PROCEEDINGS OF THE 5TH INTERNATIONAL CONFERENCE ON DEVELOPMENT AND INVESTMENT IN INFRASTRUCTURE - STRATEGIES FOR AFRICA

DII - 2018

11 - 13 July 2018, Livingstone, Zambia

READYING AFRICA FOR SUSTAINABLE DEVELOPMENT: A CAPACITY BUILDING AND STRATEGY DISCOURSE

Editors: Franco Muleya, Erastus Mwanaumo, Innocent Musonda
Co-editors: Balimu Mwiya, Chioma Okoro, Nelly Chunda-Mwango

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FOREWORD

On behalf of the Organising Committee, it is my pleasure to welcome you to Livingstone, Zambia, the host city of the International Conference on Development and Investment in Infrastructure (DII-2018). The DII-2018 conference is part of the DII Conference series on Infrastructure Development and Investment in Africa which aims to provide an international forum for leaders, researchers, practitioners and other stakeholders in infrastructure development to discuss and devise ways of maximizing benefits from infrastructure development in Africa and achieve outputs that will inform policy.

With focus on regulatory, institutional framework, general infrastructure development and investment in Africa, the 2018 conference, themed *"READYING AFRICA FOR SUSTAINABLE DEVELOPMENT: A CAPACITY BUILDING AND STRATEGY DISCOURSE"*, will address a broad range of topics around infrastructure to evaluate and draw lessons on innovations, empowerment, growth and sustainable development.

The broad topics covered by the conference include:

- Capacity-building measures for infrastructure development
- Infrastructure development strategies for developing countries
- Legislative & institutional frameworks in infrastructure development
- Infrastructure development finance and procurement strategies
- Empowerment and human factors in infrastructure development
- Sustainability in infrastructure development
- ICT and innovation in infrastructure development
- Development goals and Infrastructure

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 Scientific and Technical review Committees (STC). The organising committee is thankful for this voluntary service that is so central to the quality of the accepted papers.

Special thank you also goes to all the conference delegates that have travelled from different continents. Thank you for attending the event and please make the most of your time at the conference while enjoying the hospitality of the Zambian people here in Livingstone.

Erastus Mwanaumo
For/DII-2018

ACKNOWLEDGEMENT

The Organising Committee of the DII-2018 Conference is grateful to the University of Zambia, Copperbelt University, Zambia, National Council for Construction (NCC), Zambia, University of Johannesburg, South Africa, the Chartered Institute of Building, Tomorrow Investments Limited (UMCIL), Aviation Industry Corporation of China (AVIC) International, Zambia, the Universal Mining and Chemical Industries Limited, the South African Council for the Project and Construction Management Professions and other South African, African and International universities and Institutions for supporting the conference through their valued contributions.

The contributions and unique support of the International Advisory and Scientific Committees, who worked tirelessly to prepare refereed and edited papers, which produced this published proceedings of the highest standard including satisfying the criteria for subsidy by the South African Department of Higher Education and Training (DHET), is truly treasured. The contributions of Prof Innocent Musonda, Dr Erastus Mwanaumo, Dr Franco Muleya, Prof Trynos Gumbo, Dr Balimu Mwiya, Dr Alice Lungu, Dr Chabota Kaliba, Dr Nelly Chunda-Mwango, Prof Mundia Muya, Mrs Chioma Okoro, Ms Elizabeth Mkoba, Mr Choeu Makabate, Ms Chama Mwansa and Mr Brian Mutale are recognised. The support of Mr Ansary Nazeem and Prof Steve Ekolu is laudable.

DISCLAIMER

While every effort is made to ensure accuracy in this publication, the publishers and editors make no representation, express or implied, with regard to the accuracy of the information contained in these proceedings and cannot accept any legal responsibility of liability in whole or in part for any errors or omissions that may be made.

DECLARATION

All the papers in these conference proceedings were double-blind peer reviewed at abstract and full paper stage by the members of the International Review Committee. The process entailed detailed reading of the abstracts and full 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.

CONFERENCE COMMITTEES

Organising Committee

Zambia

Dr Erastus Mwanaumo (Chairman: Technical Programme)
Dr Franco Muleya
Dr Balimu Mwiya
Dr Alice Lungu
Dr Chabota Kaliba
Dr Nelly Chunda-Mwango
Ms Chama Mwansa
Mr Brian Mutale

South Africa

Prof Innocent Musonda (Chairman: Scientific Programme)
Prof Trynos Gumbo
Mrs Chioma Okoro

Scientific Committee

This committee ensured that the final papers incorporated the reviewers' comments, were correctly allocated to the appropriate theme and met the requirements set by the organisers in line with international standards for inclusion in the proceedings. They also arranged the papers into their final sequence as captured on the USB memory stick and Table of Contents.

