased lack of access to clean water will lead to child deaths from water-borne illnesses. Flooding from extreme weather events can introduce contaminants and diseases into water supplies and create an even more dangerous environment for children by increasing opportunities for diarrheal and respiratory disease (UN Habitat, 2011). Changes in temperature, precipitation and humidity could influence vector-borne diseases, for example malaria, Lyme disease and schistosomiasis (WHO, 2009). It is not unreasonable to conclude that many regions could also suffer undernourishment and famine. This preliminary study has clearly demonstrated that more studies are needed in South Africa and planning for the impact of climate change cannot be postponed.



90°F
80°F
70°F
60°F
50°F
40°F
30°F
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Jan 5 85°F
Feb 15 91°F
Mar 28 88°F
Jun 12 85°F
Aug 13 72°F
Oct 9 89°F
Nov 25 85°F
Jan 20 62°F
Mar 5 54°F
Apr 15 51°F
May 25 38°F
Jul 29 35°F
Sep 15 47°F
Nov 3 56°F
Dec 19 58°F
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Jan 14 91°F
Mar 11 91°F
Apr 20 88°F
Jun 12 82°F
Aug 21 84°F
Nov 2 90°F
Dec 25 84°F
Jan 6 57°F
Mar 8 52°F
May 9 45°F
Jul 3 36°F
Aug 15 39°F
Sep 30 45°F
Nov 14 48°F
Dec 24 55°F
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Jun 4 82°F
Jul 18 79°F
Sep 16 93°F
Nov 1 86°F
Dec 26 91°F
Jan 4 53°F
Mar 6 52°F
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Apr 30 86°F
Jul 1 73°F
Aug 24 84°F
Oct 3 91°F
Nov 19 93°F
Feb 12 46°F
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Jun 12 21°F
Aug 9 20°F
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Nov 26 38°F
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Apr 8 77°F
May 21 71°F
Jul 8 63°F
Aug 19 79°F
Oct 15 83°F
Nov 28 81°F
Jan 15 55°F
Feb 26 55°F
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Mar 5 54°F
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Jan 4 84°F
Mar 4 84°F
May 1 79°F
Jun 30 72°F
Aug 24 81°F
Oct 4 86°F
Nov 21 86°F
Feb 12 50°F
Apr 10 41°F
May 21 30°F
Aug 13 28°F
Sep 29 37°F
Nov 26 46°F
i

Figure 1: The daily low (blue) and high (red) temperature in Cape Town during (a) 1949, (b) 1980, (c) 2012, Bloemfontein (d) 1949, (e) 1980, (f) 2012, and Johannesburg (g) 1956 (h) 1980, (i) 2012, with the area between them shaded gray and superimposed over the corresponding averages (thick lines), and with percentile bands (inner band from 25 to 75th percentile, outer band from 10 to 90th percentile). The bar at the top of the graphs are red where both the daily high and low were above average, blue where they were both below average and white otherwise (Source: WeatherSpark Beta).

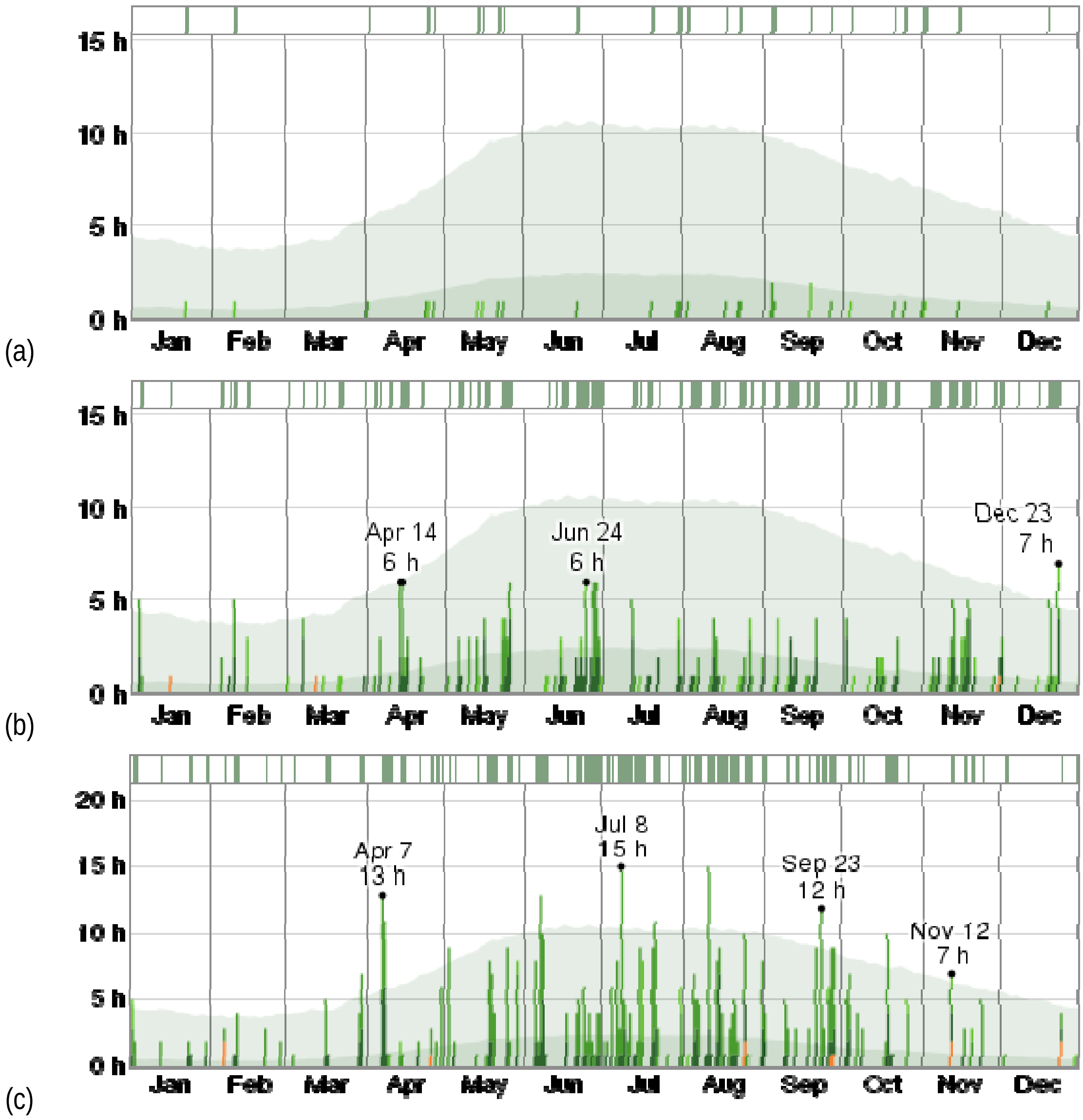

Figure 2: Daily number of hourly observed precipitation reports for Cape Town during (a) 1949, (b) 1980 and (c) 2012, color coded according to precipitation type, and stacked in order of severity. From the bottom up, the categories are thunderstorms (orange); heavy, moderate, and light snow (dark to light blue); heavy, moderate, and light rain (dark to light green); and drizzle (lightest green). The bar at the top of the graph is green if any precipitation was observed that day and white otherwise (Source: WeatherSpark Beta).

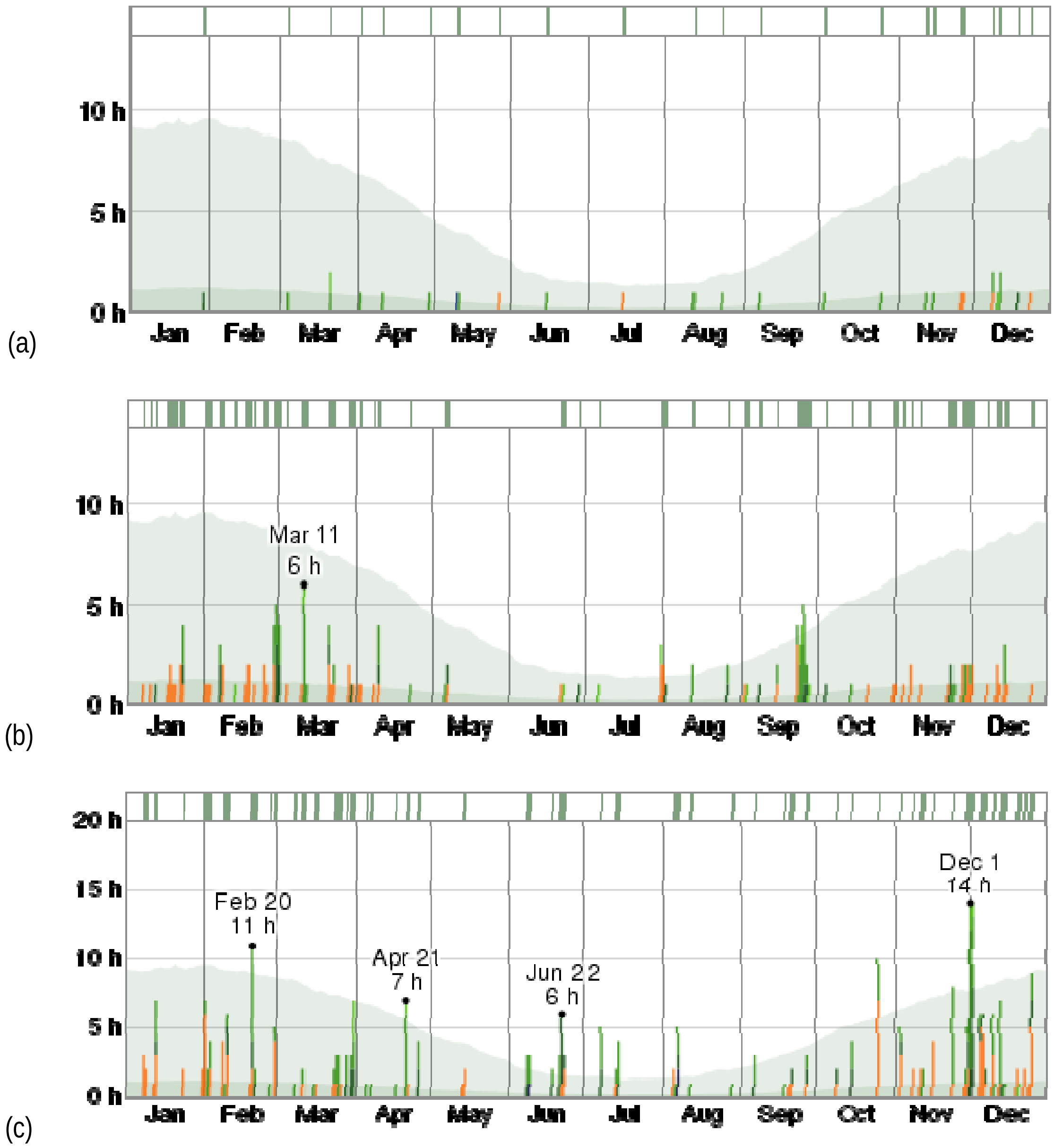

Figure 3: Daily number of hourly observed precipitation reports for Bloemfontein during (a) 1949, (b) 1980 and (c) 2012, color coded according to precipitation type, and stacked in order of severity. From the bottom up, the categories are thunderstorms (orange); heavy, moderate, and light snow (dark to light blue); heavy, moderate, and light rain (dark to light green); and drizzle (lightest green). The bar at the top of the graph is green if any precipitation was observed that day and white otherwise (Source: WeatherSpark Beta).

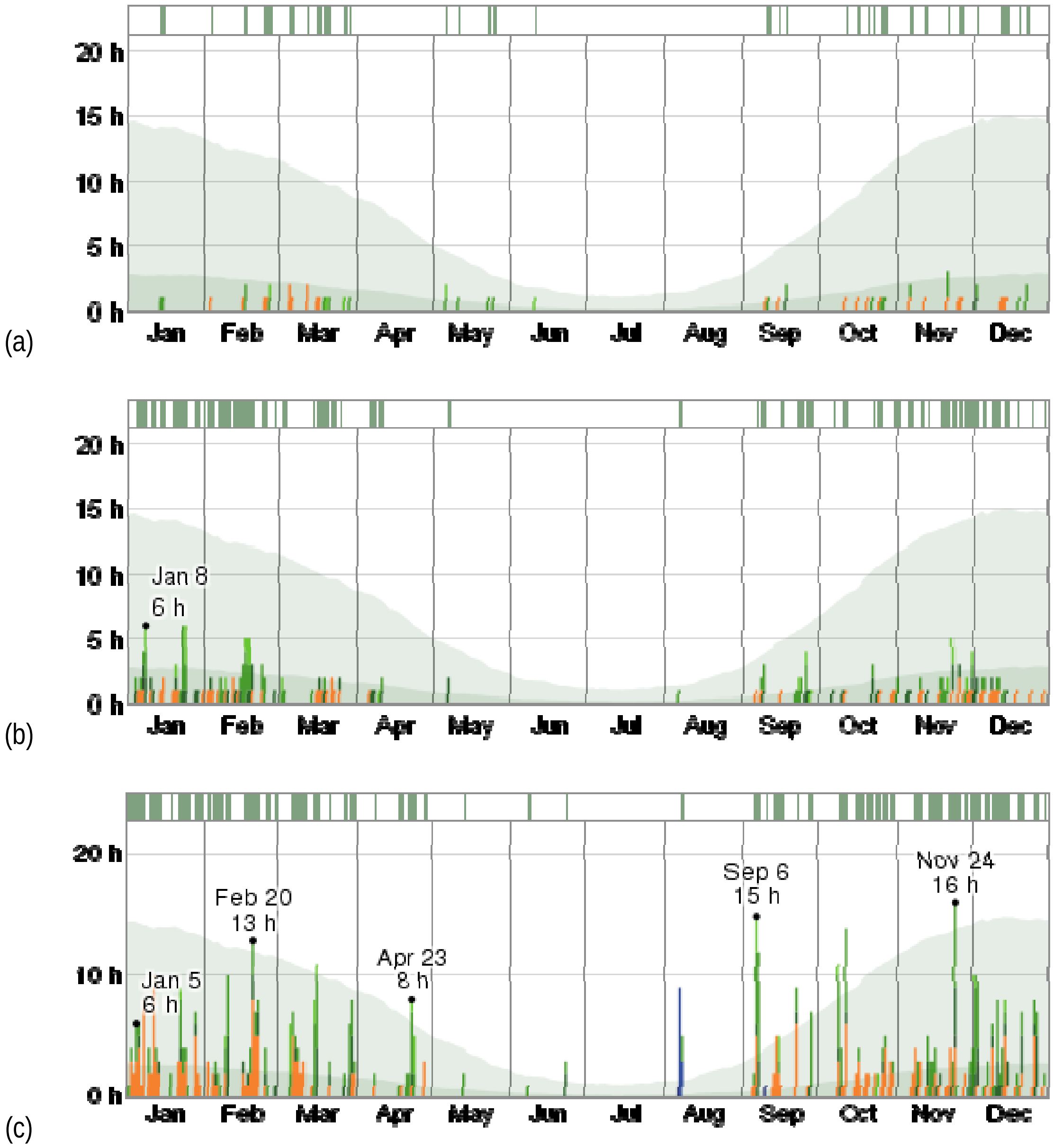

Figure 4: Daily number of hourly observed precipitation reports for Johannesburg during (a) 1956, (b) 1980 and (c) 2012, color coded according to precipitation type, and stacked in order of severity. From the bottom up, the categories are thunderstorms (orange); heavy, moderate, and light snow (dark to light blue); heavy, moderate, and light rain (dark to light green); and drizzle (lightest green). The bar at the top of the graph is green if any precipitation was observed that day and white otherwise (Source: WeatherSpark Beta).

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ACHIEVING SUSTAINABLE QUALITY WATER SUPPLY AND MANAGEMENT: A CASE OF MBEYA REGION, UNITED REPUBLIC OF TANZANIA

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Abstract:

This paper proposes to embracement of community - based water resource management (CBWRM) as an option of managing Vwawa sub catchment water resources. CBWRM spearheaded by the establishment of catchment and sub catchment committees, Water User Association (WUA) may be a more realistic option for involving local water users. The strength in enhancing CBWRM lies within the existing policy, legal and institutional framework. The approach provides tangible benefits for Water users and other development organizations because it encourages participatory monitoring of water resource, quantity and quality that sustain water resources systems. At present not all generated solid waste is collected, stored, recycled or disposed. Furthermore, the current financial and technical capacity of Tunduma and Vwawa to handle solid waste management is rather limited. Ineffective solid waste management had contributed to littering of wastes in both Tunduma and Vwawa towns posing danger of water sources pollution issue raised by community member during focus group and individual interviews. Lack of proper dumping facilities and poor town planning experiencing its 75% of people living in squatter unplanned areas add to difficult of waste management. To avoid water pollution from wastes generated in Tunduma and Vwawa it is recommended to establish community based solid waste management as the only sustainable systems that are economically affordable, socially acceptable and environmentally effective for the small towns.

Keyword: Development, Governance, Livelihood, Sustainability, Water, Tanzania

INTRODUCTION

Water is fundamental for sustainable development. It affects inter alia sanitation, health, poverty alleviation, disaster reduction, and ecosystem conservation, and cuts across all eight Millennium Development Goals, in particular MDG 7 and its target to reduce, by half, the proportion of the 2.6 billion people without access to safe drinking water and basic sanitation by 2015 (WATz, 2012). In addition, the ever growing vulnerability that is induced by global and local changes such as population challenges, climate changes and variability, socio-economic issues and environmental degradation, can result in increasing both the frequency and severity of extreme events, including droughts and floods (Montgomery *et al.*, 2009). Integrated Water Resource Management work toward optimizing the available natural water flows, including surface water and groundwater to satisfy competing water needs.

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Water resource management involves activity of planning, developing, distributing and managing the optimum use of water resources (Mwendera, 2010). In an ideal world, water resource management planning has regard to all the competing demands for water and seeks to allocate water on an equitable basis to satisfy all uses and demands (Grafton *et al.*, 2011). Waste-water treatment, water recycling and demand management measures are being introduced to counter the challenges of inadequate water supply. In addition to problems of water quantity there are also problems of water quality. Various studies had proved that pollution of water sources is posing major problems for water users as well as for maintaining natural ecosystems (IRC, 1997; HACH, 2011; Thulani, 2012). In study areas it was noted that there are low understanding on water resource management, laws and enforcement concern on resources management. The assessment done in Vwawa and Tunduma towns indicates that water governance and management (Policy and law awareness), enforcement and compliance are inadequate and ineffective. Poor stakeholders' participation and accountability mechanisms were also noted making it difficult to achieve collective responsibility in management of water resource. There are inadequate water resources data and information as well as inadequate capacity both in terms human and financial resources that limit monitoring of both underground and surface water.

Study in Vwawa and Tunduma town council show that solid waste management is not proper managed the reasons that have contributed to ineffective solid waste management include; inadequate infrastructures for waste management i.e. dumping, disposing, collection and transportation, inadequate capacity of waste management and monitoring, Poor Solid Waste disposal and lack of funds to finance solid waste collection. Littering of solid wastes and liquid wastes expose its dwellers to various health threats and water sources contamination.

Problem Statement

Urban areas in Tanzania are experiencing rapid expansion. The population is growing at a rate of more than 6% per annum **(**URT, 2002), which is exerting enormous strain on the delivery of various services including water and sanitation services. According to Tanzania Government report 2009, between one third and one half of the urban population lives in unplanned or squatter areas and in Tunduma and Vwawa 75% of town dwellers are living in squatters. Apart from being of generally poor housing, the areas are characterized by high population density and general deficiencies in infrastructure services including water and sanitation (WASSA, 2010), (VUWSA, 2011). In my ten years working experience and WaterAid Tanzania report 2010 show in many areas of Tanzania the existing water supply infrastructures and water sources are old and inadequate to meet the ever increasing demand for water. Major issues and challenges facing the urban water supply and sanitation services sector include inadequate water supply both in quantity and quality, poor billing and revenue collection, and lack of an enabling environment for private sector participation (USAID, 2010).

Integrated Water Resources Management (IWRM) play a key role in addressing these needs and challenges. However, progress towards implementing IWRM has so far varied widely depending on the area, capacity, political will, and understanding of IWRM concepts and their implementation. Experience with SEMA had shown that implementing IWRM at the river basin level is an essential element to managing water resources more sustainably, leading to long-term social, economic and environmental benefits. A river basin approach provides a practical framework, defined by geographical and hydrological characteristics, which facilitates implementation of IWRM by involving downstream and upstream basin wide issues as well as incorporating environmental and socio-economic aspects (Doe and Khan, 2004).

A 2010 report from the Tanzanian Ministry of Water and Irrigation stated that, out of 41.3 million people in Tanzania, approximately 18.5 million currently do not have daily access to a source of clean water. However, the same Report indicated that over 21,000 children under five die of diarrhoea diseases every year, disease related to poor WASH services. The majority of the un-served live in rural areas and on average, women and children spend more than two hours each day in the collection of water (SEMA, 2012). Another report from the same Ministry of Water in 2010 indicate that there is decreasing water resource and it is estimated that water supply per person had decreased from 2,700 M^2 in 1999 to 2225 M^2 in 2009 annually. However the decrease is expected to be as high as to lower level up to 1,500 M^2in 2025 and if the problem not addressed it will lead to serious shortage of water.