Dr EM Mwanaumo, University of Zambia
Dr F Muleya, Copperbelt University, Zambia
Dr J Agumba, Durban University of Technology, RSA
Dr B Mwiya, University of Zambia
Prof I Musonda, University of Johannesburg, RSA
Prof CO Aigbavboa, University of Johannesburg, RSA
Prof D Thwala, University of Johannesburg, RSA
Prof M Muya, University of Zambia
Prof T Gumbo, University of Johannesburg, RSA

Technical Review Committee

The technical review committee comprised of experts from the built environment. The committee ensured that the papers were of the highest standard in terms of originality of material; academic rigor; contribution to knowledge; critical current literature review; research methodology and robustness of analysis of findings; empirical research findings; and overall quality and suitability for inclusion in the conference proceedings.

THE PEER REVIEW PROCESS

The need for high quality conference proceedings, evident in the accepted and published papers, entailed a rigorous two-stage blind peer review process by no less than two acknowledged experts in the subject area. Experts including industry professionals and academics were assigned with the responsibility of ensuring that high standards of scientific papers were produced and included in the proceedings.

First stage of review

Submitted abstracts were twice blind-reviewed. Each abstract was reviewed in terms of relevance to conference theme and objectives, academic rigor, contribution to knowledge, originality of material and research methodology. Authors whose abstracts were accepted were provided with anonymous reviewers' comments and requested to develop and submit their full papers taking into consideration the abstract review comments.

Second stage of review

Experts were once again assigned the submitted full papers relative to their areas of expertise. The full papers were reviewed in terms of relevance to conference theme and objectives; originality of material; academic rigour; contribution to knowledge; critical current literature review; research methodology and robustness of analysis of findings; empirical research findings; and overall quality and suitability for inclusion in the conference proceedings.

Third stage review

Authors whose papers were accepted after the second review were provided with additional anonymous reviewers' comments on evaluation forms, and requested to submit their revised full papers. Evidence was required relative to specific actions taken by the authors regarding the referees' suggestions. Final papers were only accepted and included in the proceedings after satisfactory evidence was provided. To be eligible for inclusion, these papers were required to receive a unanimous endorsement by all the reviewers that the paper had met all the conditions for publication. Out of 46 submissions, 31 papers were finally accepted and included in the DII-2018 conference proceedings.

At no stage was any member of the Scientific Review Panel or the Organising Committee or the editors of the proceedings involved in the review process related to their own authored or co-authored papers. The role of the editors and the scientific committee, was to ensure that the final papers incorporated the reviewers' comments and to arrange the papers into the final sequence as captured on the USB memory stick and Table of Contents.

Regards
Innocent Musonda
Chair: Scientific Programme

UNIVERSITY OF JOHANNESBURG

The University of Johannesburg (UJ), is the largest, multi-campus, residential university in South Africa. Born from a merger between the former Rand Afrikaans University (RAU), the Technikon Witwatersrand (TWR) and the East Rand campuses of Vista University in 2005, the University of Johannesburg's unique academic architecture reflects a comprehensive range of learning programmes, leading to a variety of qualifications ranging from vocational and traditional academic to professional and postgraduate programmes, across the four campuses, namely: Auckland Park Kingsway, Auckland Park Bunting Road, Doornfontein and Soweto campuses. The campuses vary in size and each has its own character and culture, contributing to the institution’s rich diversity.

The University of Johannesburg has benefited from a large pool of researchers bringing together various fields of expertise and research focus areas. The university provides the ideal ground for interdisciplinary research and the university has more than 87 rated researchers. Five of these researchers are A-rated - all of whom are recognised as world leaders in their field. The university is also home to nine research centres.

The University fosters ideas that are rooted in African epistemology, but also addresses the needs of the South African society and the African continent as it is committed to contributing to sustainable growth and development. We continue to build a culture of inclusion, embracing South Africa's rich history, culture, languages, religions, gender, races, social and economic classes. Additionally, the University encourages a culture of service as part of the university student experience and it proudly pursues a four-language policy of English, isiZulu, Afrikaans and Sesotho sa Leboa.

Our staff and students come from over 50 countries in Africa and the world. The university has also built links, partnerships and exchange agreements with leading African and other international institutions that further enrich the academic, social and cultural diversity of campuses. It is also the recipient of the highest levels of external financial support, from donors and partners all over the world. This demonstrates the high esteem in which we are held internationally.

In its mission, UJ commits itself to the following:

- Quality education;
- Leading, challenging, creating and exploring knowledge;
- Supporting access to a wide spectrum of academic, vocational and technological teaching, learning and research;
- Partnerships with our communities; and
- Contributing to national objectives regarding skills development and economic growth.

The values guiding all University activities include:

- Academic distinction;
- Integrity and respect for diversity and human dignity;
- Academic freedom and accountability;
- Individuality and collective effort; and
- Innovation

In giving expression to its vision of being a pre-eminent South African and African University, UJ has set itself ten strategic goals. Its priorities are to:

- Build a reputable brand;
- Promote excellence in teaching and learning;
- Conduct internationally competitive research;
- Be an engaged university;
- Maximise its intellectual capital;
- Ensure institutional efficiency and effectiveness;
- Cultivate a culture of transformation;
- Offer the preferred student experience;
- Secure and grow competitive resourcing; and
- Focus on the Gauteng city regions.

THE COPPERBELT UNIVERSITY

HISTORY

With its motto "Knowledge and Service", the Copperbelt University (CBU) was established in 1987 as part of the University of Zambia. It was initially intended to be located in Ndola, about 50km South East of Kitwe, as UNZANDO (University of Zambia in Ndola). But since the University of Zambia (UNZA) had no infrastructure in Ndola at the time, UNZANDO was allowed to operate in Kitwe using the Zambia Institute of Technology (ZIT) infrastructure. ZIT was integrated into Copperbelt University in 1989, two years after the university was established. Until recently (when many public and private universities are being established), the Copperbelt University was the only other university in the country after the University of Zambia. Currently, the university has eight academic schools – Schools of the Built Environment, Engineering, Medicine, Graduate Studies, Business, Mines and Mineral Sciences, and the School of Natural Resources. In addition, the University offers distance education through its Directorate of Distance Education and Open Learning. The Dag Hammarskjold Institute for Peace Studies is accommodated at Copperbelt University.

THE SCHOOL OF BUILT ENVIRONMENT

The School of the Built Environment (SBE) (formerly School of Environmental Studies) was established in 1981 under ZIT when the School admitted its first students. The School remained temporarily situated at ZIT until 1989. The School of the Built Environment (SBE), therefore, increased its scope by taking on the ZIT Diploma courses in Architecture, Quantity Surveying, Land Surveying and Town & Country Planning, and Advanced Technician course in Construction. The University began to offer these programmes at degree level. Currently, the School consists of four departments, namely: Architecture, Construction Economics and Management (CEM), Real Estate Studies (RES, formerly Land Economy), and Urban & Regional Planning (URP). In addition, the school also offers a Master of Science programme in Project Management. The School also runs a Project and Consultancy Section called the Practice Office, which is responsible for undertaking consultancy services in various fields of the built environment. Currently, there are 5 undergraduate and 1 masters' degree programmes offered in the school. These are BSc. in Quantity Surveying, and BSc. in Construction Management (both offered by the CEM Department); BSc. in Real Estate Studies (offered by the RES Department); BSc. in Urban & Regional Planning (offered by the URP Department); Bachelor of Architecture (BArch, offered by the Architecture Department); and the MSc. in Project Management (offered by the School of Graduate Studies).

After successful completion of their degree programmes, our students join both public and private sector reputable organizations within and outside the country where they work as Architects, Design Consultants, Construction Managers, Valuers, Planners, Project Managers, Quantity Surveyors, Investment Bankers and many more. Other than the masters programme, which takes up to two years to complete, all our undergraduate programmes should take five years to complete. Our students come from within and outside Zambia. In terms of staffing, it is the policy of the University that it recruits highly qualified personnel. For this reason, the university has put in place a policy where the minimum qualification of a lecturer is not only a masters' degree but also that the masters' degree must be in the same discipline as the lecturer's first degree. In addition to this profile, the SBE has a very ambitious programme where it intends to expand the school by introducing more programmes like the MSc. Degree in Land Management. This will help in meeting the ever increasing demand for qualified professionals within and outside the SADC region. More information on CBU in general and SBE in particular, can be found on our website at www.cbu.edu.zm.

University of Zambia

THE SCHOOL OF ENGINEERING, UNIVERSITY OF ZAMBIA

INTRODUCTION

University of Zambia opened its doors in 1966, two years after Zambia attained its independence. The main purpose was to produce human resources (graduates) for the government and industry in Zambia. From the first intake of students of 300, the population has grown to the current population of over 32,000. The School of Engineering located at the main campus of the University of Zambia in Lusaka is one of the twelve (12) schools in the university. Over the years, the school has responded to various national challenges through teaching, research, training, consultancy and public service. The School of Engineering, now comprising the Departments of Agricultural Engineering, Civil & Environmental Engineering, Electrical and Electronic Engineering, Geomatics Engineering and Mechanical Engineering was established on 1st May 1969.