The CBWRMA employ community participatory approaches tools in involving and putting people to the centre on management and use of water. The approach enhances the potential roles for community members on water resource management with greater emphasis on ensuring sustainability, quality, accountability, community governance, equity and inclusiveness. This study therefore explore and identify the limiting factors toward community participation on management of water resource that will at the end help development practitioners design interventions to achieve appropriate water resource management with greater emphasis on ensuring sustainability, quality, accountability, community governance and inclusiveness. However a study provides the key recommendations that will provide a link among identified stakeholders to achieve collective responsibility in management of water resource.

This paper therefore, intends to help Local authorities in Tanzania on setting up a programme of work to increase access to clean and safe water supply leading to long term social-economic and environmental benefits. The study also identifies and assesses the challenges of community participation on management of water resource and provides alternative solution to bridge away identified gaps. The recommendation however will help development practitioners, Government agencies and donors working in unplanned towns like Tunduma and Vwawa who 75% of residents live in unplanned settlements design interventions that will help community members access both clean and safe water, hygiene and sanitation services and increase and improve revenue collections by water and sanitation authorities.

LITERATURE REVIEW

Poor access to safe and clean water, sanitation, hygiene practices and safe water influences susceptibility to infections of water borne and sanitation related disease such as diarrhoea, helianthus and others (Moeller, 2005). Poor water resource management contribute to inadequate WASH services putting majority of young people, women and men at risk of getting communicable diseases that could have been prevented by improving access to clean and safe water to the community. IWRM is an essential element to managing water resources more sustainably, which facilitates involvement of downstream and upstream water users (Molden, 2007).

Policy and legal contexts on management of water resources

The Constitution of the United Republic of Tanzania (1977) is the supreme law, Article 14 guarantees every citizen the right to life and hence the right to access and use the country's natural resources including land, water, forests, and minerals. All citizens are expected to have a stewardship responsibility over the natural resources, including water. The current policy framework for water sector is set out in the National Water Policy (NAWAPO 2002), which is oriented towards reaching the Millennium Development Goals (MDGs) for water and sanitation and incorporates the overall development goals set out by the national Vision 2025, the National Poverty Reduction Strategy. Together with these policies in practices, the Water Resources Management Act No.11 of 2009 (WRMA) and Water Supply and Sanitation Act No.12 of 2009 were enacted. The institutional framework provided for under the National Water Policy (2002) and Water Resources Management Act (2009) is quite elaborate and inclusive.

In order to effectively manage water resources in Tanzania, NAWAPO 2002, has set out appropriate levels of management which also gives mandates to communities being "responsible for local level management of allocated water resources, mediation of conflicts, participate in preparation of water utilization plans, conservation and protection of water sources and catchment areas. The policy aims at to achieve effective and efficient water use, enforcement of the law and implementation of conditions of water rights (NAWAPO, 2002). In light of the above, communities can therefore participate through established Water User Associations.

The establishment of WUAs is also in line with National Water Sector Development Strategy (NWSDS) of 2006 and the WRM act No 11 of 2009. The Water Resources Management objective of the NAWAPO (2002) is to develop a comprehensive framework for promoting optimal, sustainable and equitable development and use of water resources for the benefit of all Tanzanians based on clear set of guiding principles. For participation to take place the NAWAPO provides that WUAs or Water User Groups (WUGs) will be the appropriate level of local level water management. The institutional framework for WRM as elaborated in the NAWAPO (2002) identifies five water management levels namely the national, basin, district, catchment/sub catchment, and community or Water User Association. WUAs have a responsibility for local level management of allocated water resources.

WUA Capacity

Basin Water Board has been mandated by the law and involved in the establishment of Water User Associations (WUAs) as institutions for water governance at local level (URT, 2009). The aim is to decentralize water management with an objective to ensure decisions are taken at the lowest appropriate level through consultation and involvement of users. Establishment of WUAs is part and parcel of basin initiatives to implement the principles for IWRM so that stakeholders at each level play a positive and effective role in sustainable water resources management. Ultimately, each WUA are intended to facilitate attainment of three strategic objectives of water management namely efficiency, equity and environmental sustainability. So far interview with community members noted that, the established WUAs have not been able to achieve objectives for which they were established and hence the need to build and develop their capacities so that they are able to discharge water resources management function such as control of water pollution, water allocation, conflict resolution, ensure equity and promote stakeholder participation.

Water Policy and other ministerial policy

In 2011, Dr. Tumaini A. Kimaro, reported that Tanzania receives 200mcu litre per annum (less than 1,000 cu liters per annum) which clearly show there is a growing challenge on use and management of water in the country and worldwide. Formulated energy policy, agricultural and livestock policy, rural development, land and human development policy as well as other policies give little attention on water resource management rather emphasizes the supply of water to meet policy objectives and target. Such conflicting policies will never derive the country toward collective responsibility on management of water resource. To manage better water resource there is a need to consider different levels on water use and management giving attention in the priority areas in the country that are in critical need.

Interview with community members' revealed several competing water uses in the sub catchment for irrigation, livestock, wild life, environmental and domestic water use. Effective monitoring and regulation of water use is therefore critical from the standpoint of assessing the integrity of the water distribution system, issuing permits, and collecting water use fees. Though the Water Act (2009) establishes a regulatory framework for water allocation and use, it was also noted the culture of registration of water use has not yet taken root in the sub catchment. The 75% of water users interviewed have not applied for water use permits. This has led to several water use conflicts between downstream and upstream water users. Lack of a strong regulatory framework has often resulted in excessive water use by the upstream water users leading to significant reductions in flows and serious negative impacts on downstream water users in the Vwawa sub catchment.

Water rights

Discussion with the community revealed little awareness and understanding on water resource management and related policy and laws. It was observed that individuals with financial capability in the community construct local canal and diverge river water for irrigation purposes without permission from Basin office who are responsible by the law to offer water use right. Most of canals pass number of meters to different farms plots and the owner of the canal charge the service of irrigation water to the water users that created un-ended water conflicts to the community. It was also noted that owners of the canal however don't consider the provision of water to the whole community and including marginalized community members and therefore denied their right to access water for domestic and production purposes.

Facilitation of community members on acquiring water rights is very crucial in management of water resource. The water permit offered by the Basin board has rules and the obligation attached in which bearer have to observe. This includes management water resource and protection of environment and safeguard of water quality from all sort of pollution. Failures to abide to these obligations the authority can with held back the water right and offer to another water user or discard the offer as well. Acquiring water rights following by awareness creation on existing law and policy and enforcement however can help reduce mismanagement of water resource at community level and reduce environmental degradation and water pollution to water sources.

Water Sources pollution and destruction

Field visits to water sources and observation in Tunduma and Vwawa during primary data collection proved that pollution from point and non-point sources is a major concern. Interview with community member's show there is applications of pesticides and fertilizers to irrigated cropland along river beds that may result in significant additions of contaminants to water resources. Poor agricultural practices are also contributing to increased river erosion and siltation. The widespread deforestation in the sub catchment has left the soil vulnerable to erosion by surface runoff, increased silting of the rivers and the severity and frequency of flooding events in the sub catchments that were reported. Poor sanitation due to low latrine coverage observed in Tunduma and Vwawa (about 44%) and high generation of various wastes is also the causes of pollution of surface and groundwater (VUWASA, 2011). This however contribute to the costs of water treatment due to the increased pollution load that has a direct influence on the water tariffs by pushing up the cost of piped water beyond the reach of the urban poor and exposing them to health risks as well.

Local level institutions

Discussions with the districts and town councils noted that the local authorities are responsible for planning and development of water resources in accordance with basin plans, protection and conservation of natural resources in the villages and wards. The Councils have the responsibility in establishing by-laws on the management of water resources and conflict resolution in accordance with established laws and regulations. In addition the District Councils have to make assessment of water demands of their respective districts and participate fully in the preparation of Basin plans. Unfortunately this has not been the case in the study areas. Interviewing both the Lake Rukwa Basin and respective district/town councils, showed a broad communication gap and noted that catchment committee which are platform for opening up the gap have not been established. For water supply, the District/Town Councils through their District Water and Sanitation Teams (DWSTs) support local communities in identifying needs and preparing community water supply plans. That means services are provided based on a demand-response approach.

Water Supply and Sewerage Authorities are also key stakeholders at local level in management of water resource. In 2004 both VUWSA and TWSSA were established aimed at improving and providing a better Water Supply and Sanitation services on sustainable basis. Its Board members are appointed by the Minister responsible for local government. The organisations are regulated by the Energy and Water Utilities Regulatory Authority (EWURA) which is responsible for issuing operating licenses, monitors and regulates WSSAs based on a business plan. Village governments have social services and environment committee responsible primarily on water use, guardians and managers of water sources. However discussions with village leaders show that their participation in decision-making, planning, management and implementation of water resources management and development do not exist. Each village has a water supply committee with the responsibilities of managing the water sources and collecting fees to maintain the supply network, ensure sustainability and prevent pollution. SEMA experience show that water committees sometimes clash with village governments and Water user's associations over their responsibility and mandate. In some areas of the study area farmers' associations/groups that manage water for irrigation tend to be stronger in sub catchment areas with irrigation infrastructure and not always inclusive within the village government structures.

Community Owned Water Supply Organizations (COWSOs) are legally authorized by the community, own, manage, operate, and maintain the water supply systems on behalf of the community. COWSOs are in the form of a Water Consumer Association (WCA), Water User Groups (WUG), Cooperative Society or other groups recognized by law. COWSOs meet all their operations and maintenance costs through charges levied on water consumers. Although WUA and COWSO are defined separately, in reality its members are the same people.

Non state actors

Interview with local leaders and Rukwa water basin staff show, WUAs are legal entities to manage and protect water resources at the lowest basin level. The WUA members are smaller informal and/or formal Water User Groups including individual or groups of irrigation water users, fishermen, pastoralists and representatives from other user of water (JUWAMBOZI 2012), (JUWAMAMLO, 2012). WUAs are responsible for promoting fair water sharing among their members; drafting and enforcing water use rules in accordance with their constitutions; and providing support to the basin water board in water resources management at the local level. It was noted that the WUA sustainability and basin coverage in formation of other WUA is questionable as the basin lacks funds for strengthening their functioning and depends on external assistance which does not exist in the sub catchment.

METHODOLOGY AND DATA COLLECTION

The baseline study was conducted in February, 2013 and consisted of the administration of individual questionnaire (of different age, sex and education background); household questionnaire, focused group questionnaire, observations, formal and informal institutional questionnaires.

Description of the study area

Mbozi and Momba districts are located in the South Western corner of Mbeya Region in Tanzania, between Latitudes 8^o and 9^o 12 South of the Equator and Longitudes 32^o 7' 30" and 33^o 2' 0" East of Greenwich Meridian. Tunduma Town is located at the boarder of Tanzania and Zambia about 103 km from Mbeya City at Latitude 9^0 16’ and Longitude 32^0 44’E. It covers an area of 102 squares kilometers with a projected population of 45,167 in 2010 and an annual growth rate of 3.1 %. The town is subdivided into 11 sub areas. Vwawa Township is 71 km from Mbeya city and covers an area of squares kilometres with a projected population 51,468 People for year 2013.

Population and ethnic characteristics

The study area is predominantly rural with about 80% of the population living in rural areas and 20% in urban areas (LRWBA, 2011). Interview with head of department suggests the labour force age brackets of 16-55 years forms 44% and the oldest cohort of 55 years that makes up to approximately 7% of the district population. This situation suggests a district age dependency ratio of 0:75:1. Population growth rate exerts pressure on the basin natural resources, communities’ risks and threats to their water supplies and solid waste management. The average size of a household is five people with a patriarchal structure average of 4.6 people per family. The sex Ratio is 99:100 with life expectancy between 45-48 years of age (LRWB, 2012).

Research design

The research design used was descriptive survey aiming at collecting necessary primary and secondary information from different categories of respondents on status of Water resource management, governance and practice in which both simple random sampling and purpose sampling were employed.

Sampling techniques

Both purpose and simple random sampling were used on collection of primary data. Interview with district staff was purposely sampled in which head of department from water, land, environment, health and natural resource management were involved. A total of 98 individuals simple randomly selected 49 in each township of Vwawa and Tunduma were interviewed between 18-65 years of age.

Data Collection Methods

Focus group discussion was also conducted where by participatory methodologies and techniques were employed to ensure full participation of the sampling group irrespective of their age, sex, education and income background. Data and Information collection tools were mainly through semi structured Interviews with the Target Group. Interview was carried out to District management team, Health facilities, Water and Sanitation authorities, Basin officials and regional secretariat to obtain required data. Group interview was also carried to local Institutions, Community Based Organisations (CBOs) and Faith Based Organisations (FBOs) with their presence in the study area. Other methods of data collection was review of documents and reports to obtain secondary information from Vwawa and Tunduma Town authority, Mbeya region office and Rukwa Basin office. Physical observation and site visits was conducted to all developed and undeveloped water sources

Data analysis methods

The collected data was analyzed manually and using excel Computer programme that helped to provide relevant information and trends on management of water resource and status of water supply in Tunduma and Vwawa towns.

FINDINGS AND DISCUSSIONS

The results of the study in Vwawa and Tunduma indicates that water governance and management (Policy and law awareness), enforcement and compliance; are inadequate and ineffective including stakeholders participation and accountability mechanisms. There are inadequate water resources data and information; inadequate capacity both in terms human and financial resources; Political will, community responsiveness and commitment are the major factor that threaten water supplies for domestic and livelihood uses. Other factors are inefficient water distribution and use, environmental degradation; socioeconomic factors and Climate change. According LRWB officials, no discharge measurements was conducted this year because there were no funds allocated to carry out such activity in 2012/13 Government financial year. Boreholes and shallow wells are the most commonly used water supply options in the study area. There are more than 26 registered boreholes in the Momba and Mbozi districts. Interview with staff from Rukwa basin proved that Geophysical investigations surveys revealed good groundwater potential in the project area to the depths of up to 250 meters in some of the valleys. (WREM, 2012).

The government has put in place policies and the mandated institutions from the national to household (water users) level that are meant to respond to water resource and water supply management. However the mechanisms, processes, and institutions through which all stakeholders, including water users, interest groups, the poor and marginalized living in Tunduma and Vwawa to articulate their priorities, exercise their legal rights, meet their obligations and mediate their differences is still missing. The process of WUAs formation is very slow and their existence could have improved the situation as these are legal entities to manage

and protect water resources at the lowest basin level. Water and sanitation authorities lack leadership and management skills, have inadequate, unmotivated personnel and do not interact frequently with partners as a result low revenue collection and inability to supply clean and safe water to its customers . More to this it was noted that Lake Rukwa Water Board, Mbozi and Momba district Council, Tunduma and Vwawa town councils, VUWSA and TWSSA lack data, information, platform and capacity for feedback on the quality and quantity of water resources.
Despite the existence of good laws and by laws as far as management of water resources is concern, it was noted that the laws are not well understood by key stakeholders including the Water users. The local government at all levels lacks relevant understanding, capacities, and guidelines needed to enforce the law. Enforcement of WRMA is limited not only because of awareness, but also due to inadequate monitoring, compliance and funding.

It was also noted that the existing irrigation infrastructure is particularly problematic due to the high consumptive nature of irrigation water use. The irrigation sector in the sub catchment is dominated by traditional irrigation schemes with inadequate and poorly constructed infrastructure, managed by farmers with very limited financial capacity and managerial skills to efficiently operate a good irrigation enterprise. As a result, the schemes suffer from high water losses, poor water use efficiency, and low productivity. The water loss situation is also similar in the improved schemes where actual water abstractions are often more than the permitted allocations. Solid wastes found in Tunduma and Vwawa are the by-product of a broad spectrum of agricultural, service and manufacturing processes. Most of the waste is not collected because of poor solid waste management at household level exposing water sources to pollution. In the study area, plastic bags and bottles of all sizes and colours were found dotting the landscape.

Interview with Town health Officer in Tunduma show that waste from homes (about 65% of waste generated) is collected by family members mostly women and children directly to eight (8) transfer stations or an open dumping site. Only between 20% – 30% (40 – 70 tons) of the estimated 200- 235 tons of solid waste generated daily in Tunduma gets collected and transported to the designated dumping yard/site. The town council has a capacity of transferring to the dump site an average of 80 tonnes /day which is about 30% of the generated solid wastes. About 100 to 163 tonnes which is about 70% remain at the transfer stations every day. Due to rapid increase in population and rising of standard of living for both Vwawa and Tunduma the waste is expected to double in 5 years to come.

CONCLUSIONS AND RECOMMENDATIONS

Putting in consideration weak enforcement, low political commitment, limited technical and financial capacity faced by the LRBWO, Mbozi and Momba districts, and recognizing the need for the establishment of effective governance in enhancing transparency, openness, integration, equality, efficiency, compliance, effective participation and accountability and noting the importance of improving management of water resources at a local level it is hereby recommended to embrace Community- Based Water Resource Management (CBWRM) as the only option of managing Mlowo sub catchment water resources. CBWRM spearheaded by the established WUA may be a more realistic option for involving local water users. The strength in enhancing CBWRM lies within the existing policy, legal and institutional framework.

There is a need to harmonise water related legislation or regulations and build the capacity of stakeholders to be aware on what law apply where and how. This should go in hand with LRBWB lobbying for local political will and strengthening enforcement capabilities. If

LRBWB is to play an important role in good water resources regulation, it is crucial to invest in their staff as well in terms of skill development and required working facilities.

In ensuring sustainable financing, it is recommended Basin authority to establish levy, collect and use fees for purposes. Strategies to improve the financing and sustainable management of water resources would include improved billing and fee collection, creation of awareness to water users about importance of participatory water resources management to promote their willingness to pay, provision of incentives and disincentives for the user fee, promotion of partnership, enforcing existing bylaws/legislation on user fee, looking for external support and contributions from indirect beneficiaries e.g. national parks. Overall, increasing the enforcement and collection of water fees is considered to be the most effective way of increasing income and help basin authorities in financing WRM activities.

The first step in reducing NWR is to develop an understanding of the big picture of the water system, which involves understanding how much water is lost, the magnitude, sources, and cost of NWR when the entire system input is metered. To accomplish this, the public need to be involved and understand how they can help manage NWR. Initiatives to reduce physical losses of water may be established, replacement of old water facilities to effective new one, computerizing the leak reporting register and monitoring is recommended. To improve revenue collection development of operation and maintenance schedule, redefining the existing procedure documenting and reporting of water flow, and devising a plan for providing assured water supply at full cost recovery status. Integrated Solid Waste Management (ISWM) incorporating community based solid waste management (CBSWM) is the only sustainable systems that are economically affordable, socially acceptable and environmentally effective for Tunduma and Vwawa towns. An integrated solid waste management system involves the use of a range of different treatment methods, and key to the functioning of such a system is the collection and sorting of the waste. It is important to note that no one single treatment method can manage all the waste materials in an environmentally effective way. Hence in addition, this report recommends the promotion of the use solid and liquid waste as manure and if possible uses vermiculture treatment of vegetable food waste. Encouraging solid waste reuse, recycling and reduce approach is recommended.

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DESIGN PHASE CONSTRUCTABILITY IMPROVEMENT STRATEGIES FOR HIGHWAY PROJECTS IN UGANDA

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Abstract
There is great concern a regarding the escalation of project costs and delayed completion of road works. This has been partly associated with lack of constructability. Studies have demonstrated that improved constructability leads to significant improvements in project cost savings and reduced completion times. The main aim of this study was to establish design phase constructability improvement strategies for highway projects in Uganda. A pragmatic approach of both qualitative and quantitative research methods was used for this study. Concepts of constructability were identified and rated. Using factor analysis, major design phase constructability improvement factors were identified. These major factors include: carry out formal constructability reviews; ensure adequate design of materials, communication, coordination and schedules; analysis of jobsite accessibility and storage requirements; engage experienced personnel, and adopt CAD; ensure thorough site investigation and clear design information and; develop designs that are sensitive to safety and weather conditions. The major recommendation is to include constructability reviews to form part of the formal design process, using a separate team of construction experts (consultants), different from the design consultant before the construction stage of the project.

Keywords:
Constructability, Design phase, Highways, Strategies, Uganda

INTRODUCTION

There has been increasing concern world over among transportation officials, contractors and design professionals that the plans and specifications do not always allow highway projects to be constructed as designed (American Association of State Highways and Transportation Officials (AASHTO), 2000). When this occurs, projects are delayed, project costs increase, and frequently costly construction claims develop. Of equal concern are the delays and disruptions to motorists, and the impact of delayed transportation projects on the economy (AASHTO, 2000). In Uganda, several road projects have experienced delays and cost overruns due to lack of constructability as manifested by design disputes between the clients, contractors and consultants. According to the Public Accounts Committee (PAC) Report (2010), the 21 km long Kampala - Northern by-Pass road was delayed twice due to design disputes, and both disputes were settled by award of costly claims to the contractor. The Auditor General's Report (2010) about the roads reported that some designs for road works were found to be improper, with excessive or inadequate quantities, and often lacking necessary drawings. Furthermore it was noted in the same report that most designs were not taking into account the use of the most appropriate and economical solutions.

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According to Anderson *et al.* (1999), constructability is seen as one of the best solutions to problems where there is demonstrated potential to minimize the number and magnitude of changes, disputes, cost overruns, and delays during construction. According to Bambang (2004), the concept of constructability emerged in the late 1970s, out of research on how improvement could be achieved to increase cost efficiency and quality in the construction industry. The studies in the USA, UK and later in Australia have demonstrated that improved constructability leads to significant savings in both cost and time required for completing construction projects (Bambang, 2004). According to Wright and Obrien-Kreitzberg (1994), early constructability efforts result in a significant payback to the project, with cost reductions of between 6% and 23%, and benefit / cost ratios of up to 10:1, as well as large schedule reductions being achieved. However, as with most construction projects, implementing highway constructability improvement can be very challenging, since it is important to consider the uniqueness of the construction industry in a country. Researchers in the developed countries have identified this short coming and suggested various approaches to mitigate it (Bambang, 2004). However, in developing countries, there is a dearth of knowledge on efforts to improve constructability. This could be partly because constructability has not been understood by the stakeholders. The overall objective of this study was to establish design phase constructability improvement strategies for highway projects in Uganda.

LITERATURE REVIEW

According to the Construction Industry Institute (CII) (1986), constructability is defined as "the optimum use of construction knowledge and experience in planning, designing, procurement and field operations to achieve the overall project objectives" while the Construction Industry Institute Australia (CIIA) (1996), defined constructability as "the integration of construction knowledge in the project delivery process and balancing the various project and environmental constraints to achieve project goals and building performance at an optimal level". These definitions highlight the blending of construction knowledge into the project delivery process, encompassing all project stages and paying attention to environmental constraints, to achieve desired project goals, at an optimal level. For purposes of this study therefore, constructability was taken as an approach that integrates construction knowledge and experience in the project delivery process, especially at the design stage, to minimise the cost and time required to complete the project. To achieve this, experienced construction personnel are involved with the project from the earliest stages, especially at the design stage.

Several studies on constructability have been conducted since the late 1970s and from these studies; several concepts have been stated for the various project stages. For purposes of this research, focus has been on design phase constructability concepts. According to Anderson *et al*. (1999), it is generally agreed that the maximum benefits of constructability occur when constructability is started at the inception of a project. It is during the early project phases that key decisions regarding project scope are made and scope changes are implemented with minimum difficulty. These decisions, if made in a timely manner, can result in maximum savings to the project.

Construction Industry Research and Information Association CIRIA (1983) conducted one of the earliest studies on design phase constructability concepts in the UK. According to their study, CIRIA identified seven constructability concepts for implementation during design phase. The concepts included: carry out thorough investigation and design; plan for essential site production requirements; plan for a practical sequence of operations and early enclosure; plan for simplicity of assembly and logical trade sequences; detail for maximum repetition and standardization; detail for achievable tolerances; and specify robust and suitable materials. Research by Adam (1989) found out early phases constructability concepts of: Investigate thoroughly; consider access at the design stage; consider storage at the design stage; design for minimum time below ground; design for early enclosure; use suitable materials; design for the skills available; design for simple assembly; plan for maximum repetition and/or standardisation; maximise the use of plant; allow for sensible tolerances; allow for a practical sequence of operations; avoid return visits by trades; plan to avoid change to work by subsequent operations; design for safe construction; and communicate clearly.

Table 1: Summary of Design Phase Constructability Concepts

S no.	Design Phase Constructability Concepts	References
1	Carry Out Thorough Investigation of the Site	CIRIA, 1983
2	Provide detailed and clear Design Information, including Plans and Specification	Nima *et al*., 2002; Rosli, 2004
3	Carry out formal, and adequate Early Review of the Designs	Rosli, 2004; Siti, 2005
4	Plan for Adequate Coordination of Designs, Plans and Specifications	Adam, 1989; Anderson *et al*., 1999
5	Design for Effective Traffic Control	Adam, 1989; Anderson *et al*., 1999
6	Analyze Accessibility of the Jobsite	Adam, 1989; Nima *et al*., 2002;
7	Investigate the Practical Construction Phasing and Scheduling	Boyce, 1991; Rosli, 2004
8	Investigate Any Unsuspected, Unrealistic or Incompatible Tolerances	Ciria, 1983;Adam, 1989; Siti, 2005
9	Consider suitability of Designed Materials	Boyce, 1991; Rosli, 2004
10	Design for the Skills and Resources Available	Adam, 1989;Rosli, 2004
11	Employ Computer Software Design and Visualization Tools	Newton, 1998; Rosli, 2004
12	Consider Storage Requirements at the Jobsite	CIRIA, 1983;Adam, 1989; Rosli, 2004
13	Investigate the Impacts of Design on Safety During Construction	Adam, 1989;Rosli, 2004; Siti, 2005
14	Consider Adverse Weather Effects in Selecting Materials or Construction Methods	Nima *et al*., 2002; Rosli, 2004
15	Design for Simple Assembly	Boyce, 1991; Rosli, 2004
16	Design for Preassembly and/or Modularization	O'connor *et al*., 1986; Rosli, 2004
17	Plan to Avoid Damage to Work by Subsequent Operations	Adam, 1989;Rosli, 2004
18	Engage Design Personnel that have Practical Experience and Knowledge of Highway construction	Anderson *et al*., 1999
19	Encourage Standardisation/Repetition	CIRIA, 1983; Rosli, 2004
20	Design for Minimum Time below Ground	Adam, 1989; Rosli, 2004
21	Design to Avoid Return Visit by Trade	Adam, 1989; Rosli, 2004
22	Design for Early Enclosure	CIRIA, 1983; Adam, 1989

The other basic study was written by Boyce (1991) in which he offered ten concepts for improving constructability during the design phase only and he called them "The Ten Commandments of KISS Design". These concepts are: Keep it straight and simple; Keep its specification simple; Keep it shop standard; Keep its standards simple; Keep it standard size; Keep it same size; Keep it square and squatty; Keep it support simple; Keep it site suitable; and Keep its schedule sacred. From the study done by Rosli (2004), there are eighteen concepts for the design phase which are: Carry out Thorough Investigation of the Site; Design for Minimum Time below Ground; Design for Simple Assembly; Encourage Standardisation/Repetition; Design for Preassembly and/or Modularisation; Analyse Accessibility of the Jobsite; Employ Any Visualisation Tools to Avoid Physical Interference; Investigate Any Unsuspected, Unrealistic or Incompatible Tolerances; Investigate the Practical Sequence of Construction; Design to Avoid Return Visit by Trade; Plan to Avoid Damage to Work by Subsequent Operations; Consider Storage Requirements at the Jobsite; Investigate the Impacts of Design on Safety during Construction; Design for the skills and Resources available; Consider suitability of Designed Materials; Provide detailed and clear Design Information; Consider Adverse Weather Effects in Selecting Materials or Construction methods; and Design for Early Enclosure. The constructability concepts that were identified to be applicable to the design phase are summarized in Table 1.

METHODOLOGY

This research was carried out in two stages. Stage one involved wide literature review to identify design phase constructability concepts applicable in Highway Projects. Stage two involved data collection, to establish the Level of Importance and application of the identified design phase constructability concepts. Then, the level of importance and the level of application of the identified design phase constructability concepts on highway projects in Uganda were factored and analysed.

The research was conducted using a questionnaire survey. The questionnaire was compiled basing on the concepts identified during the literature review and refined during the pilot study. The piloting was to capture the concepts that were not identified during the literature review and to improve the wording and increase the reliability of the questions. The questions were of closed type because it is easier and faster to analyse the information collected. The respondents were requested to give the level of importance of each concept with the scale ranging from : “Very Important”, “Important”, “Moderate”, “Little Importance” to “Not Important” rated 5,4,3,2,1 respectively a 5-pointLikert scale. For each of these 22 constructability principles, the survey respondents were also asked to rate the perceived or known degree of application of each of the concepts based on their experience. They had to choose from: “Always Applied”, “Often Applied”, “Sometimes Applied”,” Rarely Applied”, and “Never Applied” (rated 5, 4,3,2,1 respectively).

This study targeted tarmac road projects completed within the period of 01st January 2004, and 31st December 2009. This is because according to the Public Procurement and Disposal of Public Assets (PPDA) Act 40 (1), the Procuring and Disposing Entity (PDE) is supposed to keep it’s procuring and disposal records for up to seven years. This period was selected so as to analyse projects which had been completed after the coming into force of the PPDA (2003) Act, while keeping within the seven year period. The respondents were the professionals, including consultants, engineers, project managers and architects involved in the design and construction of these projects. A list of 20 projects fitting the scope of this study was obtained from the Uganda National Roads Authority (UNRA), and from this list of projects, 10 projects were selected, and 80 questionnaires were sent randomly to professionals working for the corresponding private and public institutions involved in the design and construction of the selected projects.

RESULTS AND DISCUSSION

Respondents

Data analysis was done for 60 questionnaires that were dully completed and returned to the researcher, out of the 80 questionnaires that were distributed to various respondents for purposes of this research obtaining a response rate of 75%. 58.3% of the respondents work in consultancy firms, 26.7% work with highway contractors and 15.0% work with the Uganda National Roads Authority (UNRA). The distribution of respondents is representative, since the biggest players at the design stage are the consultancy firms. Contractors are the next key players, involved in the project implementation, and UNRA's role is profound during the conceptual and design stage.

Of the respondents, 70% are engineering professionals with Bachelor of Science in Engineering or equivalent qualifications, 25% are engineers with advanced degrees and the other 5% have Higher Diplomas in Civil Engineering or equivalent. This implies that most of the respondents are professionals knowledgeable about the subject matter. 5% of the respondents had 0-5 years of experience, 60% of the respondents had 6 – 10 years experience working on highway projects, while 30% of the respondents had experience of 11 -15 years. Respondents with experience of more than 15 years were 5%. 95% of the respondents knew about constructability before this survey, as defined in the questionnaire. The other 5 % of the respondents had never heard this term before. It is indicative that the majority of the respondents were aware about constructability prior to the survey, hence making the survey much more meaningful, since the respondents knew about the subject of the study.

Cronbach-Alpha Reliability test for the ratings

The Cronbach's alpha reliability analysis of the questionnaire was done so as to find out whether the questionnaire was capable of yielding similar scores if the respondents used it twice. The alpha values obtained were 0.873 and 0.903 for level of importance and level of application respectively and for all the items. According to Reynold and Santos (1999), alpha greater than 0.7 implies the instrument is acceptable. Therefore, according to the above results, the instrument was found to be of high reliability and thus acceptable.

Average Index Analysis for the Degree of Importance and Application

Average Index analysis was used in the study to show the degree of importance and application of the various constructability concepts in the design phase of highway projects. It was computed using the following formula adopted from *Al-Khalil* and Al Ghafly (1999: 649):

$$\text{A.I} = \sum \left(a_i f_i / N \right) \qquad \text{equation (2)}$$

Where
a = constant expressing the weight assigned to each responses;
f_i = frequency of each response; and
N = total number of responses.

Table 3 shows the overall results for the average index analysis values for the identified constructability concepts during the design phase degree for the level of importance and the level of application. The concept with the highest average Index value was ranked 1st and that with the lowest value, ranked last. The concept serial numbers are according to those given in Table 1.

Factor Analysis

Factor analysis was carried out on the degree of importance and the level of application of the 22 design phase constructability concepts. During the factor analysis, the principle component analysis was used to extract components whose Eigen values were over 1.000. According to Amin (2005), components whose Eigen values are less than 1 are no better than individual variables. Before carrying out the factor analysis, the Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy were used to determine whether factor analysis was possible.

Table 2: Indices for importance and application ranks of constructability concepts

Concept Sn.	Average Index	Importance Rank	Average Index	Application Rank
C1	4.93	1	3.90	1
C2	4.90	2	3.87	2
C3	4.55	5	3.62	4
C4	4.45	6	3.55	5
C5	4.15	11	3.13	12
C6	4.17	10	3.27	8
C7	4.28	7	3.28	7
C8	3.98	14	2.80	16
C9	4.67	3	3.52	6
C10	4.22	9	2.93	14
C11	3.90	15	3.27	9
C12	3.57	16	2.93	15
C13	4.15	12	3.17	11
C14	4.27	8	3.08	13
C15	3.53	17	2.58	17
C16	3.15	18	2.52	18
C17	4.05	13	3.22	10
C18	4.62	4	3.73	3
C19	2.75	21	2.30	21
C20	2.92	20	2.42	19
C21	3.03	19	2.32	20
C22	2.75	22	2.17	22

Furthermore, according to Field (2005), a value of 0 indicates that the sum of partial correlations is large relative to the sum of correlations, indicating diffusion in the pattern of correlations (hence factor analysis is likely to be inappropriate). A value close to 1 indicates that patterns of correlations are relatively compact and so factor analysis should yield distinct and reliable factors. And those values between 0.5 and 0.7 are mediocre, values between 0.7 and 0.8 are good, values between 0.8 and 0.9 are great and values above 0.9 are superb. These tests were carried out on the overall responses to the degree of importance and the level of application of the 22 design phase constructability concepts.

The KMO measure was found to be 0.712. The approximate Chi-Square in the Bartlett's Test of Sphericity was 686.360 and the significance of the Bartlett’s test was 0.000. Therefore, for these data, the KMO falls in the range of good, hence factor analysis was possible. Table 3 shows the Rotated Component analysis for the level of Importance and the level of Application.

Table 3: Rotated Component Matrix for the level of importance and Application

	Level of Importance							**Level of Application**				
	Components							*Components*				
	2	3	4	5	6			1	2	3	4	5
C1				0.832			A1	0.665				
C2	0.446			0.768			A2	0.687				
C3							A3	0.75				
C4	0.816						A4	0.811				
C5	0.503				0.650		A5	0.759				
C6		0.666					A6	0.675				
C7	0.559						A7	0.65				
C8	0.851						A8	0.411	0.648			
C9	0.609						A9	0.843				
C10		0.478	0.511				A10	0.553	0.513			
C11		0.44	0.525				A11	0.735				
C12		0.606					A12	0.437	0.508	0.6		
C13					0.705		A13	0.591			0.558	
C14		0.434			0.661		A14	0.763				
C15		0.565					A15	0.508	0.505			
C16							A16	0.626				
C17			0.755				A17	0.612				
C18			0.788				A18	0.728				
C19							A19	0.472		0.428		
C20		0.756					A20	0.451	0.543			
C21				-0.547			A21	0.52				0.512
C22							A22	0.548	0.49			

5 components were extracted for level of importance
5 components extracted for application

Five components were extracted for level of Importance and five factors were extracted for level of Application as in Table 3. With these components, 69.9 % of the total variances were accounted for and for both Importance and Application.

Discussion
Table 2 shows the results for the average index analysis values for the degree of importance and applicability of the various constructability concepts during the design phase. The overall average index is 3.95 which are “important”, according to the adopted classification of the index scales in Table 4. Hence from the results obtained, it is indicative that overall, respondents consider all the listed constructability concepts to be “important” during the design phase. The highest average index obtained is 4.93, for the concept “Carry out Thorough Investigation of the Site”, which is “very important”, and the Lowest is 2.75, for the concept “Design for Early Enclosure”. Five concepts were rated as being “very important”, twelve concepts were rated as being “important”, and five concepts were rated as being “moderate”. Hence, the results show that seventeen out of

the twenty two concepts are rated as very important or important, and only five concepts are rated as being moderate.

Table 4: Classification of index scales

Index scale	Importance range	Application range
1.0 ≤ Average Index < 1.5	"Not Important"	"Never Applied"
1.5 ≤ Average Index < 2.5	"Little Importance"	"Rarely Applied"
2.5 ≤ Average Index < 3.5	"Moderate"	"Sometimes Applied"
3.5 ≤ Average Index < 4.5	"Important"	"Often Applied"
4.5 ≤ Average Index < 5.0	"Very Important"	Always Applied"

Source: Al-Khalil and Al- Ghafly (1999)

Table 2 also shows results for the average index analysis for the degree of application of the various constructability concepts during the design phase. The overall average index is 3.07 which are "sometimes applied". Hence from the results obtained, it is indicative that overall, respondents consider all the listed constructability concepts to be "sometimes applied" during the design phase. The highest average index obtained is 3.90, for the concept ,' Carry Out Thorough Investigation of the Site ', which is "often applied", and the Lowest is 2.17, for the concept, 'Design for Early Enclosure' , which is "rarely applied". None of the concepts is rated as being "always applied". This result suggests that none of these concepts is "always applied", according to the classification of the index scales in Table 4.

Six concepts were rated as being "often applied", twelve concepts were rated as being "sometimes applied" and four concepts were rated as being "rarely applied". With the overall average index of 3.07 which is rated as "sometimes applied", it can be stated that from these results, it is indicative that all these concepts are judged as being "sometimes applied" during the design phase of highway projects. In comparison to the perception of importance, this is a lower rating. Hence, it is apparent that the respondents are of the view that the application of these listed concepts is not that high, but rather a low application on the projects they have participated in.

Five factors for the level of application were extracted in the factor analysis. These are: Ensure thorough site investigation and clear design information; Develop designs that are sensitive to safety and weather conditions; Asses the jobsite accessibility, storage requirements and encourage standardization; Engage experienced personnel, and adopt CAD and Ensure adequate design of materials, communication, coordination and schedules. Six factors for the level of importance were extracted in the factor analysis. They are carry out formal constructability reviews; ensure adequate design of materials, communication, coordination and schedules; analyse the jobsite accessibility and storage requirements; engage experienced personnel and adopt CAD, ensure thorough site investigation and clear design information; develop Designs that are sensitive to Safety and Weather conditions.

Formal constructability reviews involving an independent and detailed analysis of all the contract drawings and construction documents should be conducted before their release for construction. This review should ensure that the final design is simple to execute. The simplicity of design should encompass adoption of preassembly and modularization where suitable, instead of using insitu members especially for works involving application of concrete such as bridges, and fly-overs (Siti, 2005). This factor should also cater for reviewing the elimination of return visits by trade, and encourage early enclosures as well as standardization and repetition of best practices in highway construction based on lessons learned.

CONCLUSION AND RECOMMENDATIONS

This study investigated design phase constructability improvement strategies for highway projects in Uganda. Twenty two design phase concepts were identified from literature and used in the questionnaire to find out their level of importance and degree of application. It was found out that whereas the degree of importance of the identified concepts was very high, with an overall average index of 3.95, the level of application of the identified concepts was very low with an overall average index of 3.07. Factor analysis was used to determine the most important design phase constructability improvement factors for highway projects in Uganda. Five main design phase constructability improvement factors were identified as: Carry out formal Constructability Reviews; ensure adequate design of materials, communication, coordination and schedules; Analyse the jobsite accessibility and storage requirements; Engage experienced personnel, and adopt CAD; Ensure thorough site investigation and clear design information and; Develop designs that are sensitive to safety and weather conditions. These identified factors when applied should serve as a basis for strategies to improve design phase constructability for highway projects in Uganda.

Constructability will achieve greater success when its improvement factors become a formal part of the way in which a construction project is conceived, organized and managed. For benefits to be guaranteed therefore, the regulator of the sector should have a formal constructability review policy through which these factors are applied. This policy should be actively pursued through a structured programme of measures designed to encourage constructability from day one of the project's conception. Since highway projects in Uganda are delivered using the traditional approach, a project management consultant should be retained, different from the design consultant, whose task should include constructability review as well as incorporation of construction inputs into the design from the beginning of the design process. This consultant should have the qualities of a highly experienced highway construction expert to ensure the timely and appropriate practical construction inputs in the design. These lessons learned should be kept to guide in subsequent projects, and hence ultimately lead to constructability improvement on highway projects in Uganda.

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AN INVESTIGATION INTO ESCALATION OF PAVED ROAD CONSTRUCTION UNIT RATES IN UGANDA

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Abstract

The global economic situation that has affected all sectors of economies has seen widespread variations in prices of many sectors including construction. In Uganda, the road sector has seen an upward trend in the prices of construction and maintenance over the past years. This trend has caused concern not only to the Government but also to the public which has attributed it to corruption, inefficiency of government departments handling procurements and non-competitive procurement practices. There has been no in-depth analysis of what causes road construction cost escalation and hence the necessity of this research. The methodology involved the use of checklists, interviews and case studies. This entailed derivation of unit rates for individual inputs of pavement layers based on recommended specifications and comparing with the contractors rates. A comparative analysis was done to establish whether there were significant differences between the derived and contractors' rates for the regional and international contractors. In addition, construction cost trends were determined from previous projects while putting into consideration the financial indices. Data analyses showed that there were strong correlations between contractors' rates and derived rates with coefficients of 0.915 and 0.745 for international and regional contractors respectively. It was realized that for gravel and surfacing materials, the costs were increasing hence responsible for the escalating costs of road construction. The study is of benefit to researchers, contractors, and clients/governments in developing countries.

Keywords: Construction, Cost escalation, Developing countries, Paved roads, Uganda

INTRODUCTION

The global economic situation has led to widespread variations in prices. Many sectors including transportation have been affected (Africon, 2008). The increasing worldwide demand for construction materials such as cement, bitumen, steel, concrete has driven fuel prices up (Dayton, 2006). In Uganda, the road sector has seen an upward trend in the prices of road construction and maintenance over the past 8 years (Asuman, 2008). This trend has caused concern not only to the Government of Uganda but also to the public which has variously attributed this trend to corruption, inefficiency of government departments handling procurements and non-competitive procurement practices. The Ministry of Finance, Planning and Economic Development (MFPED) has indicated that past explanations that have sought to explain that this trend was dictated by market forces and over reliance on foreign contractors have not provided satisfactory results for this subject (MFPED, 2009). The rise in the construction costs of transport infrastructure projects has received a great deal of publicity when the tenders clearly exceed the client's own cost estimates of the construction costs (Emil, 2009).