The school has a student population that is more than 490 undergraduate, 400 Master of Engineering students and 15 Doctoral Candidates across all the departments. The postgraduate programmes aim at training engineers with advanced and in-depth knowledge in specialised fields. The number of postgraduate programs remained small for a long period of time until the year 2010 when it became clear that there was a serious gap in trained manpower in the energy sector.

To address this gap, the University of Zambia, School of Engineering with the financial support from NUFFIC, developed a master's degree program in Renewable Energy. From this experience, the School identified many gaps in engineering management fields, the ICT sector, environment, structural and project management, and developed several other programs in electronics, construction and engineering management. The aim was to elevate the calibre of engineers in the country to improve the management of engineering firms in line with the new technologies.

POSTGRADUATE PROGRAMMES OFFERED IN THE SCHOOL

PhD research programmes

PhD research programmes offer a vast range of opportunities to students who relish the chance to undertake a research project with clear intellectual, scientific, industrial or commercial relevance and challenge. Currently the school has PhD Candidates in the Departments of Civil & Environmental Engineering and Mechanical Engineering. The School also undertakes interdisciplinary research in conjunction with other institutions.

Taught MEng programmes

Part I – Taught Component (First Year)

1) Master of Engineering in Agricultural Management (Taught or by Research)
2) Master of Engineering in Engineering Management (Taught or by Research)
3) Master of Engineering in Structural Engineering (Taught or by Research)
4) Master of Engineering in Environmental Engineering (Taught or by Research)
5) Master of Engineering in Construction Management (Taught or by Research)
6) Master of Engineering in Project Management (Taught or by Research)
7) Master of Engineering in Water Resources Engineering (Taught or by Research)
8) Master of Engineering in ICT (Taught)
9) Master of Engineering in ICT Security (Taught)
10) Master of Engineering in ICT Regulation, Policy and Management (Taught)
11) Master of Engineering in Computer Communications (Taught)
12) Master of Engineering in Telecommunications Systems (Taught)
13) Master of Engineering in Wireless Communications (Taught)
14) Master of Engineering in Electrical Power Engineering (Taught or by Research)
15) Master of Engineering in Geo-Information & Geodesy (Taught)
16) Master of Engineering in Production Engineering & Management (Taught or by Research)
17) Master of Engineering in Thermo-Fluids Engineering (Taught or by Research)
18) Master of Engineering in Renewable Energy Engineering (Taught or by Research)
19) Master of Engineering in High Voltage Engineering and Power Management (Taught or by Research)
20) Master of Engineering in Electromagnetic Compatibility and Electrical Safety (Taught or by Research)

Part II – Research Component (Second Year)

Part II comprises research work and a dissertation. A candidate is, at the end of his/her research work, and prior to the submission of his or her dissertation, expected to present the results of his/her research work at an open Seminar organised by the Directorate of Research and Graduate Studies for the purposes of discussion and comments. The Examination includes a viva-voce.

All Master Programmes are also offered by Research (Two-year programmes)

With these new strides, the university answers the call from society, which requires a pool of well-trained engineers meeting the challenges of operating in the developing world while meeting the challenges of both the developing and developed economies.

KEYNOTE SPEAKERS' PROFILES

The Development and Investment in Infrastructure (DII) conference is an international conference which provides a forum for discourse on the status quo regarding Africa's massive shortfall in infrastructure development and investment that limits its productive capacity and global competitive advantage. Inaugurated in 2014 in Livingstone, Zambia, the conference has been jointly hosted by the University of Johannesburg, the University of Zambia, Copperbelt University, and the National Council for Construction - Zambia. The DII-2018 conference will see collaboration between the DII and the University of Toronto on Engineering Education for Sustainable Cities in Africa. Previous meetings have been supported by the Network of Energy Excellence for Development (NEED), a project funded by the European Union (EU) and the African, Caribbean and Pacific Group of States (ACP). The conference is a great platform for development and Built Environment professionals, researchers, academics and post-graduate students who are passionate about eliciting solutions to the infrastructure challenges and sustainability in Africa.