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In addition, the unit cost for road construction and maintenance works are higher in Uganda than elsewhere in East and Central Africa (Alexeeva *et al.,* 2008). This was reinforced by studies commissioned and conducted by the Government of Uganda and actual figures obtained from the then Road Agency Formation Unit. For example, the cost per kilometre of upgrading to paved standards of a 7 m wide two lane inter urban road would be an astronomical US$ 420,220 in Uganda compared to US$ 322,373 and US$ 348,209 in Ethiopia and Tanzania respectively (Alexeeva *et al*. 2008). Such escalations are creating serious problems in the implementation of development projects, since they significantly reduce the amount of infrastructure that can be provided from a given funding source. There has been no in-depth analysis of what causes road work construction cost escalation and its trend in Uganda. The main objective of this study was to investigate the trends in the derived pavement construction unit rates based on prevailing market prices and actual contractors' bid rates over the period 2000 - 2010.

LITERATURE REVIEW

Construction projects have been plagued by cost escalation. On many occasions, the final project cost has been higher than the cost estimates prepared and released during initial planning, preliminary engineering, final design, or even at the start of construction (Emil, 2009). The ramifications of differences between early project cost estimates and bid prices or the final cost of a project can be significant. Over the time span between project initiation, concept development and the completion of construction many factors may influence the final project costs. The development of cost estimates that accurately reflect project scope, economic conditions, and attuned to community interest and the macroeconomic conditions provide a baseline cost that management can use to impart discipline into the design process. Projects can be delivered on budget but that requires a good starting estimate, an awareness of factors that can cause cost escalation, and project management discipline. Preliminary cost estimation is considered as the most significant starting process to influence the fate of a new road construction project (Jamshid, 2005). Major difficulties which arise while conducting cost estimation during the conceptual phase are lack of preliminary information, lack of database of road construction costs, and lack of up-to-date cost estimation procedures. Additional difficulties arise due to larger uncertainties as a result of engineering solutions, socio-economic, and environmental issues. Parametric cost estimation or estimation based on historic database during the conceptual estimate is widely used in developed countries. However, developing countries face difficulties related to the creation of a road construction costs database, which may be used for cost estimation in either the conceptual stage or the feasibility study of a project cycle because such information is not available (Jamshid, 2005). Jamshid (2005) discussed how to handle data gaps, analysed the impact of a different set of variables on the project cost, and evaluated the proposed cost estimation model and proposed a cost estimation technique for developing countries using an artificial neural network. Cost escalation on construction projects is a universal phenomenon and road construction projects are no exception.

The cost of construction materials has been driven up by the unpredictable nature of key resources (particularly fuel and steel) in conjunction with increasing prices (Langdon, 2008). A spike in tender prices for specific trades in specialist industry sectors has occurred over a relatively short period. This has resulted into a higher degree of risk being factored into pricing strategies by sub and main-contractors to counterbalance uncertainty. Unprecedented demand from overseas compounded by the other price sensitive factors have contributed to tender results being in excess of anticipated values for certain types of projects (Langdon, 2008). According to the findings of the Africa Infrastructure Diagnostic (Africon, 2008) the major causes of recent unit cost escalation are rising input prices, tight construction markets, and inadequate competition. In their study, all the projects that were considered for the study, experienced delays in implementation from the date anticipated in the project appraisal reports. The delays ranged from one to five years but averaged 22 months for the sample as a whole. The longer it takes to procure materials and execute a project, the greater the chance that costs and prices will increase. In general, price inflation and changes in the prices of specific inputs, notably oil, affect road construction through the cost of direct inputs and the cost of transportation are to blame (Langdon, 2008). The global construction business is substantially busier today than it was just a few years ago. When the market is busy and contractors' surplus capacity is to be absorbed, prices are bound to rise. In the last decade, the capability of material sources has not increased as much as demand has increased. This gap in supply and demand has resulted in increases in material prices. Steel, asphalt, cement, and aggregates are some of the most strongly affected commodities (Langdon, 2008). The intensity of competition can be measured along two dimensions: the number of bidders and the spread of the bids. It is generally agreed that at least three technically qualified bidders are needed to provide adequate competition, and that the price spread should be such that the lowest three bidders fall within a 10% range. An analysis of projects revealed that only half attracted a sufficient number of bids and only half of those showed a spread that was tight enough that the bids could be considered truly competitive (Africon, 2008).

METHODOLOGY

This research was concerned with studying the variations in prices of recently concluded and on-going paved road construction projects (for the period running from 2000 to 2010) with emphasis on the pavement construction unit rates in Uganda. To accomplish this research, the methodology employed entailed the use of checklists interviews and case studies. The research involved derivation of unit rates for individual inputs to pavement layers based on recommendations of the Ministry of Works and Transport Specifications for Road and Bridge works for comparison purposes. Contractors' rates were obtained from the leading implementers of both development and rehabilitation road projects and were stratified into two groups of regional and international contractors. In order to obtain information concerning input rates of individual layers was obtained from Uganda National Roads Authority (UNRA), Ministry of Works and Transport (MoWT), Local Governments (city, municipality and town councils), contractors, material suppliers and equipment suppliers. A data collection checklist was used as a tool for data collection to capture information concerning the rates of the different pavement construction inputs. To ensure validity of the checklist, the data collection tool was developed in accordance with items in bills of quantities for paved road construction (for earthworks and for bituminous layers) and it was prior compared against both development and rehabilitation projects' bills of quantities.

For this study, the population considered was for all the paved roads that had been constructed / rehabilitated and those that were undergoing construction for the years between 2000 and 2010. A total of 38 bills of quantities of on-going and concluded projects were obtained for the study. They were stratified into regional (21No.) and international (17No.) contractors whereby, regional contractors were classified as those firms whose head offices had been incorporated within East Africa while international Contractors were taken to be firms whose head offices are registered outside East Africa. For consortia, the lead firm was considered during classification. The method of sampling employed was snowball sampling whereby implementing agencies were contacted to give references and directions to contractors who were involved with implementation of the respective projects. From the Bills of Quantities, unit rates of the various pavement construction items were obtained and entered into a computer Excel file. Regional and international contractors' rates were entered into separate excel sheets. The data were brought to a common platform i.e. equivalence as of 2010 taking into account inflation and indices on inputs over the years.

RESULTS AND DISCUSSION

Prior to analysis of the collected data from contractors, the data were tested to determine reliability. This was done by determining the Cronbach's Alpha. The value of 0.835 obtained showed that the data were very reliable since the alpha value was higher than 0.70 which is considered the minimum Cronbach's Alpha coefficient for reliable data. A correlation coefficient of 0.915 for international contractors showed a very strong positive correlation (Archambault, 2002) between the bill rates and the derived rates. For regional contractors, the correlation coefficient was 0.745. Correlation analysis showed a stronger relationship of derived rates with the rates used by international contractors. Table 1 and Table 2 show the average unit rates for the international contractors and the regional contractors in relation to the derived rates. From the unit rates, trend lines were derived. Figure 1 shows that for the years 2001-2008, rates for clearing and grubbing did not differ much but there was a sudden rise in the year 2009 which later reduced in 2010. This sudden rise in 2009 can be attributed to the so many numbers of projects that were implemented in 2009 which meant that contractor's surplus capacity had to be absorbed and this resulted in price increase. This implies that since there was a sudden increase in funding for road construction during the 2008 / 9 financial year, there had to be a sudden increase in the number of projects to be implemented in the year 2009. Thus, with contractors' surplus capacity being absorbed, rates had to rise suddenly. The reduction in prices for the period 2009 / 2010 can be attributed to increased competition. Generally, the rate of clearing and grubbing by regional contractors has been increasing logarithmically for the period 2000-2010. "X" is the time interval (year-2000) and y represents the changes in rates within the respective years. Figure 2 shows that the rate for clearing and grubbing for international contractors fluctuated between six and fourteen millions per hectare apart from the years 2006, 2009 and 2010. This kind of trend is different from that of regional contractors.

The reason for high rates in 2009 was associated to the so many projects that were implemented in that year; and this had resulted from sudden increase in funding for road construction. This is in line with the findings of the African Infrastructure Diagnostic (Africon, 2008) implying that the industry could have experienced tight construction market forces in 2006 and 2009. This kind of trend is inconsistent and therefore makes it difficult to refer to for valid future projections. Figure 3 trend lines indicate that rates for top soil stripping have been reducing, common excavation to spoil have been fairly constant, while scarification and re-compaction and excavation in hard rates have been increasing linearly for regional contractors between 2000 and 2010. Figure 4 shows that generally, rates for top soil stripping, scarification, common excavation to spoil and excavation in hard, have reduced from 2007 to 2010 for international contractors. This could have resulted from increased number of large projects that have been implemented between these respective years. This is in agreement with the findings of Ivan *et al.* (2009) that large projects offer economies of scale to contractors and therefore result into lower rates.

Table 1: Cost trends for Regional Contractors in Uganda Shillings (UGX) (1USD = UGX 2282.99 at 30th June 2011)

Item Description	**Unit**	**2001**	**2003**	**2004**	**2006**	**2007**	**2008**	**2009**	**2010**	**Derived**
Clear the site as directed by the Engineer.	ha	5,912,564	6,868,206	6925379	6,801,943	6,684,300	7,717,000	16,034,594	8,813,156	6,638,071
Strip top soil to a depth of 200mm and to a width directed by the Engineer and stockpile for later use	m^3	14,429	15,453	15,390	10,203	10,695	10,955	11,482	12,498	11,468
Scarify and recompact to a depth of 200mm and compaction to 95% Modified (MOD) American Association of State Highway and Transportation Officials (AASHTO)	m^3	15,503	13,420	20,007	8,219	27,000	30,037	29,767	15,826	19,411
Common excavation to spoil	m^3	10,484	20,605	15,390	17,713	16,042	14,600	14,537	15,893	11,468
Rock excavation	m^3	68,364	65,194	53,864	66,602	40,106	75,467	77,810	61,621	71,348
Improved subgrade layer to required minimum G15 quality	m^3	18,649	5,151	17,492	29,049	18,238	26,085	17,525	21,010	17,717
Provide approved gravel material, transport, shape and compact to 95% MDD at AASHTO T.180 compaction, to form subbase layer.	m^3	17,334	25,225	18,468	31,884	31,457	35,325	27,692	23,807	19,411
Provide approved gravel material, transport, shape and compact to 97% MDD at AASHTO T.180 compaction, to form base layer.	m^3	35,235	25,225	20,007	31,884	34,518	28,425	30,134	25,980	34,518
Processing and mixing in of lime stabilization agent to the base layer at the nominal rate of 5% by weight of material.	m^3	4,959	10,303	53,864	6,164	31,012	22,571	15,503	11,353	27,926
Road lime	t	389,387	551,819	423,218	878,584	401,058	651,185	630,413	682,865	286,742
Prepare the surface of the base layer, provide, transport, heat as specified and spray MC 30 cut-back bitumen prime coat to the carriageway and shoulders at the nominal spray rate of 1.0 litre/m^2.	l	3,827	4,099	6,512	5,952	6,551	28,441	5,506	6,861	4,006
Aggregate for blinding approx 1cum per 250 sqm	m^3	142,128	108,600	64,338	113,366	67,645	87,612	122,485	60,864	39,989
Provide, transport, heat as specified and spray 80/100 pen grade bitumen at the nominal spray rate of 1.2 l/m^2 and provide, transport, spread, roll and broom 14/20 mm sized chippings at the nominal spread rate of 70m^2/m^3 as first seal coat	m^2	4,547	4,579	2,990	6,802	6,684	6,552	17,012	8,844	5,997
Provide, transport, heat as specified and spray 80/100 pen grade bitumen at the nominal spray rate of 1.1 l/m^2 and provide, transport, spread, roll and broom 10/14 mm sized chippings at the nominal spread rate of 90m^2/m^3 as second seal coat	m^2	5,548	4,196	2,990	5,640	11,999	6,517	13,011	8,160	7,187
Bituminous binder variation, 80/100	l	6,947	5,210	6,215	1,700	3,906	6,578	5,277	3,658	2,655
10/14mm Aggregate variation	t	222,616	123,971	97,885	184,219	122,038	183,540	98,753	52,146	56,469
14/20mm Aggregate variation	t	222,616	169,301	97,885	178,740	140,788	155,820	102,503	85,126	51,319

Table 2: Cost trends for International Contractors (1USD = UGX 2282.99 at 30th June 2011)

Item Description	Unit	2000	2002	2003	2006	2007	2008	2009	2010	Derived
Clear the site as directed by the Engineer.	ha	7,153,747	8,370,403	7,373,519	13,519,496	5,966,981	6,104,700	10,160,543	7,626,551	6,638,071
Strip top soil to a depth of 200mm and to a width directed by the Engineer and stockpile for later use	m^3	15,093	12,375	9,441	19,778	8,930	17,936	22,488	11,948	11,468
Scarify and recompact to a depth of 200mm and compaction to 95% MOD AASHTO	m^3	28,879	31,797	23,431	19,899	33,910	37,029	33,353	21,035	19,411
Common excavation to spoil	m^3	11,335	63,938	12,700	22,385	16,967	40,847	13,145	11,180	11,468
Rock excavation	m^3	107,944	117,954	77,407	81,639	130,158	96,654	93,092	62,506	71,348
Improved subgrade layer as specified in drawings to required minimum G15 quality	m^3	15,933	46,008	14,394	35,023	24,050	40,241	40,935	23,565	17,717
Provide approved gravel material, transport, shape and compact to 95% MDD at AASHTO T.180 compaction, to form subbase layer.	m^3	32,376	23,547	19,370	53,140	26,535	79,858	58,455	33,589	19,411
Provide approved gravel material, transport, shape and compact to 97% MDD at AASHTO T.180 compaction, to form base layer.	m^3	32,376	26,985	21,666	53,849	26,535	92,659	71,725	43,821	34,518
Processing and mixing in of lime stabilization agent to the base layer at the nominal rate of 5% by weight of material.	m^3	14,167	4,434	26,714	98,189	27,021	30,726	14,340	34,200	27,926
Road lime	t	850,061	354,066	687,400	1,151,009	805,959	989,958	1,403,876	475,000	286,742
Prepare the surface of the base layer, provide, transport, heat as specified and spray MC 30 cut-back bitumen prime coat to the carriageway and shoulders at the nominal spray rate of 1.0 litre/m^2.	l	4,590	3,570	4,802	4,332	4,866	5,679	7,975	4,737	4,006
Aggregate for blinding approx 1cum per 250 sqm	m^3	135,079	72,330	987,410	207,006	186,610	97,033	6,913	114,739	39,989
Provide, transport, heat as specified and spray 80/100 pen grade bitumen at the nominal spray rate of 1.2 l/m^2 and provide, transport, spread, roll and broom 14/20 mm sized chippings at the nominal spread rate of 70m^2/m^3 as first seal coat	m^2	6,746	4,547	8,703	6,018	7,586	7,536	7,081	9,642	5,997
Provide, transport, heat as specified and spray 80/100 pen grade bitumen at the nominal spray rate of 1.1 l/m^2 and provide, transport, spread, roll and broom 10/14 mm sized chippings at the nominal spread rate of 90m^2/m^3 as second seal coat	m^2	6,695	5,035	8,703	9,028	7,633	5,959	7,081	6,873	7,187
Bituminous binder variation, 80/100	l	4,756	5,636	987,410	6,093	7,586	3,107	6,150	2,881	2,655
10/14mm Aggregate variation	t	215,888	182,235	987,410	637,682	186,610	111,002	130,530	117,551	56,469
14/20mm Aggregate variation	t	195,470	182,235	987,410	637,682	186,610	113,502	142,153	133,847	51,319

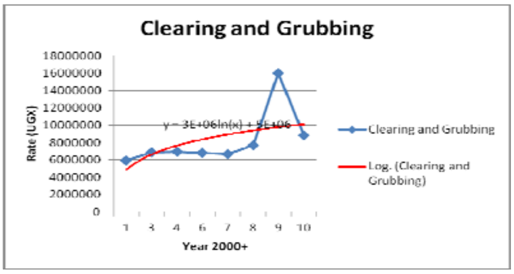

Figure 1: Clearing and Grubbing Trends for Regional Contractors

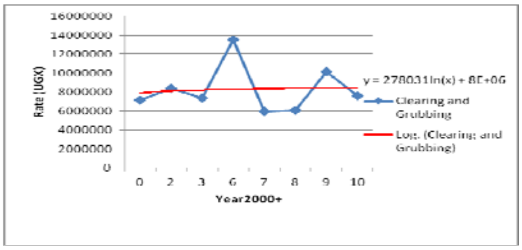

Figure 2: Clearing and Grubbing Trends for International Contractors

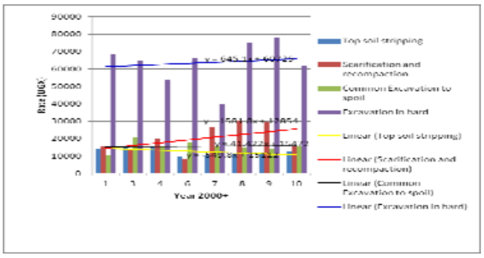

Figure 3: Stripping, Scarification and Compaction and Common Excavation Cost Trends for Regional Contractors

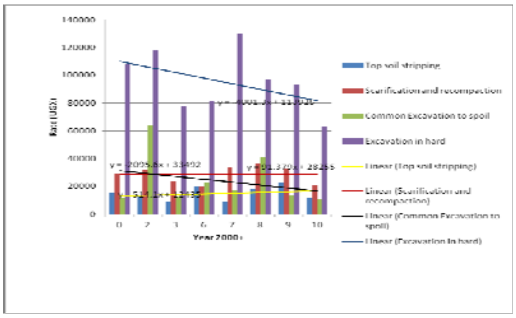

Figure 4: Stripping, scarification and compaction cost trends for international contractors

Contrary to regional contractors' trend, rates for excavation in hard and scarification and re-compaction, have been reducing linearly. Top soil stripping and common excavation to spoil rates have been fairly constant. Figure 5 shows that construction rates increase in order of improved sub grade, gravel for sub base and gravel for base respectively. Rates for improved sub grade have been inconsistent for the entire period. The sudden increase in prices during 2006 can be attributed to fast tracked and accelerated projects in preparation for Commonwealth Heads of Government Meeting (CHOGM). This is in line with the findings of Ivan *et al*. (2009) which attribute cost escalation to project acceleration. Generally, rates for sub base and improved sub grade have been increasing linearly. The rate for base gravel has been fairly constant. Figure 6 shows that between 2000 and 2007, rates for capping layer, sub base and base were fairly low except for the year 2006. The rise in prices during 2006 could have been as a result of fast tracking and acceleration of projects in preparation for CHOGM. For the period 2008 to 2010, rates for improved sub grade, gravel for sub base and base; have been reducing.

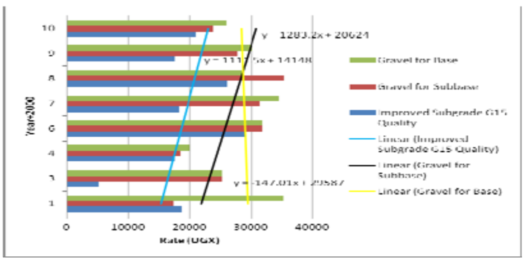

Figure 5: Improved sub grade, sub base and base cost trends for regional contractors

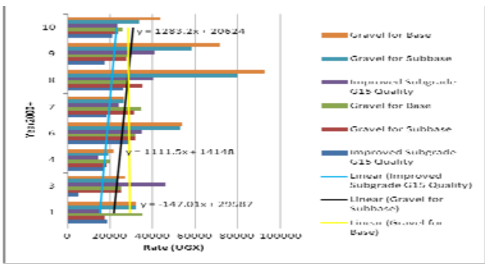

Figure 6: Improved sub grade, sub base and base cost trends for international contractors

The fairly high prices in 2008 could have been as a result of a few projects that were implemented then and therefore, very few international construction companies tendered resulting into inadequate competition. This is in line with the findings of Dayton (2006) which associate high prices with inadequate competition. In addition, these very high prices could also be associated to specialty items and quality that was required for Kampala-Gayaza Zirobwe project because of being an urban highway, the pavement had to meet the required equivalent standard axles Loads (ESAL). Generally, improved sub grade and gravel rates have been increasing linearly.

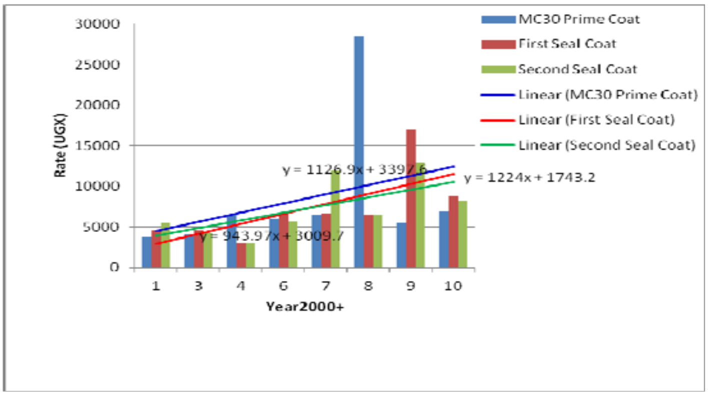

Figure 7: Prime coat, 1st and 2nd coat surfacing cost trends for regional contractors

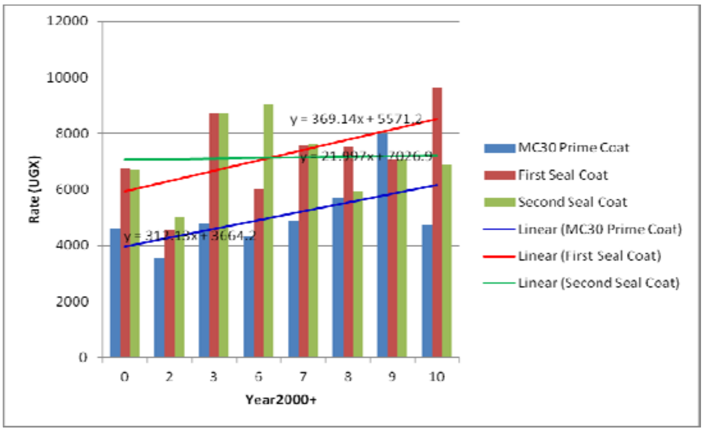

Figure 8: Prime coat 1st and 2nd coat cost trends for international contractors

Figure 7 shows that for regional contractors, rates for prime coat, first and second seal coats have been increasing linearly. This is in concurrence with the findings of Dayton (2006) which attribute this rise in prices to the increasing worldwide demand for construction materials such as cement, bitumen, steel, concrete; rising prices of crude oil and other energy supply issues Figure 8 shows that rates for bituminous materials have been increasing linearly for the entire period of construction. This could be because of the risks that are anticipated during bidding due to the nature of the construction industry and hence resulting into high rates. This is in agreement with the findings of Langdon (2008) which indicate that there has been great uncertainty in trends of road construction input prices thereby resulting into high prices.

Reasons for price variations under similar conditions

From the data collected, it was realized that different contractors had quoted for far different rates for the same project. Therefore, interviews were conducted to find out why there were large variations in tender rates for different contractors bidding for the same projects and therefore same operating environment. Some of the variations came from variations in mark-ups provided for. Many contractors indicated that even if they were to study the consumer price indices for fuel prices in Uganda, it was still impossible to predict price trends. Therefore, different contractors attach different weights to this risk and hence variations in prices of other construction costs since they largely depend on fuel. This is in agreement with the findings of Langdon (2008) where a higher degree of risk is always factored into pricing strategies by sub and main-contractors to counterbalance uncertainty. A number of contractors mentioned that, they often do front end loading to have a better cash flow. This is in agreement with the discoveries of Vermeulen (2007) that bid balancing result into major variations in activity costs. Contractors said that their rates for the different personnel for particular assignments vary per contractor. It was said that some contractors would involve expatriate staff members while others employed regional staff for similar activities. Thus, since workers' salaries are incorporated in bid rates, this automatically results into variations in tender rates.

This is in line with the findings of Ivan *et al.* (2009) which attribute specialty items on contracts double mark-up on the same item and hence resulting into variations in prices. Some contractors mentioned that in some cases, low bid rates are adopted in order to win projects especially where it is mentioned that "the tender will be awarded to the lowest bidder". It should be noted that for the same assignment, other contractors may not attach much attention to this statement thereby causing large tender rate variations. This is in agreement with the observations of Ian (2009) where he mentions that clients are always interested in low price tenders provided that quality is not compromised. A few contractors indicated that there are some firms especially international contractors from specific countries that are given tax holidays as a means of attracting them to operate in Uganda, whereas others do not enjoy such exemptions although they operate in the same environs.

Since tax component is built in the bid rate, this results into large variations. Some contractors, especially international contractors, said that they would offer lower rates compared to their counterparts when they know that they would subcontract the project to a regional and hence cheaper sub-contractor. In addition, variations in prices due to risk rating are in agreement with the findings of Langdon (2008). It was found out that at any time of bidding, different firms have different levels of desires to take up new assignments. Thus, much as direct costs would be more or less the same, the tendering departments of those particular companies would adjust mark-ups to favour their needs. This ultimately results into different bid rates. This is in line with the findings of O'leary *et al.* (2006) which indicate that companies would offer unjustifiable rates when they are excessively committed with other projects as a means of not winning such tenders. In selective tendering where contractors of the same classes are invited, variation between bid rates are expected to be minimal whereas in open bidding, there are bound to be large variations since companies with varying overheads would bid for the same projects. This is in agreement with the observations of Ivan *et al.* (2009) where they clearly indicate that contract restrictions limit competition and increase prices. Like all other industries, the road construction industry is no exception when it comes to corruption. This is in agreement with the findings of O'leary *et al*. (2006) which associate prices to the geographical location of the bidding company. Depending on the level of corruption that is anticipated and thus factored in the bid rate by the different people preparing bidding documents, large variations are bound to happen. This is in agreement with the observations of Ades *et al.* (1997) that "if bribes are offered, there must be some perspective profits out of which to pay them" and hence affects mark-up.

CONCLUSION AND RECOMMENDATIONS

It has been established that rates for improved sub grade material G15, gravel for base and sub base, prime coat and seal coats have been increasing for both regional and international contractors. This therefore explains why road construction costs have been increasing of late. For international contractors, rates for scarification and re-compaction and excavation in hard have been reducing while they have been increasing for international contractors. For both classifications of contractors, rates for top soil stripping and excavation in hard, have been fairly constant. For the year 2009, very high rates were realized for both regional and international contractors. This can be related to the so many projects that were implemented that year due to increased funding to a tune of 17% of Uganda's annual budget allocation for road construction. It is recommended that the contractors, Government and researchers tackle those factors that lead to increase in costs.

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COMPARATIVE ASSESSMENT OF HOUSING SATISFACTION IN MEDIUM INCOME ESTATES OF LAGOS, NIGERIA

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Abstract:

This study examines the housing satisfaction of occupants of public and private medium density residential estates in Lekki, an emerging suburb of Lagos, Nigeria. Abraham Adesanya Estate (public) and Mayfair Gardens (private) were purposively selected. The study employed a conceptual model which identified three housing components consisting of the dwelling, neighbourhood and management subsystems as being of highest relevance to user satisfaction. Indicators arising from theses subsystems include socioeconomic condition of the occupants, land use, infrastructure and environmental condition, building quality and estate management. Data collation was by the administration of structured questionnaires. 50% of all inhabited dwelling units were sampled. 554 questionnaires were administered using systematic random sampling technique. There was a 79% response rate as 438 questionnaires (203 in Mayfair and 235 in Abraham Adesanya) were retrieved and acceptable for further analysis. Data analysis was done using simple descriptive statistics and the Relative Satisfaction Index was measured using the Kendall's Coefficient of Concordance and Friedman's test. The results indicated that occupants' satisfaction levels with the environmental conditions are high, especially seeing that both estates are gated communities. However, management satisfaction levels are higher in the private estate, even though community participation levels are quite low. The paper concludes by recommending measures for increasing housing satisfaction and these mainly centred on improving urban governance as well as housing liveability.

Keywords: Housing, Satisfaction, Lagos

INTRODUCTION

Housing is universally acknowledged as one of the basic components for human survival (Olayiwola, 2003). Konadu-Agyemanyg *et al*. (1994) established a strong correlation between housing, good health, productivity and socio-economic development). There is also a significant association between housing conditions, physical and mental health (Gilbertson *et al*., 2008). So and Leung (2004) established a significant correlation between the quality of life and the comfort, convenience and visual acceptability of the house and according to Doxiadis Associates (1978) the satisfaction of housing needs creates incentives for balanced growth, improves living standards, and provides conditions of security and

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happiness - thereby increasing efficiency of the productive populations. It can thus be surmised that housing is important to social well-being.

Rapoport (2000) defines housing as a system of settings within which a certain system of activities takes place and in this context therefore housing is more than the dwelling, the neighbourhood and its environmental quality profiles become important. As a shelter, housing is more than mere physical barrier against the natural elements or weather; it provides economic, social, biological and physiological needs of man (Mabogunje *et al*., 1978). Housing satisfaction, as a concept has become the prominent indicator used by numerous researchers and analysts as an evaluative measure of private and public sectors' building performance; as an indicator of residential mobility; and as an evaluation of occupants' perception of their residential environment and improvements in new projects (Potter, Chiconie and Speicher, 2001). Some studies in this area include those of Western, Weldon, and Mating, 1974; Olatubara and Fatoye (2006) and Kellekc & Berkoz (2006).

Housing in Nigeria is characterised by both qualitative and quantitative inadequacies (NHP, 1991). Literature attests that while quantitative challenges can be overcome by increasing the housing stock, the qualitative challenges have largely been due to the failure of housing providers to consider factors and parameters that determine occupants' satisfaction (Onibokun, 1973; Ukoha and Beamish, 1997; Ilesanmi, 2010).

Research on housing satisfaction in Nigeria has majorly been targeted at public housing (Ojo and Oloruntoba, 2012; Aduwo, Ibem and Opoko, 2013), low income housing (Oduwaye, Ilechukwu and Yadua, 2011); and campus housing (Akinjare, Adejoyin and Izobo-Martins, 2012). A particularly neglected cross-section of the society is the middle class who account for 34.5million people or 26.8% of the population (ADB, 2008). A general profile of the Nigerian middle class by Renaissance Capital (2011) is that 68% live in leased or rented accommodation, with 18% intending to move to self-owned housing (purchased or built) within five years. This analysis has positive implications for the housing development sector; therefore it is imperative that the housing satisfaction indices of the middle class are clearly understood in order to provide housing solutions that will be acceptable to the potential clientele. Furthermore, there is no evidence in literature of any study comparing the satisfaction levels of occupants of public and private housing at the same income level.

The paper will examine the housing satisfaction indicators in public (Abraham Adesanya Estate) and private (Mayfair Gardens) medium density housing estates in Lagos, with a view to determining the major factors influencing housing satisfaction at the dwelling and neighbourhood levels because as Campbell, Converse and Rodgers (1976) opined, housing is a key determinant of quality of life that can be measured at individual, household, and community levels.

LITERATURE REVIEW

Literature on housing has moved beyond investigating 'habitability' to 'satisfaction' which considers psychosocial issues that influence occupants pleasure with their living environment (Mabogunje *et al*., 1978), because according to Oladapo (2006), a dwelling that is adequate from the engineering or the design point of view may not necessarily be adequate or satisfactory. Housing satisfaction is defined by Galster (1987) as the perceived gap between a respondent's needs and aspiration and the reality of the current residential context. Galster (1987) identified the following as major determinants of residential satisfaction:

- objective characteristics of the individual or household, i.e. personal and socioeconomic characteristics;

- objective characteristics of the environment, i.e. dwelling and neighbourhood characteristics, and
- individual's subjective perceptions, valuations and aspirations.

Olayiwola (2003), corroborating Onibokun (1974), noted that satisfaction is largely dependent on dwelling - environment - management interactions. Therefore, the concept of habitable and satisfactory house is related to the physical, architectural and engineering components of the house, as well as to the social, behavioural, cultural and personal characteristics of the inhabitants, the components of the environment of which the house is a part; and the nature of the institutional arrangements under which the house is managed. Accurate occupant satisfaction assessment can only be performed through an evaluation of the dynamics arising from a particular housing unit located within a particular environment that is managed under a certain type of institutional management or administration (Oladapo 2006).

Various researchers have highlighted some factors considered as important in determining housing satisfaction. They include safety (Bruin and Cook (1997), dwelling size (Mohit *et al.* 2010), integrity of building structure and neighbourhood cleanliness (Liu, 1999) social interaction (Blair and Larsen (2010), and culture (Rapaport (2000), Other factors include family size (Theodori, 2001), socioeconomic status - income, education and employment (Varady *et al*., 2001), satisfaction with housing physical condition and management services (Varady and Corozza, 2000), past living conditions as well as residential mobility and future intention to move (Varadi and Corrozza, 2000). Dekker *et al.* (2011) also discovered that housing tenureship and education have strong influence on housing satisfaction as house owners have a higher level of satisfaction compared to tenants, and the residents who attained a low level of education indicated a high level of satisfaction towards all aspects of their dwellings (except neighbourhood aspects) as compared to those with higher level of education.

Evaluating housing satisfaction according to Djebani and Al Abed (2000) should be done using criteria related to the dwelling, environment and management components grouped in a manner to suit the peculiarities of the case study. A summary of criteria identified in the studies by Onibokun (1974) and Oladapo (2006) shows that occupants satisfaction could be measured by housing attributes such as the function and physical adequacy of the dwelling, quality and adequacy of social and community facilities, the nature and effectiveness of official policies and personnel attitudes, convenience for living, the condition and maintenance of the home environment, maintenance of the dwelling facilities, privacy, territoriality and neighbourhood security among many others. According to Ukoha and Beamish (1997), the standard framework for measuring housing satisfaction is divided into four categories namely:

- Satisfaction towards the dwelling unit: This refers housing characteristics such as number and sizes of rooms, location of rooms, level of privacy and the overall size of the house. A good building structure is an important indicator determining the quality of housing and the value of a dwelling (Westaway, 2006).
- Satisfaction towards neighbourhood qualities: this refers to such factors as accessibility to workplace, security and surrounding area control; good public transport; proximity to commercial areas; building exteriors with high aesthetic values; proximity to open spaces; not noisy and no traffic congestion; good reputation; good quality along the building surrounding; proximity to town centres and a conducive environment (Hui and Zheng, 2010).
- Satisfaction towards the management and the services provided: the relationship between the housing management and the tenants poses a large influence on tenants' housing

satisfaction (Jaafar, et al., 2009). Matters considered include the quality of services offered and the time taken by the management in handling tenants' complaints, friendliness; building and neighbourhood quality; environmental security; and overall quality of maintenance carried out by the management (Hipp (2009).

- Satisfaction towards the facilities and amenities available in the dwelling unit and its surrounding area in terms of quality relative to the socioeconomic status. When a household lives in an area that fits their social status, their level of satisfaction towards their social surrounding will also increase (Frank and Enkawa, 2009).

As such the study will examine the level of satisfaction of residents of the study area based on these criteria.

RESEARCH METHODOLOGY

The Study is set in the Lekki- Epe axis of Lagos, Nigeria. Lekki is a fast growing Lagos suburb and has been described as Nigeria's fastest growing real estate hub (Odusote, 2008). The study will compare resident satisfaction levels at the Abraham Adesanya Estate and the Mayfair Gardens respectively. These estates were purposively selected because they exclusively cater to the middle class, are private and publicly owned, and are both located along the Lekki Epe axis, a distance of about 15km apart, hence residents are exposed to similar external stimuli.

Mayfair Gardens is a private estate located in Awoyaya Community. The estate occupies 75 hectares of 1200 semi-detached and fully detached bungalows at capacity, which were constructed by the developer. Development started in 2003 and currently is over 75% completed. The estate is fully serviced with infrastructure (electricity, water, telecommunication, sewage and waste disposal), children's playground and a 6.5km jogging track. Abraham Adesanya Estate is a government owned estate located in Ogombo Community. It occupies about 71 hectares of 1500 semi-detached and terraced bungalows, which were constructed by various government contractors. Development began in 1991, was abandoned soon after until 1999 when work resumed. The estate is currently fully occupied. The estate is serviced with infrastructure (tarred roads and drainages) along the main arterial road (June 12 road) and electricity from the national grid. Recreational land uses had been reallocated for housing and major infrastructure improvements such as in-estate roads, shopping complex and aesthetics are mainly through self-help efforts under the auspices of the residents associations.

A census of both estates was done and it was discovered that there are 572 inhabited dwelling units in Abraham Adesanya and 537 in Mayfair gardens; hence this was adopted as the sample frame. 50% was chosen as sample size hence 286 and 268 questionnaires were administered respectively. There was a 79% response rate as 438 questionnaires (203 in Mayfair and 235 in Abraham Adesanya) were retrieved and acceptable for further analysis. Residents' satisfaction with their housing was examined based on the interacting variables or factors of the dwelling, the neighborhood and management.Indicators arising from theses subsystems includes socioeconomic condition of the occupants, land use, infrastructure and environmental condition, building quality and estate management

Data collation was by the administration of structured questionnaires. The questionnaire was designed to elicit information on housing characteristics and relevant indicators of housing satisfaction. Respondents' satisfaction levels with these variables were obtained using a five-point Likert scale ranging from very dissatisfied (rated as 1), to very satisfied (rated as 5). This was further condensed to 1 and 2 (dissatisfied), 3(indifferent), 4 and 5 (satisfied). The significant agreement or level of satisfaction being tested was determined by adopting the mid-point value, which is three (that is, average or fairly satisfactory) as the acceptable mean. Data analysis was done using simple descriptive statistics and the Relative Satisfaction Index and Kendall's Coefficient of Correlation (taub_b).

FINDINGS AND DISCUSSION

Socio Economic Profile of Respondents

The study revealed relative age and gender balance with about 59% male respondents and 41% female across both estates. Over 75% of respondents were aged between 31 and 60, inferring an active working population. Most of the respondents were married with children, accounting for 82% of all respondents. Residents of both estates are also highly educated with 93% having some form of tertiary educational qualification. The respondents were mainly self-employed (31.9%), or employed in the private sector, usually in management cadre (23.5%). However, 36.5% of Abraham Adesanya respondents were retired compared to only 3.9% in Mayfair Gardens Estate. Average monthly income in Abraham Adesanya estate was between N100, 000 and N150, 000 ($750 - $1,000), while in Mayfair Gardens, average monthly income was between N200, 000 – N250, 000 ($1333 - $1666)

It was also discovered that about 42% of respondents in Abraham Adesanya had lived there for over ten years, while only 42% of respondents in Mayfair Gardens had lived there for more than five years. Reasons for choosing the specific estate varied, with those in Mayfair choosing infrastructure, social status and safety as the major reasons, while those in Abraham Adesanya considered the major reasons for staying in the estate to be affordability and closeness to work. It is interesting to note that 74% of houses in Mayfair Gardens are owner occupied, while in Abraham Adesanya estate, 47.6% fell in the same category.

Housing and Environmental Profile of Study Area

Housing in both estates is by prototype buildings. There are basically three building types in the study area: two or three bedroom apartments in semi-detached twin bungalows, terrace bungalow with five apartments and detached bungalows. Those residing in the twin bungalows make up 42.5% and 33% of respondents in Abraham Adesanya and Mayfair Gardens respectively. Respondents residing in five apartment blocks are 34% within the study, while those residing in detached buildings account for 33% in Mayfair Gardens and 22% in Abraham Adesanya.

Neighbourhood infrastructure is better in Mayfair Gardens as the entire estate has tarred roads and flowing drainage system. Only 54% of respondents in Abraham Adesanya have motor able access and flowing drainage. While 86.2% of respondents in Mayfair have piped water run into their homes via the Estate water works, 92% of Abraham Adesanya estate respondents source of water is privately dug boreholes or surface wells. Garbage disposal in both estates is by private collection. While Mayfair Garden Estate respondents pay for this service as part of the estate maintenance charges and so all residents are entitled, those in Abraham Adesanya have to register individually with the garbage collection company and pay the fees on a monthly basis as shown in Table 1. Estate maintenance in Mayfair Gardens is handled by the developer and charges cover street landscaping, street sweeping, water supply, garbage disposal, estate security and general maintenance of neighbourhood facilities. Estate maintenance in Abraham Adesanya is handled by the residents association. Maintenance charges in Abraham Adesanya only cover estate security. Respondents have to make individual arrangements for the improvement of their building exteriors and periodic levies are imposed for drainage clearing and road fixing. While flat rates are charged in Abraham Adesanya for estate maintenance, charges are rated on an individual basis in Mayfair and depend mainly on housing type and frequency of waste collection.

Table 1: Average Monthly Expenditure on Housing and Environmental Services

	≤ 10,000 ($66)		10,001- 20,000($66 - 1333)		≥20,000 ($133)	
	Mayfair Garden (%) n =203	Abraham Adesanya (%) n=235	Mayfair Garden (%) n =203	Abraham Adesanya (%) n=235	Mayfair Garden (%) n =203	Abraham Adesanya (%) n=235
ome Repairs/ Improvements	55.6	79.4	34.9	16.6	9.4	4.0
Electricity	52.2	52.8	32.5	40.0	15.3	7.2
Fuel for Power	1.97	51.5	47.3	37.8	50.7	10.6
Waste Disposal	66.5	97.8	33.5	2.1	-	-
Home Security	24.1	54.5	46.7	44.5	29.1	5.7
Estate Maintenance	3.8	33.2	39.8	55.7	56.3	11.1

The Study showed that most home repairs and improvement cost less than N10, 000.00 though in Abraham Adesanya, a higher quantum of respondents had to effect some measure of repairs on their houses. Electricity costs for the two estates was relatively equal, though the cost of fuel for powering electricity generators was higher for Mayfair, implying less access to electricity from the national grid. The cost for home security was also relatively balanced at between N10, 000 and N20, 000. Home security systems adopted in both estates include the rearing of dogs, employment of private security guards and home alarm systems, even though this was much higher in Mayfair gardens than in Abraham Adesanya.

Housing Satisfaction in the Study Area

To measure level of satisfaction with their housing and environment, the respondents rated their level of satisfaction on a three point scale of dissatisfied, indifferent and satisfied. Table 2 shows the ranking of those aspects of these indices they were most satisfied and least satisfied with respectively. While residents of Mayfair Gardens expressed high level of satisfaction with practically all indices and none expressed dissatisfaction with individual dwelling units, 16.2% were dissatisfied with the neighbourhood recreational facilities, and 5.4% with the neighbourhood association. With regards to community interactions, 10.4% were dissatisfied, 52.7% of the respondents expressed indifference and 36.9% were satisfied.