Themed, *"READYING AFRICA FOR SUSTAINABLE DEVELOPMENT: A CAPACITY BUILDING AND STRATEGY DISCOURSE"*, the 2018 conference will focus on the role of empowered and capable stakeholders in ensuring sustainable infrastructure development in Africa. The conference will address a broad range of topics around infrastructure to evaluate and draw lessons on innovations, empowerment, growth and sustainable development. The confirmed DII-2018 keynote speakers include:

Prof. José Carlos LINO

JOSE CARLOS LINO is a Board member and engineering Coordinator at IBERD, SA and Newton - Engineering; BIM Consultant, at BIMMS-Management Solutions; Invited Lecturer and BIM researcher, at University of Minho; Academic Director and Teacher on the Master BIM Manager for Zigurat and NossoBIM.

Lino is a pioneer of BIM development and implementation in Portugal. He is currently working with international teams, managing BIM on several projects and in many countries. He sits on many boards of interest groups leading BIM standardization and implementation either at a National or at international level. Lino has been invited to participate on multiple conferences and workshops to discuss BIM and has just lead the creation of Portuguese National chapter of Building smart.

Dr. Lubinda HAABAZOKA

LUBINDA HAABAZOKA is a Director at the University of Zambia's Graduate School of Business. He also worked as Senior Lecturer in Economics, Banking and Finance and Post Graduate Studies Coordinator in the School of Business at the Copperbelt University. He also served as Head of the Accounting and Finance Department at the Copperbelt University in Zambia from 2012 to 2016. He holds a Master of Science degree in Finance and Credit with a specialization in Banking from Rostov State Economics University (Russia). He also has a Doctor of Philosophy Degree in Economics, with a focus on Banking, from Rostov State Economics University, Russia.

Dr. Haabazoka has done several research works among which are a study on Capital Market developments in Zambia, the National Economic Advisory Council commissioned studies on youth employment creation in Zambia and Railway industry developments in Zambia. He has also done a number of advisory notes to the Zambian Republican President on economic matters through the National Economic Advisory Council. Dr. Haabazoka has also appeared before Zambian parliamentary committees to provide advice on national economic matters. He is currently a member of the negotiating team on behalf of the Zambian government with Russia's Rosatom for the construction of the Centre for Nuclear Science and Technology.

Dr. Haabazoka is also author of more than 20 academic research papers and several books and monographs.

Dr. Sambo ZULU

SAMBO ZULU is a Senior Lecturer in Quantity Surveying/Construction Management at Leeds Beckett University. His research interests are in project management, organizational and management studies, and built environment education. His attention regarding built environment research has been drawn to the impact of innovation in digital technologies on the occupational structure and skill-set demands in the construction industry. He leads a research group on built environment education research.

Prof. Nuno GIL

NUNO GIL is Professor of New Infrastructure Development at the Manchester Business School, United Kingdom. His research focuses on the structures that bring the best of people in consensus-oriented collaborative networks formed to produce long-lived infrastructure and tackle major societal problems such as poverty relief, climate change, health care provision, and drug resistance. His work develops theory, cognitive frameworks, and methods for communicating with key stakeholders, the structure of collaborative networks, how these networks can perform effectively and efficiently, and how to measure performance in consensus-oriented collective action arenas. Specifically, Nuno investigates development processes, design structures, contracting and procurement strategies, governance structures, and the practice of leadership. Nuno has worked, or done research, with various organisations around the globe notably in the USA: CH2M HILL and Intel; in the UK: Rolls Royce, BAA (now Heathrow), BP, Constructing Excellence, Manchester City Council, Network Rail, Beetham Organisation, Cross-rail, London2012, High-speed 2, and L.E.K. Consulting; in Portugal: EDP-Energy, Cross-rail; in India: Larsen & Toubro, Dedicated Freight Corridor Corporation of India (DFCCIL); in Nigeria: Lamata; in Uganda: Road Fund. Nuno is the co-founder and research director of the Centre for Infrastructure Development. In 2013, Nuno and Professor Carliss Baldwin of Harvard Business School jointly coined the term design commons.

Mr. Maxwell ZULU

MAXWELL ZULU is the Manager Technical Services at the Lusaka South Multi Facility Economic Zone Ltd in Zambia. He has the responsibility of ensuring that the company develops its infrastructure and support services in order to create an enabling environment for investors to operate. This includes mobilising resources to develop the infrastructure, run it and maintain it. He has held this position for one year now. Previously, he was the Chief planner for the Zone. He has extensive experience in infrastructure development under the Ministry of Works and Supply where he was involved in various infrastructure development for government Ministries, including housing development, schools, health facilities and road infrastructure.

Maxwell has occupied various positions in Government notably the provincial planner for Luapula, Lusaka and Central Provinces for a period of 18 years under the Ministry of Local Government and Housing, Ministry of Works and Supply and Livingstone City Council.

Maxwell is a frequent speaker on business forums organised locally and internationally.