Among residents of Abraham Adesanya estate, dissatisfaction with electrical works within the dwelling unit (81.7%), road and drainage condition in the neighbourhood (72.8%) and community interaction ranked highest (28.7%). Respondents were most satisfied with their general housing condition (94.0%) and general environmental condition; while over 70% expressed satisfaction with security and child friendliness of the estate. The Relative Satisfaction Index of the entire study area was computed as shown in Table 3. A holistic consideration of RSI value of both estates, shows that respondents of Mayfair Gardens are highly satisfied with their housing and neighbourhood (RSI=4.34), while respondents in

Abraham Adesanya Estate are fairly satisfied with their housing and neighbourhoods (RSI=3.53).

Table 2: Respondent satisfaction level with Housing and Environmental Services

		Dissatisfied (%)		Indifferent (%)		Satisfied (%)	
	Variable	MG n=203	AA n=235	MG n=203	AA n=235	MG) n=203	AA n=23 5
Dwelling	Electrical	0	81.7	2.9	4.3	83.8	14.8
	Painting	0	34.02	2.5	18.7	97.5	65.9
	Flooring	0	19.1	1.2	21.3	98.5	84.2
	Windows and Doors	0	17.1	1.9	8.5	98.9	74.5
	Walls	0	20.0	3.9	5.1	96.1	74.8
	Plumbing	0	20.8	2.1	22.1	98.0	57.0
Neighbourhood	Child Friendliness	0	18.7	2.9	4.2	97.4	77.0
	Safety and Security	0	22.6	2.5	4.3	97.5	73.2
	Environmental Aesthetics	0	71.5	2.9	12.3	97.1	16.2
	Roads and Drainages	0	72.8	3.9	11.5	96.1	15.5
	Waste Management	0	15.7	3.9	11.1	95.6	17.2
	Recreation Facilities	16.2	65.9	11.8	8.5	71.9	25.5
Management	General Environmental Satisfaction	0	3.8	2.9	4.6	99.0	91.5
	General Housing Satisfaction	0	5.1	0.9	0.8	99.0	94.0
	Community Interaction	10.4	28.7	52.7	27.6	36.9	30.6
	Neighbourhood Association	5.4	6.4	6.4	25.6	93.1	67.7
	Estate Maintenance	0	16.2	4.3	9.4	95.6	74.5
	Response rate to complaints	0	7.6	7.4	29.8	92.6	62.5

AA= Abraham Adesanya; MG= Mayfair Gardens

A ranking of the RSI values revealed that resident of Mayfair Gardens were most satisfied with the painting works (RSI=4.47) within their dwelling units and least satisfied, albeit marginally, with the flooring (RSI=4.12); while residents of Abraham Adesanya were most satisfied with the flooring of their dwelling units (RSI=4.02) and quite dissatisfied with the electrical works (RSI=1.96). Causal observation showed that many homes in Abraham Adesanya had to be rewired as poor quality materials were employed in the initial electrical installations. Furthermore, frequent cases of power fluctuation were observed, causing destruction of household electrical appliances. At the neighbourhood level, RSI index for both estates show that Mayfair Garden residents are more satisfied with their neighbourhoods, Abraham Adesanya are marginally indifferent to theirs as they recorded a RSI value of 3.08 compared to 4.26 recorded in Mayfair Garden. The disparity lies on environmental aesthetics, roads and drainages as well as condition of recreation facilities where the RSI values for Abraham Adesanya were significantly lower than those of Mayfair Gardens. The estate management in both estates were relatively satisfactory as an RSI value for both estates was at least 4.0. A ranking of the satisfaction indices showed that both residents of Mayfair Gardens and Abraham Adesanya were most satisfied with their housing condition, which could be because of the extensive repairs and improvements that have taken place as well as the high level of home ownership in both estates.

Table 3: Relative Satisfaction Index of the Study Area

		Mayfair Gardens		Abraham Adesanya		Kendalls tau_b
	Variable	**Mean Value**	**Ranking**	**Mean Value**	**Ranking**	
Dwelling	Electrical	4.44	3	1.96	6	-0.724
	Painting	4.47	1	3.80	4	- 0.314
	Flooring	4.12	6	4.02	1	- 0.286
	Windows and Doors	4.45	2	3.81	3	- 0.267
	Walls	4.36	5	3.93	2	- 0.039
	Plumbing	4.44	3	3.54	5	- 0.427
	Total	**26.28**		**21.06**		
	RSI	**4.38**		**3.51**		
Neighbourhood	Child Friendliness	4.08	5	3.89	1	- 0.724
	Safety and Security	4.44	2	3.77	2	- 0.219
	Environmental Aesthetics	4.43	3	2.29	5	- 0.112
	Roads and Drainages	4.46	1	2.22	6	- 0.685
	Waste Management	4.39	4	3.77	2	- 0.331
	Recreation Facilities	3.76	6	2.51	4	- 0.445
	Total	**25.56**		**18.45**		
	RSI	**4.26**		**3.08**		
Management	General Environmental Satisfaction	4.41	3	4.27	2	- 0.011
	General Housing Satisfaction	4.52	1	4.32	1	- 0.137
	Community Interaction	4.34	4	3.79	6	- 0.224
	Neighbourhood Association	4.49	2	3.94	3	- 0.196
	Estate Maintenance	4.27	6	3.83	5	- 0.638
	Response rate to complaints	4.30	5	3.87	4	- 0.201
	Total	**26.33**		**24.02**		
	RSI	**4.39**		**4.00**		
	RSI ENTIRE ESTATE	**4.34**		**3.53**		

CONCLUSION AND FURTHER RESEARCH

The study has revealed a significant difference in the level of satisfaction between public and private housing estates in the study area. The negative correlation coefficient for all indices is also indicative of the disparities experienced between the two estates with regards to dwelling unit, services and facilities. While residents of the private estate were relatively satisfied with their dwelling units, the same was not the case for those in the public estate, as many had done extensive repairs to make those units habitable. The fact that houses in Abraham Adesanya were built by contractors, as against those in Mayfair Gardens that were built by the estate developer/cum owner may be responsible for this. It is important that quality control strategies be introduced and implemented, especially when contractors are used in the construction of public housing. A significant percentage of residents in both estates were dissatisfied with community interactions and recreational activities/ facilities within their estates. It is important that provision must be made for those facilities which foster social interactions and physical fitness. The absence or lack of common areas may have been responsible for the general disconnect within the communities, despite socio-economic homogeneity within the estates. Most residents have had to satisfy their desire for social interactions, physical fitness and recreation outside of their neighbourhoods, hence it important that provision of physical facilities that aid community interactions are provided.

A high proportion of owner occupiers in Mayfair Gardens, compared to Abraham Adesanya, coupled with the higher housing satisfaction values recorded there, point to the potentials of privately owned and managed housing solutions for the middle class. Institutional support can then focus on creating an enabling atmosphere, either through the strengthening of the housing finance sector or the allocation of land to private developers as well as providing housing for the low income cadre. This study has considered housing satisfaction indices among medium income earners in Lagos, Nigeria. Further research will consider the effects of residents housing satisfaction with well-being, as well as a comparison of housing satisfaction across income groups.

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CONSTRUCTION PROFESSIONALS' PERCEPTION ON THE CAUSES AND EFFECTS OF PROJECT DELAY IN LUSAKA, ZAMBIA

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Abstract:

The construction industry is a key sector in the development and economic growth of Zambia, however, the industry has not escaped the challenges facing other countries worldwide in terms of delivering construction projects on time as stipulated in the contracts. This paper assesses the construction professionals' perception on the major causes of construction project delays and there consequential effects of on the Lusaka – Zambia, construction industry. The data used in this paper were derived from both primary and secondary sources. The secondary data was collected via a detailed review of related literature. The primary data was collected through a well-structured questionnaire which was distributed to construction professionals, which include: Architects, quantity surveyors, builders, civil engineers, land surveyors and project managers. Out of the 50 questionnaires sent out, 32 were received back representing 64% response rate. Data received from the questionnaires was analysed using descriptive statistics procedures. Findings from the study revealed that delay in progress payments, difficulties in financing projects by the contractor, delay in approving major changes in the scope of work amongst others, were the major causes of construction delays. The study also revealed that extension of project time and cost over runs were the major effects of construction project delays. The study contributes to the body of knowledge on the subject of the causes and the effects of construction project delays in Lusaka, Zambia.

Keywords: Delays, Construction Industry, Lusaka, Zambia

INTRODUCTION

The construction industry is a key sector in the development and economic growth of Zambia according to the National Council for Construction report (2004). However, the construction industry in Zambia has not escaped the challenges facing other countries worldwide in terms of delivering projects on time as stipulated in the contracts. Projects or construction works that are not delivered on time to the client are referred to as delayed projects. Mohamad (2010) defines delay as an act or event that extends the time to complete or perform an act under the contract. Also, Assaf and Al-Hejji (2006), defined delay as the time overrun either beyond completion date specified in a contract, or beyond the date that the parties agreed upon for delivery of a project. It is basically a project slipping over its planned schedule and is considered as a common problem in construction projects worldwide. Assaf and Al-Hejji

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(2006) further illustrate that, to the owner, delay means loss of revenue through lack of production facilities and rent-able space or a dependence on present facilities. In some cases, to the contractor, delay means higher overhead costs because of longer work period, higher material costs through inflation, and due to labour cost increases.

Theodore (2009) classifies delays into two, those caused by the client and those caused by the contractor. Delays caused by the client such as late submission of drawings and specifications, frequent change orders, and incorrect site information generates claims from both the main contractors and sub-contractors which many times entail lengthy court battles with huge financial repercussions (Theodore, 2009). Delays caused by contractors can generally be attributed to poor managerial skills. Lack of planning and a poor understanding of accounting and financial principles have led to many a contractor’s downfall (Theodore, 2009). Hence, this paper is aimed at identifying the causes and effects of construction project delays in Lusaka, Zambia. This is because the aim of any construction project is to successfully complete the project on time, within budget and with high quality. This study focuses on the completion of projects on time thus overcoming delays. Alkhathami (2004) states that delay can be defined as the extra time needed to complete a construction project beyond its original planned duration, whether compensated for or not.

CONSTRUCTION PROJECT DELAY – CAUSES AND EFFECTS

Causes of delays are factors or events that occur before and during the construction process that will affect the time of completing a project. Ali et al. (n.d) states that there are four factors of delay categorized in broad categories, namely contractor- related factors, consultant-related factors, client-related factors and external factors.

Motaleb and Kishk (2010) identify at least five factors that can cause time overrun and these include change orders, slow decision making by client, lack of capability of client representative, construction financial difficulties and late delivery of materials. Further, Sambasivan and Soon (2007), Assaf and Al-Hejji (2006), Wei (2010) and Theodore (2009) identified seven categories of causes of construction project delays and grouped them as follows; owner related, contractor related, consultant related, material related, equipment related, labour related and causes by eternal factors. Literature reviewed showed that the scholars identified individual causes of delays in each of the seven categories. In the owner related category of causes of delays, the scholars identified the following as the causes of delays; delay in progress payments, delay to furnish and deliver the site, change of orders by owner during construction, late revising and approving design documents, delay in approving shop drawing and sample materials, poor communication and coordination, slowness in decision making process, conflicts between joint-ownership of the project and suspension of work by owner. The scholars further identified the following cases in the contractor related category of causes of delays; difficulties in financing project, conflicts in sub-contractors schedule in execution of project, rework due to errors during construction, conflicts between contractor and other parties, poor communication and coordination, ineffective planning and scheduling of project, improper construction methods implementation, delays in sub-contractors work, inadequate contractor's work, frequent change of sub-contractors, poor qualification of the contractor's technical staff and delays in site mobilization.

Literature showed the following as causes in the consultant related category of causes of delays; delay in approving major changes in the scope of work, poor communication and coordination, inadequate experience of consultant, mistakes and discrepancies in design documents, delays in producing design documents, unclear and inadequate details in drawings, insufficient data collection and survey before design and lack of advanced engineering design software. Further, the scholars identified the following in the material related category of causes of delays; shortage of construction materials in market, changes in material types during construction, delay in material delivery, damage of sorted material while they are needed urgently, delay in manufacturing special building materials and late procurement of materials. In the equipment related category of causes of delays, the following where identified; equipment breakdowns, shortage of equipment, low level of equipment-operator's skill, low productivity and efficiency of equipment and lack of high technology mechanical equipment. Further, in the labour related category of causes of delays, the following were identified as the factors that cause delays; shortage of labour, obtaining of working permit for workers, low productivity level of workers and personal conflicts among workers. In the final category of causes by external factors the following were identified; effects of subsurface and ground conditions, delay in obtaining permits from municipality, weather effect on construction activities, traffic control and restriction at job site, accidents during construction, changes in government regulations and laws, delay in providing services from utilities and delay in performing final inspection and certification.

Effects of delays are the consequences that will occur when the causes of delays are not identified and worked on effectively. The study of Pourrostam and Ismail (2011) identify and rank the effects of construction delays as follows; time overrun; cost overrun; dispute; arbitration; litigation; and total abandonment of projects. These findings are in general agreement with other studies as carried out by Aibinu and Jagboro (2002) and Motaleb and Kishk (2010). However, the study of Baki (1999) brings in the aspect of claims as one of the effects of delays in construction projects.

RESEARCH METHODOLOGY

The data used in this paper were derived from both primary and secondary sources. The primary data was obtained through the survey method, while the secondary data was derived from the review of literature and archival records. The primary data was obtained through the use of a structured questionnaire survey. This was distributed to a total of 50 construction professionals that included; quantity surveyors, civil engineers, architects, builders, land surveyors, and contractors who are currently involved in construction works in Lusaka, Zambia. This yardstick was considered vital for the survey in order to have a true reflection of the causes and effects of construction project delays. All professional and contractors in Lusaka had an equal chance to be drawn and participate in the survey. Out of the 50 questionnaires sent out, 32 were received back representing a 64% response rate. This was considered adequate for the analysis based on the assertion by Moser and Kalton (1971) that the result of a survey could be considered as biased and of little value if the return rate was lower than 30–40%. The data presentation and analysis made use of frequency distributions and percentages of all the respondents. The research was conducted between the months of June to August, 2013.

Mean Item Score (MIS)

A five point Likert scale was used to determine the causes, effects and methods of minimising construction project delays in Lusaka with regards to the identified factors from the reviewed literature. The adopted scale was as follows:

1 = Strongly disagree
2 = Disagree
3 = Neutral
4 = Agree
5 = Strongly agree

The other scale used was as follows;

1 = Extremely unlikely
2 = Unlikely
3 = Neutral
4 = likely
5 = Extremely likely

The five-point scale was transformed to mean item score (MIS) for each of the factors of causes and effects delays as assessed by the respondents. The indices were then used to determine the rank of each item. The ranking made it possible to cross compare the relative importance of the items as perceived by the respondents. This method was used to analyse the data collected from the questionnaires survey. The mean item score (MIS) was calculated for each item as follows;

$$MIS = \frac{1n1 + 2n2 + 3n3 + 4n4 + 5n5}{\sum N} \quad \text{……………………Equation 1.0}$$

Where;

n1 = Number of respondents for extremely unlikely or strongly disagree;
n2 = Number of respondents for unlikely of disagree;
n3 = Number of respondents for neutral;
n4 = Number of respondents for likely or agree;
n5 = Number of respondents for extremely likely or strongly agree;
N = Total number of respondents

After mathematical computations, the criteria are then ranked in descending order of their mean item score (from the highest to the lowest).

FINDINGS AND DISCUSSION

Findings from the 32 usable questionnaires revealed that 25% of the respondents had diploma degree as their highest qualification while 75% had bachelor's degrees. Further findings revealed that 53% of the respondents, who were all construction professionals, were government employees, 25% were employed by consultants and 22% were employed by contractors. The statistical mode for years of experience of the respondents was in the range of 1-5 years while majority (65%) of the respondents were handling an average of 3-4 construction projects in Lusaka. The following sections present the causes of delay as classified.

Owner-related causes of delays

Based on the ranking (R) of the weighted average of the mean item score (MIS) for the listed causes of delays, it was observed that the most dominant cause of delays that are client related on construction project delivery time in Lusaka were delay in progress payments (MIS=3.91; R=1), slowness in decision making process (MIS=3.44; R=2), change of design by owner during construction (MIS=3.38; R=3) and poor coordination (MIS=3.29; R=4). Other factors identified in the study include; conflicts between joint-ownership of the project (MIS=2.66; R=7), suspension of work by owner (MIS=2.63; R=8), delay in approving shop drawing (MIS=2.59; R=9) and delay in approving sample materials (MIS=2.48; R=10) as shown in Table 1. These findings were in agreement with the studies of Theodore (2009), Assaf and Al-Hejji (2006) and Hasseb et al. (2011) who all identified delay in progress payments as the major cause of client related delays. However, the study of wei (2010) identified late revising and approving design documents as the major cause of delays cause by the client.

Table 1: Owner-Related causes of delays

Owner-related factors	MIS	RANK (R)
Delay in progress payments.	3.91	1
Slowness in decision making process.	3.44	2
Change of design by owner during construction.	3.38	3
Poor coordination.	3.29	4
Late revising and approving design documents.	3.03	5
Delay in handing over the site.	3.03	5
Poor communication.	3.00	6
Conflicts between joint-ownership of the project.	2.66	7
Suspension of work by owner.	2.63	8
Delay in approving shop drawing.	2.59	9
Delay in approving sample materials.	2.48	10

Contractor-related causes of delays

The study further revealed the causes of delays that are contactor related and the following were the results as presented in Table 2. Difficulties in financing projects (MIS=3.87; R=1), poor coordination (MIS=3.67; R=2), ineffective planning and scheduling of projects (MIS=3.61; R=3) and poor qualification of the contractor's technical staff (MIS=3.41; R=4) were all found to be the major contract-related causes of delay in construction project in Zambia. Other contractor related causes of delays that were identified in the study include; Poor communication (MIS=3.16; R=7), conflicts between contractor and other parties (Construction team members) (MIS=2.94; R=8), conflicts in sub-contractors schedule in execution of projects (MIS=2.90; R=9) and frequent change of sub-contractors (MIS=2.61; R=10). These results are in agreement with the study by Assaf and Al-Hejji (2006) and Theodore (2009) where difficulties in financing projects by contractors was the major cause of delays identified. However the studies of Wei (2010) and Hasseb et al (2011) identified delays in sub-contractors work as the major cause of contractor related causes of delays.

Table 2: Contractor-Related causes of delays

Contractor-related factors	MIS	RANK (R)
Difficulties in financing projects.	3.87	1
Poor coordination.	3.67	2
Ineffective planning and scheduling of projects.	3.61	3
Poor qualification of the contractor's technical staff.	3.41	4
Delays in site mobilization.	3.32	5
Rework due to errors during construction.	3.32	5
Improper method statements.	3.19	6
Delays in sub-contractors work.	3.16	7
Improper construction methods implementation.	3.16	7
Poor communication.	3.16	7
Conflicts between contractor and other parties (Construction team members).	2.94	8
Conflicts in sub-contractors schedule in execution of projects.	2.90	9
Frequent change of sub-contractors.	2.61	10

Consultant-related causes of delays

Likewise, when the respondents were asked to rate the consultant related causes of construction project delays in Lusaka, the following results were obtained as shown in Table 3. Delay in approving major changes in the scope of work, insufficient data collection and survey before design, delays in producing design documents, poor coordination, and poor communication were top in this category. Also, lack of advanced engineering design software and inadequate experience of consultant were rated as not major causes of delay in Zambia. These results concur with the studies by Wei (2010) and Theodore (2009) where delay in approving major changes in the scope of work was identified as the major cause of delays that are consultant related. Whilst, the studies of Sambasivan and Soon (2007) and Hasseb et al (2011) identified contract management by consultants as the major cause of delays of construction projects in their study. Further, Motaleb and Kishk (2010) identified that inadequate consultant experience was the major cause of delays associated with consultants in their study.

Table 3: Consultant-Related causes of delays

Consultant-related factors	MIS	RANK (R)
Delay in approving major changes in the scope of work.	3.26	1
Insufficient data collection and survey before design.	3.19	2
Delays in producing design documents.	3.09	3
Poor coordination.	3.03	4
Poor communication.	2.94	5
Mistakes and inconsistences in design documents.	2.88	6
Unclear and inadequate details in drawings.	2.88	6
Lack of advanced engineering design software.	2.65	7
Inadequate experience of consultant.	2.61	8

Material-Related causes of delays

When the respondents were asked to rate the consultant related causes of construction project delays in Lusaka, the following results were obtained; delay in material delivery (MIS=4.06; R=1), late in ordering of materials (MIS=3.78; R=2), availability of specified construction materials in market (MIS=3.50; R=3), damage of sorted material while they are needed urgently (MIS=3.13; R=4), and delivery of wrong materials (MIS=3.10; R=5) were found to be the dominant causes of materials related causes of delay in Zambia (Table 4).

These results are in agreement with the results obtained from the study of Wei (2010) where delay in material delivery was identified and ranked as the highest cause of delays that are material related. Further, the studies by Assaf and Al-Hejji (2006) and Theodore (2009) identified availability of specified construction materials in market as the major causes of delays. However, work by Sambasivan and Soon (2007) and Hasseb et al (2011) identified quality of material and shortage of material as the two major causes of delays that are material related in the construction industry.

Table 4: Material-Related causes of delays

Material-related factors	MIS	RANK (R)
Delay in material delivery.	4.06	1
Late in ordering of materials.	3.78	2
Availability of specified construction materials in market.	3.50	3
Damage of sorted material while they are needed urgently.	3.13	4
Delivery of wrong materials.	3.10	5
Fluctuation in material prices.	3.00	6
Changes in material types during construction.	2.97	7
Inappropriate storage of materials leading to damages.	2.88	8

Equipment-Related causes of delays

The study further revealed the causes of delays that are equipment related and after being ranked by the respondents, the following were the results; Equipment breakdowns, use of outdated equipment, shortage of equipment, lack of high-technology mechanical equipment, low productivity and efficiency of equipment and shortages of skilled operators were all found to be major causes of delay in construction projects in Zambia (Table 5). These results are in general agreement with the work done by Sambasivan and Soon (2007), Theodore (2009) and Assaf and Al-Hejji (2006) where it was identified that equipment breakdown is the major cause of delays in construction projects that are related to the equipment hat is being used on sites. Further the study of Wei (2010) identified that the major cause of delays that are equipment related was Lack of high-technology mechanical equipment. However Hasseb et al (2011) identified the use of improper equipment as the major cause of delays on construction projects. Other causes identified by the scholarly studies above were use of outdated equipment and Shortage of equipment as some of the major causes of delays.

Table 5: Equipment-Related causes of delays

Equipment-related factors	MIS	RANK (R)
Equipment breakdowns	3.84	1
Use of outdated equipment	3.81	2
Shortage of equipment	3.63	3
Lack of high-technology mechanical equipment	3.56	4
Low productivity and efficiency of equipment	3.31	5
Shortages of skilled operators	3.00	6

Labour-Related causes of delays

The study further revealed the causes of delays that are labour related and after being ranked by the respondents, the following were the results (Table 6); low productivity level of workers (MIS=3.22; R=1), shortage of labour (MIS=3.06; R=2), conflicts among workers (MIS=2.69; R=3) and work permits of workers (MIS=2.48; R=4).

Table 6: Labour-Related causes of delays

Labour-related factors	MIS	RANK (R)
Low productivity level of workers.	3.22	1
Shortage of labour.	3.06	2
Conflicts among workers.	2.69	3
Work permits of workers.	2.48	4

These results are in agreement with the work of Sambasivan and Soon (2007) and Wei (2010) where low productivity level of workers and shortage of labour were the two major causes of delays identified. However, Assaf and Al-Hejji (2006) identified availability of qualified workforce as a major cause of delays that are labour related.

Causes of delays by external factors

When the respondents were asked to rate the causes of construction project delays in Lusaka that are caused by external factors, the following results were obtained; Weather effect on construction activities, political interference, delay in providing services from utilities, effects of subsurface and ground conditions and delay in obtaining permits from municipality. Other external factors related causes of delays that were identified in the study include; Delay in performing final inspection and certification, natural disasters, accident during construction and changes in government regulations and laws as shown in Table 7 below. Results support the work of Sambasivan and Soon (2007); where effects of weather conditions on construction activities were identified as the major cause of delays. However, studies by Wei (2010), Assaf and Al-Hejji (2006) and Theodore (2010) identified effects of subsurface and ground conditions as the major cause of delays that is linked to causes by external factors.

Table 7: External factor - causes of delays

External factors	MIS	RANK (R)
Weather effect on construction activities.	3.59	1
Political interference.	3.41	2
Delay in providing services from utilities.	3.34	3
Effects of subsurface and ground conditions.	3.31	4
Delay in obtaining permits from municipality.	3.22	5
Change in economic factors.	3.09	6
Traffic control and restriction at job site.	2.81	7
Delay in performing final inspection and certification.	2.72	8
Natural disasters.	2.72	8
Accident during construction.	2.59	9
Changes in government regulations and laws.	2.38	10

Effects of construction project delay to the construction professionals

When the respondents were further asked to rate the effects of construction project delays to the construction professionals in Lusaka, the following result were obtained; Time overrun (extension of Time), cost overrun, bad reputation with client, bad reputation with construction team and claims were found to be the most dominant effects as a result of the delay to construction projects (Table 8). Other effects of construction project delays that were identified in the study include; Arbitration (MIS=3.26; R=7), litigation (MIS=3.06; R=8), total abandonment (MIS=2.63; R=9) and loss of un-skilled employees (MIS=2.56; R=10).

Table 8: Effects of construction project delays to Zambia professionals

Effects of delay	MIS	RANK (R)
Time overrun (Extension of Time).	4.19	1
Cost overrun.	4.19	1
Bad reputation with client.	3.78	2
Bad reputation with construction team.	3.75	3
Claims.	3.75	3
Loss of profit.	3.68	4
Termination of contracts.	3.34	5
Dispute.	3.28	6
Loss of skilled employees.	3.28	6
Arbitration.	3.26	7
Litigation.	3.06	8
Total abandonment.	2.63	9
Loss of un-skilled employees.	2.56	10

These findings are in general agreement with the studies done by Aibinu and Jagboro (2002), Motaleb and Kishk (2010), wei (2010), Sambasivan and Soon (2007) and Hasseb *et al.* (2011) where time overrun (extension of time) and cost overrun were identified as the two major effects of construction projects delays.

CONCLUSIONS AND RECOMMENDATION

Literature review showed that the causes of delays are at different level ranging from those caused by the client or owner to those that are caused by other external factors. Literature also showed that each category of causes of delays had different factors that can lead to delays on construction projects. This study examined causes of construction project delays from the seven identified categories as compiled from an extensive literature review. Findings from the study supported work done by previous researchers and scholars that not a singular factor is responsible causing delays on construction projects. Further findings revealed that there are corresponding negative effects to the professionals of construction project delays in Lusaka, Zambia.

In recommendation, it has been observed that construction project delays usually occur during the construction phase and this is mostly caused by; poor coordination, ineffective planning and scheduling of projects, delay in approving major changes in the scope of work, delay in material delivery, late in ordering of materials, equipment breakdowns, use of out-dated equipment, low productivity level of workers, shortage of labour, weather effect on construction activities and political interference among other causes. It is recommended that the construction team need to be aware of the factors stated above in order to minimise the construction project delays. Furthermore, the construction team should practice the identified measures of reducing construction project delays such as; Site management and supervision, effective strategic planning, clear information and communication channels, use proper and modern construction equipment, and proper project planning and scheduling among other identified measures.

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FACTORS AFFECTING THE PERFORMANCE OF PAVEMENT ROAD CONSTRUCTION PROJECTS IN UGANDA

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Abstract:
This paper is intended to identify the factors affecting road construction projects performance in Uganda through review of literature. Many road construction projects in Uganda and in many countries are never completed within the estimated time and cost in addition to the numerous quality problems. Other issues of concern include: change of scope, health and safety issues, functionality and environmental anxiety. It is rational to determine the most significant factors affecting paved road project performance and decisively deal with so that the scarce resources are directed where they are most needed. Findings have revealed that poor project planning and poor management of the implementation have remained the major factors affecting paved road project performance. The solution to the road construction project performance problem will not only help in the tackling of Uganda National Development Plan of strengthening the country's underdeveloped physical infrastructure, but will also help in dealing with the Millennium Development Goals (MDGs) 1, 7 and 8 of: eradication of extreme poverty, ensuring environmental sustainability and developing a global partnership for development respectively. The academicians, policy makers, construction parties and all other stakeholders will benefit from this information with consequences of better road networks that will spur social-economic transformation and development across Uganda, Africa and globally.

Keywords: Construction, Paved Roads, Performance, Uganda

BACKGROUND

The performance of road construction projects has been a subject of concern in Uganda and many countries for quite some time. The problem of underperformance is not only affecting the road construction projects but also the construction industry (Meyer, Witt, Kashiwagi & Kashiwagi, 2010). Studies show that construction projects and the industry at large have performed poorly in both the developed and under developed countries (Takim & Akintoye, 2002). Faridi and El-Sayegh (2006) asserts that shortage of skills of manpower, poor supervision and poor site management; unsuitable leadership; shortage and outdated equipment are among the factors that contribute to construction delays and subsequent performance problem.

A study in South Africa (Hanson *et al*., 2003) reveals that conflict, poor workmanship and incompetence of contractors are among the factors affecting project performance.

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According to the United Nations Relief and Works Agency (UNRWA, 2006), there is no exception in Palestine as many local construction projects report poor performance due to: unavailability of materials; excessive amendments of design and drawings; poor coordination among participants, ineffective monitoring and feedback, and lack of project leadership skills and regional conflicts.

In Uganda out of the 21,000km of Uganda's national roads, only 21% are paved (MoWT, 2010). United States has 21 kilometres of roads per 1000 people, while Uganda has about 0.126km per 1000people yet 97% of Uganda's cargoes are transported by roads. The National Development Plan (NDP, 2010) identifies the major physical infrastructure deficits that are constraining the country's development potential as lying in the sectors of transport, energy, water for production and communications. In response a number of major roads in Uganda have been earmarked for reconstruction besides the poor project performances. The mission of Uganda National Roads Authority (UNRA) to develop and maintain a national roads network responsive to the economic development needs of Uganda is being hampered by poor road project performance. The goal to optimize the quality, timeliness, cost effectiveness, guarantee safe and efficient movement of people and goods throughout the country (MoWT, 2011) have all become very difficult to achieve. The identification of the factors affecting road project performance in Uganda is therefore very crucial if paved roads construction project performance is to improve.

DILEMMA IN PAVEMENT ROAD CONSTRUCTION

Many road projects in Uganda are never completed within the estimated time, cost, quality and scope. Health and safety considerations, environmental concerns, functionality issues, low profitability and difficulty in satisfying the project parties have all remained a tight spot. Several researches have been done on construction project performance aimed at improvement, but the problem continues to manifest itself.

The developed countries like the United States of America, Germany and Britain, have however given hope that something can still be done to reduce the severity of the problem and this has only been through research and development. According to National Highways Authority of India (NHAI, 2013), 15 kilometres per day of new highways (pavement) is being added to the Indian national network. This came out as a result of increased research and use of Information Technology for better monitoring and tracking of works and the man power. Kampala Northern-By-Pass highway in Uganda on the other hand was constructed at a rate of 0.01km per day with time and cost overruns of 83% and 46% respectively. A report from MoWT (2011) indicates that one kilometre of flexible pavement road in Uganda cost up to US dollars 570,692/= which can construct a similar road in concrete yet the later has a longer life. It is therefore important to identify the specific significant factors affecting project performance in Uganda and deal with. Reduced pavement road project performance affects governments, consultants, contractors, suppliers and the overall economic and social transformation subsequently affecting national and global development.

Objectives

The aim of this study was to use literature review to identify the factors affecting the performance of pavement road construction projects in Uganda in order to provide contribution for pavement construction project improvement.

Rationalization for the Study

In order to contribute towards the improvement of road transport and to the industry, knowledge of the factors affecting road project performance and development is indispensible. This knowledge will help the academia and other stake holders in forging a benchmark for an improved road project performance. The result will be an efficient and effective road network enhancing mobility, thereby maximising economic and social benefits significant in bringing about national and international development. If a solution to the problem of poor road project performance is not urgently dealt with, road construction projects may well continue to underperform.

LITERATURE REVIEW

This section is the main body of the study and presents a review of relevant books, journals, abstracts, and case studies regarding the performance of pavement construction projects. The critical factors affecting project performance have previously been investigated among construction project actors and owners of the companies with different answers. Others think the clients are the once responsible, while others point fingers at the contractors (Alinaitwe, 2008; Low & Chuan, 2006).

In an earlier study (Alinaitwe *et al*., 2007) a number of factors that are influenced by the clients and can affect the progress of work were found to include; design changes, stoppages due to disputes between contractors with owners, stoppages because of insolvency, lack of adherence to regulatory requirements, and inspection delays. Many though think the initiation and the initial planning done by the client and the consultants determines the future direction (Wang, 1994). Performance is about how well something can be done and to measure project performance, a number of performance indicators such as time, cost, quality, client satisfaction, client changes, business performance, functionality, profitability, health and safety (Cheung *et al*., 2004; Shahrzad & Hamidreza, 2011) have been considered.

To establish the performance factors, project success has been widely considered by many scholars as an indicator of good performance. Project success can be categorised into the objective measures of time, cost, safety and environmental considerations and subjective measures of quality, functionality and satisfaction of project participants (Chan & Chan, 2004; Crawford & Pollack, 2004). According to Cho (2009), most past studies done on project performance and the characteristics that affect such performance consist of simple presentations of the relationship between project performance and a few characteristics. Cho (2009) asserts that important characteristics like the effects of relevant political, legal and economic systems, market conditions, importance for the project to be completed on time, form of and the division of responsibilities and liabilities, specific location, weather and environmental concerns, level of technological advancement, project life span, value of a project, and quality of a project are all left out.

The Construction Industry

Globally numerous researches have been carried out all pointing to the fact that the construction industry has performance problems in both developing and the developed countries. A study by Tindiwensi (2006) identifies parameters to measure construction industry performance which include: the economic performance indicators, quality performance indicators; environmental and informal sector performance indicators.

This study cannot be done in isolation of the construction industry because of the direct impact it has on projects. Secondly construction projects form one of the most important constituents of the industry. The construction industry has an important role of transforming the various resources into constructed: physical, economic and social infrastructure necessary for socio-economic development. The factors affecting construction project performance thus directly impacts on the performance of the construction industry and hence national and global developments.

CONSTRUCTION PROJECTS

Chitkara (2005) describes 'construction projects' as high- value, time bound, and special construction missions with predetermined performance objectives. Construction project development involves numerous parties, various processes, different phases and stages of work and a great deal of input from both the public and private sectors (Wang, 1994). The level of performance in carrying out construction project development activities depend heavily on the quality of the managerial, financial, technical and organisational performance of the respective parties. Ten parameters for benchmarking construction project performance have been developed as a result of various studies (Takim & Akintoye, 2002; Cheung *et al*. 2004; Shahrzad & Hamidreza, 2011). Seven of these include: cost, time, cost predictability, time predictability, defects, client satisfaction with the product and the service; and three company performance indicators of safety, profitability and productivity.

Focuses however have to be directed to project characteristics in analysing project performance (Ling, 2004) as characteristics like: complexity, size and construction type are known to affect projects. Bennett (1991) includes the economic situation as an important characteristic that cannot be left out. Environmental characteristics like politics, local market situation and legislation had also earlier been cited to have influence on project performance (Tukel & Rom, 1998).

Construction Project Performance and its Measurement

Project performance can be explained using "two success concepts" (Baccarini, 1999): project management success and product success. The first concept focuses upon the successful accomplishment of the project time, cost and quality, which can be measured in terms of meeting the project budget, schedule, and conformance to functional and technical specifications respectively. The later concept deals with the effects of the project's final product with three key components which are; to satisfy the project goal, purpose and stakeholders. Another criteria for evaluating project performance (Pheng & Chuan, 2006) is by firstly relating to the owner, users, stakeholders, and the general public (looks at projects from macro view point of overall goals of functionality and benefits) and secondly the developer and the contractor; the groups of people who look at project performance from the micro viewpoint (Completion time, cost, quality, safety and profitability).

Performance measurement is an integral part of construction and any other business management (Albert, 2004). To be able to know the goals of a project are being delivered requires identification of indicators of their success (Key Performance Indicators, KPI) and using them to keep an eye on the way they are performing.

Performance indicators are measurable facts necessary to prove that a planned effort has achieved the desired result. When indicators can be measured with some degree of precision and without ambiguity they are called measures. Performance measurement on the other hand is the systematic way of evaluating the inputs and outputs of a construction activity, a tool for continuous improvements (Love, *et al*., 2000). Ogunlana and Shamas, (2009) reveals three major areas of concern for improvement: project planning and control; personnel; and involvement of client. Construction projects require good planning before the actual execution and then control on its way with full involvement of the client.

In construction the output of the requirements at the analysis stage determines the output of the entire development process. They indicate the origination and initiation phase, where major decisions are made, regarding the project's objectives and planning for the execution. The outcome of this earlier activities determine the kind of and the successes of activities that should be undertaken (Ogunlana & Shamas, 2009). Setting clear, realistic, identifiable goals by all project participants is vital. It allows the team members to know where they stand at the moment, how far they stand from the goal, what they need to do to achieve success, and when they are going to get there.

Construction Participants

Construction clients

Studies indicate that little attention is given to the performance of the clients in the construction industry and there is a paucity of research that allows one to better under-stand the key roles of clients (Alinaitwe, 2008). Low and Chuan (2006) argue that poor project performance may not necessarily be due to the incompetence of anyone else but the client's actions before, during and after the project. Client's influence is one of the key contributing factors resulting in lack of commitment and contractor's inefficiency in the project (Hemanta, Sawhney & Iyer, 2012).

Government

The infrastructure has historically been the domain of government, from buildings, roadways to waterways to subways. Safety, training, hiring, and wage bargaining are each enmeshed within the huge public sector expenditures on construction industry services (Gerald, 1997). In most countries, roads are predominantly funded and constructed by the state and in Uganda, the MoWT's role of policy formulation, regulation, setting standards; strategic planning, monitoring and evaluation greatly influence road project performance and development.

Construction consultants

The nature of the tasks assigned by the clients to consultants varies (Chitkara, 2005 & Anderson, 2009) but generally consists of: Project feasibility engineering investigations, coordination of designs and drawing works. They also estimate, plan; budge; prequalify construction agencies; and award contracts to the successful bidders; designing project organisations for executing works and developing standard operating procedures and systems; developing detailed construction plans; supervising works; including administration of contracts and controlling of project time, cost, quality and scope management. These are the activities that determine the future actions and success.

Contractors

Construction contractors play an important role in the construction business as they execute most of the construction works. A competent construction contractor is one of the indispensable conditions of a proper process and completion of a construction project according to Xiaohong (2011).

METHODOLOGY

This section presents the procedure and details on how this research was carried out. It has the research design regarding what, where, when, how much, by what means the inquiry was carried out. Kothari (2004) emphasises on this. This research was an exploratory study, both qualitative and quantitative in nature, involving extensive desk studies of secondary data from previous studies. The study was carried out in Uganda and on paved road construction projects. The study was meant to identify the factors affecting paved road construction project performance using literature review. Information on projects that were carried out from 2008 to 2013 were collected and studied as this is the period the government of the republic of Uganda embarked on serious pavement road construction.

FINDINGS AND DISCUSSIONS

According to engineering audit of Uganda National Roads Authority (UNRA, 2009), and the reviewed literature, the following were found to be the major factors affecting road construction projects in Uganda.

Poor planning and poor management by UNRA

Weaknesses were observed in the planning, supervision and monitoring of work contracts by UNRA. There were many projects going on at the same time creating a contract management crisis to UNRA leading to ineffective monitoring. This signifies poor initial planning yet it is the determinant of the future of projects. In India however, the use of information technology in monitoring made it possible to improve on road project performance.

Lack of experience

UNRA is currently using Small-Medium Local contractors and consultants who are not well versed with contractual issues leave alone engaging them long after the projects have started. This is a symptom of lack of capacity to take up the tasks at hand and has put on a lot of pressure on the UNRA Staff with consequences of ineffectiveness.

Coordination

The research was able to establish that there is no clear linkage between UNRA activities with the National Road Sector Master Plan. There is no roadmap for implementation of this plan. Three major areas that affect project performance include project planning and control; personnel; and the involvement of client (Ogunlana & Shamas, 2009). With lack of coordination between the personnel and the client, chances of good performance become very slim.

Late engagement of consultants

It was observed that some of the projects had been awarded to contractors prior to having a supervising consultant in place. This again is a sign of poor planning. Contract management aspects are better handled when the supervising consultant is first in place and has reviewed the contract documentation.

Inadequate Controls during road construction

In construction, performance is predominantly measured using time, cost, quality and scope. The costs of construction for a number of projects were noted to be high and inconsistent. Comparison of project costs within the same geographical area indicate that the rates of constructing a kilometer of a road vary by great margins, for example, the rate/Km for the construction of Soroti-Dokolo road was approximately $423,077 while that of Dokolo-Lira road was $540,000. This is an indication that there is poor cost analysis and control during tendering and award of contracts.

Scarcity of Road Construction Materials

Scarcity of good gravels in certain areas demands for concerted efforts and research in utilising the locally available soils for road building (for example use of stabilizers). In some areas of Uganda there is lack of adequate and suitable materials such as gravel and aggregates. Transportation of such materials over long distances is a big cost to the projects. This is partly responsible for the poor quality in addition to workmanship problems. In Palestine a similar problem was reported (UNRWA, 2006).

Delayed commencement of works

Clause of the Special Conditions of Contract (PPDA, 2005) states that contractors are expected to start work, 14 days after signing of the contract. The actual start dates were reportedly extended by months later with subsequent misuse of advance payment. In some cases it was a result of failure to avail a supervising consultant in time.

Lack of capacity

Most contractors were reportedly found to lack the equipment and money to handle road projects. They ended up misusing the advance payment which greatly affected the progress of the works hence the delayed completion of the contract. From the progress of most works among other factors it was evident that the contractors had poor cash flow that affected the financial capacity to undertake the contracts.

Expiry of guarantees

Advance payment guarantee, performance security and insurance cover were allowed to expire without any recovery, and putting the entity at risk of financial loss and failure to achieve the intended goals of the projects. There were also cases of failure by the client to verify the authenticity of the securities putting the government at great risks of financial loses.

Delay to make decisions

UNRA reportedly delayed to take decisions regarding issues raised by supervising consultant. These delays impact negatively on the smooth implementation of works and eventually lead to claims. In one of the roads where the project had a time overrun of 100%, the consultant had recommended the contractor to be stopped and the contract cancelled. The Government delayed in making decision until there was public outcry about the inconveniences. Timely decisions should be made by the authorities (Consultants/UNRA) to avoid unnecessary delays and eventual cost implications.