Mr. Matthew NGULUBE

MATTHEW NGULUBE is the Executive Director at the National Council for Construction, Zambia. He has been a Principal Consultant for over 16 years. He has consulted as Project Manager and Quantity Surveyor for several multi-million dollar projects, in both the private and public sectors, which have left a landmark in Zambia's infrastructure development. Key among them include-Upgrade of the Kenneth Kaunda International Airport; Kasumbalesa border post One-+stop-Shop; Radisson Blu 4-Star Hotel in Lusaka; Levy Business Park Shopping Mall; The New Engineering Institution of Zambia Office Complex and others. He is the incumbent Chairman of the Quantity Surveyors Registration Board of Zambia and Vice President for the Association of Quantity Surveyors for Southern Africa Region (AAQS) and Commonwealth Association of Surveyors and Land Economists (CASLE) Southern Africa Region. He is also a member of the International Federation of Surveyors (FIG) and serves as board member of the Habitat for Humanity.

DII – 2018
11 – 13 July 2018, Livingstone, Zambia

International Conference on Infrastructure Development and Investment Strategies for Africa

11 July 2018

To whom it may concern

PEER REVIEW PROCESS (PRP) CONFIRMATION

On behalf of the DII-2018 International Conference on Infrastructure Development and Investment Strategies for Africa, we confirm that the manuscripts accepted for oral presentation and publication in the Conference proceedings were blind peer-reviewed by two (2) or more technical specialists.

The reviewers were selected from the experts in the Scientific and Technical Review Committee. To be eligible for inclusion, the papers, reviewed through a three-stage review process (abstract, full paper and final paper) received a unanimous endorsement by all the reviewers that they had met all the conditions for publication. All accepted manuscripts will be published via the conference proceedings.

The conference proceedings with **ISBN 978-0-620-77537-3** will be provided at the conference to be held in Livingstone, Zambia, from 11 – 13 July 2018.

Regards,

Dr Justus Agumba

DII-2018 PRP Manager

justusa@dut.ac.za

Conference website: www.diiconference.org

Email: info@diiconference.org

Development and Investment in Infrastructure (DII)

University of Zambia

Copperbelt University
Knowlege and Service

CONFERENCE PROGRAMME

WEDNESDAY, JULY 11, 2018	
10:00 – 19:30	**Registration**
08:00 – 16:00	**EESC-A Workshop**
14:00 – 17:30	**BIM Talk and Workshop – Be Ready for the Digital Construction Industry**
14:00 – 17:30	**Use of GIS & Drones in Infrastructure Workshop**
19:30 – 21:30	**Networking Opportunity & Welcome Cocktail**
THURSDAY, JULY 12, 2018	
07:00 – 08:00	**Registration**
08:00 – 08:30	**Welcome & Keynotes** **Chair: Dr Erastus Mwanaumo** – Assistant Dean Post Graduate, School of Engineering – ***University of Zambia, Zambia*** ***Vice Chancellor - Copperbelt University, Zambia***
08:30 – 08:55	The State of the Construction Industry: Where to from here? ***Mr Mathew Ngulube – Executive Director of the National Council for Construction (Conference Sponsor)***
08:55 – 09:20	Organizational Contraptions: Adding Collective Action to Contractual Governance to Upgrade the Cairo´s Zabbaleen 'Garbage Cities' ***Prof Nuno Gil – Professor of New Infrastructure Development, University of Manchester, United Kingdom***
09:20 – 09:45	Building Information Modelling (BIM) - From Strategy to Application ***Prof Jose Carlos Lino - Director of Executive Program in BIM for Owners & Developers and the International Master in BIM Management , Global Institute of Technology, Portugal***
09:45 - 10:00	**Tea break/Networking**
10:00 – 10:50	Achieving Collective Ends with Limited Resources: Developing Africa´s Infrastructure - ***Book launch***
	Technical Sessions
	Plenary Session 1
	Theme: Sustainability and Development Goals in Infrastructure Development **Session Chair: Dr Balimu Mwiya**
10:50 – 11:05	Interplay between Infrastructure Development and Climate Change Vulnerability in Lusaka: A Desktop Survey ***Chisumbe S. et al.***
11:05 – 11:20	Servitisation in Construction: An Identification of Drivers ***Ramafalo R. et al.***
11:20 – 11:35	Exploring the Concept of Value for Money Assessment in Sierra Leone ***Massaquoi B. O. et al.***
11:35 – 11:50	Critical Analysis of Design Standards for Zambia Transportation Infrastructure: The Implication of Climate Change ***Kaonga et al.***
11:50 – 12:05	Professional Ego versus Maslow's Hierarchy of Needs during the Execution of Infrastructure Projects ***Ndihokubwayo R.***
12:10– 13:10	**Lunch Break**
	Plenary Session 2 **Chair: Dr Chabota Kaliba**
13:15 – 13:40	Keeping up with Innovation: The Challenge for the Built Environment Education – ***Dr Sambo Zulu***
13:45 – 14:10	Avoid or Exploit Institutional Voids? Organizational Duality in the Design of Capital Project Organizations in Emergent Markets ***Prof Nuno Gil - Professor of New Infrastructure Development, University of Manchester***
14:15 – 14:35	**Tea Break/ Networking**
14:40 – 15:45	Interactive Panel Discussion on Urban Sustainability – EESC-A – ***Dr Rahim Rezaie, University of Toronto***
19:00 – 22:30	**Gala Dinner** - ***Platinum sponsored***

FRIDAY, JULY 13, 2018		
	Keynotes **Chair**: **Dr Franco Muleya**	
08:30 – 08:55	Contractor Development Challenges in Zambia ***Mr Chanda A. Katotobwe – CEO- Tomorrow Investments (Conference Platinum Sponsor)***	
08:55 – 09:20	Dr Julius Kaoma – **UMCIL**	
09:20 – 09:45	Nuclear Energy – Is Zambia Ready? ***Dr Lubinda Haabazoka – Socio-economic Commentator & Researcher, Director, Graduate School of Business, University of Zambia, Zambia***	
09:45 – 10:10	Technological Development and Skills Transfer in the Lusaka South Multi Facility Economic Zone ***Mr. Maxwell Zulu – Principal Planner & Manager at Lusaka South Multi Facility Economic Zone, Zambia***	
10:10 – 10:30	**Tea break/ Networking**	
	Technical sessions	
	Plenary Session 3	**Plenary Session 4**
	Theme: Human Factors in Infrastructure Development **Session chair: Dr Gabriel Nani**	**Theme: Innovation in Infrastructure Development** **Session chair: Dr Ayodeji Aiyetan**
10:30 – 10:45	Multi Stakeholder Consultative Framework for Construction Health and Safety: Role of Client and Project Manager – ***Mambwe M.. et al.***	Electronic Integration of Urban Public Transport through Automated Payment Systems - ***Mbatha S. et al.***
10:50 – 11:05	Addressing Gender Inequality on Construction Sites in Bloemfontein: An Exploratory Study – ***Sechoaro T. et al.***	Structural Health Monitoring of Highway Bridges in Zambia using Sensor Technology: A Case Study of Nansenga Bridge ***Kasumba H. et al.***
11:10 – 11:25	Perception of Students about the Technician Profession in Science and Laboratory Technology ***Sumary D.***	The SMME Contractors' Business Survival Traits and Competitiveness – ***Anugwo I. et al.***
11:30 – 11:45	Assessing the Training Needs and Competencies for Quantity Surveying Graduates in the Zambian Construction Industry - ***Chiponde D. et al.***	A System Thinking Model of the Impact of Dwelling Internal Heat on Carbon Emissions within the South African Housing Sector ***Oladokun M. et al.***
11:50 – 12:05	An Assessment of the Workplace Environment on Productivity and Delivery of Infrastructure - ***Aiyetan A.***	Barriers to Enhancing Environmental Sustainability of Construction Projects in Zimbabwe: Perspective of Construction Consultants ***Njere T. et al.***

12:10 - 13:10	**Lunch Break**	
	Plenary Session 5	**Plenary Session 6**
	Theme: Infrastructure Development Finance and Procurement **Session chair: Dr Michael Mulenga**	**Theme: Sustainability and Development Goals in Infrastructure Development** **Session chair: Mr Danstan Chiponde**
13:15 – 13:30	Sustainability in Road Infrastructure Development: Financing Strategies - ***Tembo Y. et al.***	The Sacrifice of Groundwater by Urbanization: A Glance at Ngwerere Catchment **–** ***Phiri L.***
13:35 –13:50	Multifaceted Financing Constraints in Public Infrastructure Investment and Development ***Xhala N. et al.***	An Assessment of the Adequacy of Maintenance Activities in Public Higher Learning Institutions: A Case Study of the Copperbelt University - ***Mutwale-Ziko J. et al.***
13:55 – 14:10	Critical Success Factors for an Effective Performance of the Procurement Department Function: The Case of Local Government Offices in Ghana. **–** ***Yevu S. K. et al.***	Sustainability in Infrastructure Development: Overcoming the Challenges Pertaining to the Supply of Electricity in Nigeria ***Awoyokun N. et al.***
14:10 – 14:25	**Tea break/ Networking**	
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14:50 – 15:05	The Green Building Movement in Zambia - ***Sichali, M.***	Critical Factors influencing Success of Infrastructure Projects ***Makabate C. T. et al.***
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15:30 – 16:00	**Conference End and Closing** DII Conference: Achievements and Road Ahead **Prof Innocent Musonda (Scientific Chair) and Dr Erastus Mwanaumo (Technical Chair)**	
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KEYNOTE ABSTRACTS