Failure to address Road Safety

Safety of road users was not adequately addressed. There were cases of lack of road signs and speed control humps in some areas yet improved roads are known to lead to higher vehicle speeds and presents risks to road users. In some cases, the signs were reportedly vandalized. There is need to adopt the use of concrete.

Project Characteristics

Complexity, size and construction type were found to seriously affect projects. Other characteristics of concern include: economic situation, politics, local market situation and legislation which must all be seriously addressed. Kampala northern by-pass is one such road that was affected due to its complexity and design changes.

Other factors

Other factors noted include: stakeholder’s lack of continual participation, attitude to service, excessive amendments of design and drawings; ineffective monitoring and feedback, and lack of project leadership skills. Procurement systems, project team performance, conflict between the project parties, poor workmanship, and external conditions were all reportedly found to lead to poor project performance. Project Managers' ignorance & lack of knowledge; faulty project conceptualization; and aggressive competition during tendering were also found to affect project performance.

CONCLUSIONS AND FURTHER RESEARCH

From the findings it can be concluded that poor project planning and poor management of the implementation are the major factors affecting paved road project performance. Most studies pointed out the factors and gave recommendations without implementation frameworks for improvement. What is more realistic is how the results from the several studies on project performance can be harmonised for improvement implementation.

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MANAGING THE EFFICIENT USE OF ENERGY ON CONSTRUCTION SITES AND COST REDUCTION

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Abstract

South Africa is a high energy intensity country by world standards; it has the highest emission of greenhouse gases per capita in Africa whose energy production processes rely on coal powered stations. The construction sector consumes approximately 40% of all energy consumed in the economy; previous studies have focused mostly on energy usage in building operation which is well accounted and profiled. However, a significant amount of energy is consumed by the construction processes but its efficiency level is not understood. The paper explores factors that influence inefficient use and conservation of energy in construction processes to determine measures that can be used conserve energy in the construction process. A questionnaire was randomly administered to site managers, foremen, and machine operators on site. A likert Scale was used to measure opinions of respondents on scale of 1 to 5 and was subjected to a multi-attribute method of analysis. The study shows that inefficient site management is a major constraint to conservation of energy in the construction processes. Efficient utilization and conservation of energy on site can lead to 10-20% cost savings on energy usage. The construction activities that consume most energy are transportation, hoisting and concreting. Effective site management, maintenance of plant and equipment and the choice of machines intended for the activities for which they have been designed are the most important factors for improving energy efficiency in the construction processes. These findings are be useful to those managing construction sites to improve energy efficiency and reduce energy costs and overall cost of construction. It is also useful for global warming mitigation strategy and policy formulation.

Keywords: Climate Change, Construction, Site Management, Energy Efficiency

INTRODUCTION

Energy efficiency is increasingly becoming an important subject worldwide due to the link between the rising energy demand, the greenhouse gas emissions and global warming (Watson, 2003). The subject is also of importance to South Africa due to unstable power supply. The main electricity producing body-Eskom, reported that the production reserve was lower than the world's recommended level which is between 15% to 18% (Eskom 2007), this ultimately leads to the common phenomenon of load shedding during interruption of generation schedules (for example during repairs, maintenance or excessive peak demand). The situation is compounded by the fact that the South Africa's energy sector is largely dependent on coal as the primary source.

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The US Department of Energy, Energy Administration Office (2007) observed that in the year 2004, energy related Carbon Dioxide (CO_2) emissions was 430 million metric tons with contributions by source as follows; Coal (82%), Oil (17%) and Natural Gas (1%). The 2007/2008 United Nations Development Programme (UNDP, 2008), the human development report observed that by international standards South Africa's economy is extremely high energy intensive in terms of energy consumption in relation to its Gross National Product. Studies in energy efficiency are of great importance to South Africa. This is underscored in the government's energy strategy paper (Department of Minerals and Energy (DME), 2005) which sets the target for demand reduction through energy efficiency at 12% by the year 2014.

United Nations Environmental Programme (UNEP) reports that the amount of energy used in buildings is 30-40% of all primary energy worldwide (UNEP, 2007). In South Africa, this figure has been calculated as 27% (Department of Minerals and Energy, 2003). Consequently, energy efficiency in buildings has been identified as one of the key mitigating factors in climate change. However, studies on energy efficiency in buildings have concentrated on building design and operations (Mathews *et al.*, 1999, Wentzel 2006 and Jaini *et al.,* 2013). There is limited information regarding energy utilization on construction sites. This paper highlights the main issues that contribute to energy efficiency on the construction site.

Energy in construction processes

Although energy is used in the project life cycle at different levels, it is during building operation that the bulk of energy is consumed (Jones, 1998). However, it is important to account for energy usage at all levels of the building life cycle. Construction operations consume huge amounts of energy in various forms but have never been sufficiently accounted for. A significant portion of energy utilization on construction site is associated with the mechanical plant used for transportation, levelling, earthworks, lifting, compacting and mixing, including the embodied energy in materials extraction (Fog, *et al,* 1983). The major forms of energy used in construction production processes on site include diesel, electricity, petrol and gas. To illustrate this point reference is made of the U.S. statistics on energy use as an example. As stated by the U.S. Environmental Protection Agency (2006), construction equipment consumed 5.968 million gallons of diesel, equivalent to 827.8 trillion Btu at 138,700 Btu / Gal, and 688 million gallons of gasoline, equivalent to 86.04 trillion Btu at 138,700 Btu/gal. As total construction industry use in 2006 was 913.85 trillion Btu, the construction process alone represented 1.2% of total US energy consumption.

The different forms of energy are used for different purposes in the construction process. For instance, diesel fuel is an important petroleum product and offers a wide range of performance, efficiency and safety features. It also offers a greater power density than other fuels, and contains between 18% and 30% more energy per litre compared to petrol (gasoline as used in the US) (US Energy Information Administration, 2007). According to Energy Information Administration (2004), diesel is a safer fuel compared to petrol and other alternatives because it is less flammable. The major disadvantage of diesel fuel is its high emissions of CO_2.

Electricity on the other hand is a derived energy and is one of the most widely used forms of energy. Electricity is used for the operation of almost all the power tools or equipment on site. Fused distribution boards are used to enable easy pluging of power tools to the electrical source (McMullan, 2002; Foster and Harrington, 1998). In South Africa, the building Industry accounts for 27% of electricity use and 12% of the final energy use (DME, Eskom and ERI, 2002).

Petrol is also in used construction processes and is used for powering small petrol engines especially power tools, such as hammers and small compressors. Natural gas on the other hand, burns more cleanly than other fossil fuels. It has lower emissions of sulphur, carbon, and nitrogen than coal or oil, and when it is burned, it leaves almost no ash particles. Like other fossil fuels, burning of natural gas produces CO_2.

In dollar terms, as reported by Department of Commerce (DOC) (2005a), the construction industry spent \$15 billion on energy of which \$ 11 billion was spent on gasoline and diesel fuel, \$ 1.1 billion on natural gas and \$ 2.6 x 10^9 on electricity. With the above statistics, it is important that there is a crucial need for energy efficiency with relation to cost in the construction industry.

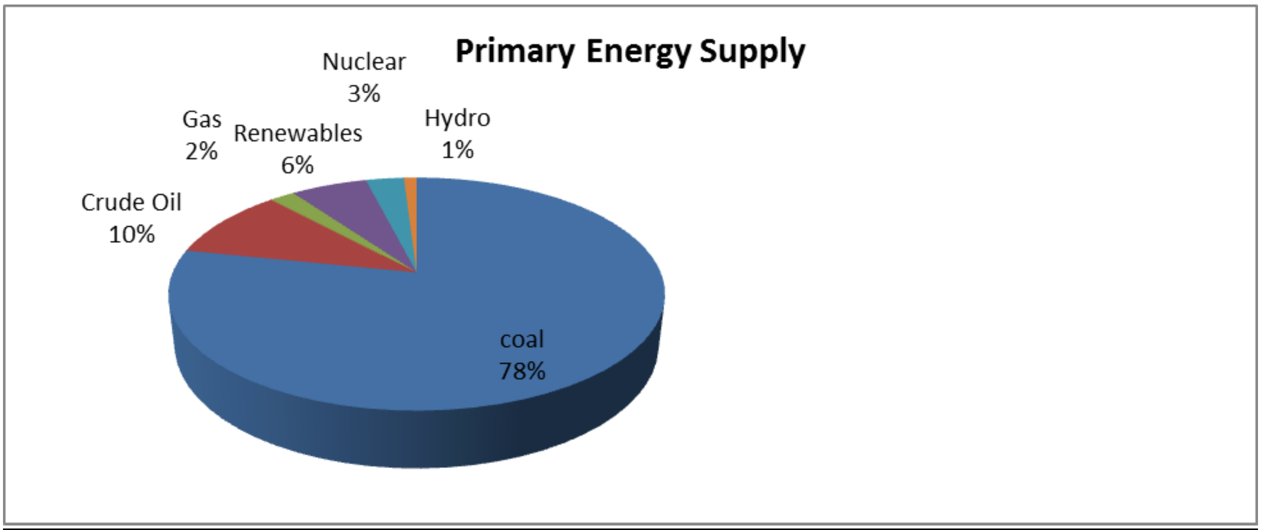

Figure 1: Energy usage by form in South Africa (Source: DME, 2005)

Activities that utilize energy in construction processes

The knowledge of the activities or processes that consume the most energy is an important step towards determining how energy is utilized in the construction processes. Demolition, transportation (including concreting), excavation, and hoisting are some of the processes that consume huge amounts of energy in the construction process.

The demolition process can be either manual or mechanical through use of large hydraulic breakers, elevated work platforms, cranes, excavators or bulldozers. Large buildings may require the use of a wrecking ball, a heavy weight on a cable that is swung by a crane into the side of the buildings. Wrecking balls are especially effective against masonry, but are less easily controlled and often less efficient than other methods. Other methods may use rotational hydraulic shears and silenced rock breakers attached to excavators to cut or break through wood, steel, and concrete. The use of shears is especially common when flame cutting would be dangerous. Large buildings, tall chimneys, smokestacks, and increasingly some smaller structures may be destroyed by building implosion using explosives and this is preferred in dense urban areas to minimize damage to neighbouring structures. In a nutshell, demolition involves the use of large plant that consumes high levels of diesel and electricity.

The excavating processes include both surface and deep excavation of soil and often involve the movement of excavated soil from one place to another. The machines used in this process are divided into two; excavators (such as face shovel, skimmer, dragline, crane and grab, pile driving and drilling and tractors (trench digger, scraper, bulldozer, grader, trenching machine, and mechanical auger) and mostly powered by diesel (Foster and Harrington, 1998). Dippers are used for exportation of excavated materials.

Table 1: Categorises the plant, tool or epuipment according to the type of energy used and the construction processes they perform

Plant,tool or equipment	**Energy used**	**Contruction Processes**
placers rebators and routers	Electricity	Grooving ,moulding other joinery
Saws,	Electricity,comprassed air,pertol engine	Cutting,grinding,
rotary drill,rock drill ,picks and breakers	Electricity,comprassed air,pertol engine	Drilling,driving screws,
Hammers	Electricity, comprassed air,pertol engine	Hummering,
poker vibrater,tempers	Electricity, comprassed air,pertol engine	Vibrating concrete,consolidation of concrete
Power foat	Electricity or pertol engine	Trowelling screeds
Sanders	Electricity,comprassed air,pertol engine	Foor surfacer
Conveyors	Electricity	Transporting soil ,concrete or other light materials
Forklift,dumpers,	Diesel	Transporting concrete
Mobile	diesel and electricity	hoisting and transportation
Elevators	Petrol or disel engine	Hoisting
cranes(stationary)	Electricity	Hoisting
Plant,tool or equipment	Energy used	Contruction Processes
Mechanical auger	Diesel	Boring
Trenching machine, grader, buldoser and angle dozer, scraper, skimmer, dradline	Diesel	Excavation
Pumps	Electric motor,petrol or diesel engine	Keep surfaces free from water
Compressers	Electric motor or diesel engine	Supply compressed air

Hoisting may be done using manually, electrically or pneumatically operated machinery. These include cranes, elevators and hoists which sometimes carry materials. Cranes are electrically and or diesel engine powered while hoists are powered by petrol or diesel engines. Elevators are used to raise bags of cement, bricks and tiles and are also powered by small engines and amounted on two wheels so that they can be moved around the site (Foster and Harrington, 1998). A telescopic handler is used for hoisting and is powered by diesel.

According to UNEP (2003), transportation of construction materials consume more energy than all the construction processes. This activity involves the largest percentages of diesel as a form of energy. The transportation also includes the movement of concrete from one place to another (from trucks or point of mixing to the point of placing). The heavy trucks are used to transport materials such as sand and stones and are powered by diesel. Concrete is transported by trucks and are powered by petrol or diesel. Small petrol engines in conveyors, concrete pumps and placers are also used and these are mechanically or pneumatically operated (Foster and Harrington, 1998).

Concreting processes require a significant amount of energy. The machines used in this process are; mixers, concrete pumps, placers, vibrators and conveyors and are either mechanically or pneumatically operated (Foster and Harrington, 1998). Concreting and the type of equipment used have a large embodied energy in the ingredients used and the transportation process. It can be observed that, at different levels of construction process, energy is used. Knowing the construction method statement, an opportunity arises on how energy can be used efficiently on site. Table 1 below summarises the plant, tool or epuipment with the corresponding type of energy used and the construction processes they perform.

METHODOLOGY

The study was carried out in Gauteng and as reported by the Sustainable Energy Africa (SEA) (2009), Gauteng province is the economic hub of South Africa. Many significant industries and business sector bodies are situated in the province. Therefore the province provides opportunities for economic development and competitiveness of its industries through the establishment of a low carbon economy to ensure sufficient energy supply to support sustainable development and cleaner production. This justified the need for study for the study area. For the purpose of this research, a survey was undertaken to obtain practice based opinions. This was via investigative structured scheduled interviews from a sample of five randomly selected construction sites. The interviews targeted managers, foremen, machine operators on sites in Gauteng. Questionnaires were also used and administered to corroborate the findings from the interviews. Fifty questionnaires were randomly distributed to people who work on construction sites (that included managers, foremen, and machine operators). In total 42 questionnaires were received. This accounted for 38% of foremen, 32% of machine operators and 30% of site managers. The mix was on the basis of the willingness of the respondents to complete the questionnaire. The analysis involved the computation of the mean rating (MR) for every aspect within a specified divide. This was calculated using 5 point rating system. Ranking of each factor: From Very High Influence (VHI) = 5, High Influence (HI) = 4, Neutral (N) = 3, Low Influence (LI) = 2, Very Low Influence (VLI) = 1, Rankings also included total response (TR), mean rating (MR) which indicates whether a factor has an influence or not, and relativity index (RI) which indicates the comparative influence in percentages.The total number of respondents (TR) involved in rating every aspect was attained within every computation, and the number of the respondents that relate to a rating of the particular aspect / variable was calculated as a percentage.

RESEARCH FINDINGS

Summarised research findings are discussed in the following sections.

Factors influencing inefficient use and conservation of energy on construction processes

The study highlighted the extent to which pre-identified key factors influenced inefficient use and conservation of energy in construction sites. Respondents were asked to rank from their informed opinion the extent to which these factors influenced inefficient energy use trends and conservation. The rankings results are as outlined in Table 2. It can be seen that lack of efficient site management and ignorance are the main causes of inefficient use of energy on site. This corroborates the findings in studies undertaken by Harlow (1992) and Davis (1982).

Table 2: Factors influencing inefficient use and conservation of energy

Factor	VHI (5)(%)	HI(4) (%)	N(3) (%)	LI(2) (%)	VLI(1) (%)	TR	MR	RI	RI %
Lack of site management	52.4	35.7	11.9	0.0	0.0	42	4.41	0.286	28.6
Lack of skilled operators	14.2	23.3	33.3	16.7	11.9	42	3.11	0.202	20.2
Ignorance	50.0	28.6	16.7	4.8	0.0	42	4.24	0.275	27.5
Plant	21.4	28.6	23.8	16.7	9.5	42	3.65	0.237	23.7
Sum ($\sum$)							15.41	1.00	100

The scale of cost reduction

Proper efficiency mechanisms can impact on the reduction of costs on energy costs. The results from the survey indicate that between 10 -20% reduction can be achieved by carefully implementing energy efficiency and conservation strategies. It is evident from the respondents that efficient energy utilisation and conservation has a positive impact on the reduction of energy costs on construction sites.

Table 3: Cost Reduction and Responses in percentages

	Responses	
Cost reduction in Percentage	**(%)**	**Number**
Less than 10%	28.6	12
Greater 10 but less than 20%	35.7	15
Greater 20 but less than 30%	16.6	7
Greater 30 but less than 40%	9.5	4
Greater 40 but less than 50%	7.2	3
Greater 50 %	2.4	1
Total	100.0	42

Construction areas/activities which consume more energy in construction processes

Table 4 shows key activities that consume more energy in construction processes. It can be seen that transportation, hoisting and concreting, in that order of merit would need more attention and effort towards conserving energy on site. This supports the findings by UNEP (2007)

Table 4: Construction areas/activities with high energy consumption

Activity	VHC (5)	HC(4)	MC(3)	LC(2)	VLC(1)	TR	MR	RI	RI%
Demolition	23.81	30.95	38.10	7.14	0.00	42	3.71	0.183	18.3
Excavations	26.19	28.57	45.24	0.00	0.00	42	3.81	0.188	18.8
Concreting	35.71	42.86	14.29	7.14	0.00	42	4.07	0.201	20.1
Hoisting	50	28.57	16.67	4.76	0.00	42	4.24	0.209	20.9
Transportation	50.00	42.86	7.14	0.00	0.00	42	4.43	0.219	21.9
Sum (∑)							20.26	1.00	100

Various types of energy used on sites

Figure 2 shows the percentage in Rand value of energy used on construction sites. It can be seen that diesel is the most used form of energy in construction processes, followed by electricity, petrol and gas. Diesel is associated with transportation activities. This makes it the most consumed form of energy. This is an indication that more attention must be given to consumption of diesel fuel as revealed in the literature that it is the most CO_2 emitter (DME, 2005).

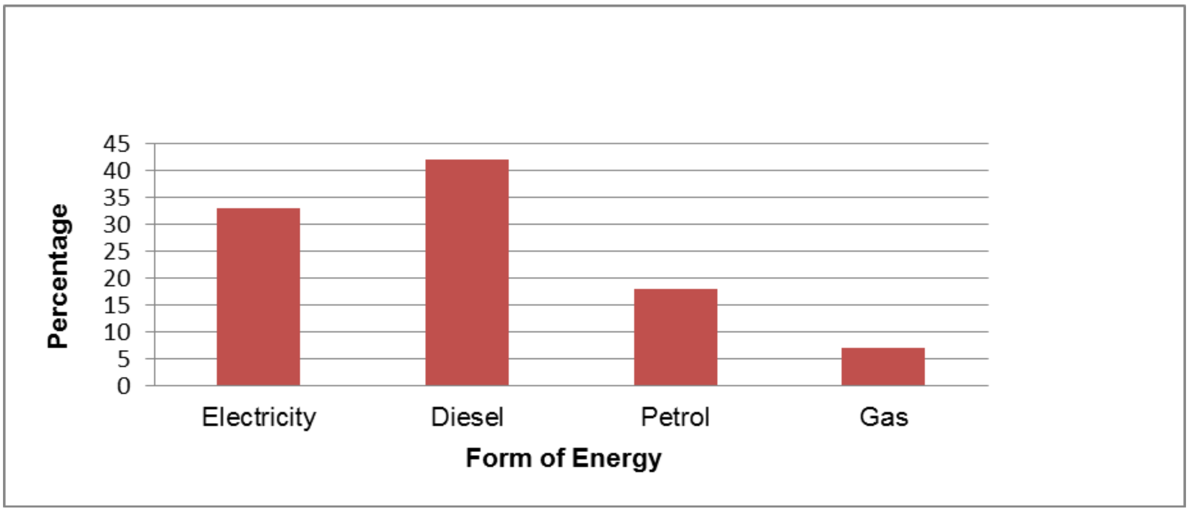

Figure 2: The types of Energy used in Construction Processes

Other Findings

Other findings were obtained through open ended questions on how energy conservation on site can be improved. Among them is the use of machines and equipment. It was found that it is common amongst subcontractors to tender and win projects for which they have no capacity. They end up using machines inefficiently. In addition they use machines for which are not designed for the task, others use equipment that are not sanctioned or are not maintained. In adition safety rules and best practices of management of equipment were not followed. For instance it was common to observe equipment in operation but was not doing any task. It was also clear that staff were not trained on maintenance of equipment in order to conserve energy.

CONCLUSIONS

The paper has highlighted the extent to which certain factors influence inefficient use of energy in construction processes, and how proper energy utilisation and conservation can reduce costs. Areas that comparatively consume more energy have been identified. Transportation, hoisting and concreting are some of the processes that demand more energy usage. It can be seen that for energy efficiency to be achieved on site, a lot more effort will be required to improve site management and training of workers to be more conscious of the use of energy. The future of the efficient energy use on construction site will rely on a number of things. One among them is efficient site management practices, which include efficient site layout; the use equipment for which it has been designed, and its maintenance according to the manufacturers' instructions; and the training of staff to be conscious of energy conservation. Transport as a major consumer of energy, it is necessary that a proper logistical transport system be in place that synchronizes the delivery of materials and removal of waste on site.

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