DII-2018-047

Organizational Contraptions: Adding Collective Action to Contractual Governance to Upgrade the Cairo's Zabbaleen 'Garbage Cities'

Prof Nino Gil[1]

Abstract

Slum upgrading is a central challenge to meeting the UN's sustainable development goals. Complicating the coordinated collective action that is necessary to resolve this grand societal challenge is the diffusion of decision-making authority across multiple autonomous actors in an environment of ill-defined property rights and inefficient markets. This chapter draws on in-depth analysis of a participatory development project for upgrading Cairo's Zabbaleen Garbage cities to theorize a form of organising work that enables to tackle grand challenges whilst navigating the institutional voids in the environment. We introduce the notion of an organizational 'contraption' to refer to the way by which a core set of contracts is supplemented with a collective-action structure for encouraging cooperation and voluntary contributions of the resources that exist in a regime of ill-defined property rights. Our central contribution is to illuminate how by "contracting for collective action", a contraption is trading off economizing on the high transaction costs needed to define property rights for the costs of collective action and risk of a tragedy of the commons. We conclude by discussing implications to our understanding on new inter-organizational forms of organising work.

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DII-2018-048

Building Information Modelling (BIM): From Strategy to Application

Prof José Carlos Lino[1]

Abstract

Building Information Modelling (BIM) is no longer an option. Everywhere we may find use and success cases of application of this concept and methodology, taking profit of technology enhancements and advances. However few are still doing it from an entire top down or bottom up approach, this is, governing the application of BIM by the vision and the strategy and, on the other hand, supporting it by the operative skills and competences. We need to discuss and spread this type of approaches in order to help and support policies and implementations either at a National, associative, or organizational levels to endure. Africa in general, nowadays, has this major opportunity of applying this new concept to the infrastructural and buildings works that still is needed, taking profit of the knowledge and experiences that are spreading everywhere in the world.

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DII-2018-049

Keeping up with Innovation: The Challenge for Built Environment Education

Dr Sambo Zulu[1]

Abstract

The construction industry continues to see significant innovation-led changes that have a potential disruptive effect on management and organizational practices. It is considered that such changes should reflect on the skills set required for "tomorrow's" construction organization, both at a firm and project organization level. The agenda in this paper is to evaluate the influence of current innovation drivers on the occupational structure and skills in the construction industry. It acknowledges that the nature of innovation suggests that changes will be inevitable. A critical analysis of the extent to which built environment education is keeping up with innovation is therefore necessary. The discussion takes a three-pronged approach. First, an extensive review of literature on the impact of innovation on occupational structures and skills requirements is presented. The dual relationship between innovation and construction industry skills is considered. These include: the impact of innovation on the occupational structure and demand for skills; and the extent to which skilled workforce can drive innovation. And second, the role of the higher education sector in responding to the innovation-led skills challenge and its influence on the innovative-behaviour of future leaders is considered. On one hand a debate has been hard on whether the higher education sector is producing graduates with all the required skills in this age of fast developing changes. On the other hand, it is acknowledged that the higher education sector is the training ground for leaders of tomorrow and therefore have an influence on future decision makers. Models of how the education sector can keep up with innovation and/or drive innovation are considered. In addition, an agenda for future research is proposed.

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DII-2018-050

Avoid or Exploit Institutional Voids? Organisational Duality in the Design of Capital Project Organisations in Emergent Markets

Prof Nino Gil[1]

Abstract

This inductive study examines a duality in the design of organisations in emerging markets. We ground the research on a sample of project organisations set up to develop basic public transportation assets in Sub-Saharan Africa and India. All capital projects were financed by loans provided by development agencies - the institutional intermediary between the state and the contractors. We trace variation in the design and evolution of the project organisations to differing guiding principles to navigate the institutional voids in the environment. When the intermediary is a "traditional" donor (e.g., World Bank), the project organisation grows step-by-step and transparently. When an "emerging" donor is involved (e.g., China Eximbank), the growth of the project organisation is fast-tracked and opaque. We link orderly organisational growth to a choice to avoid (or fill first) institutional voids at the expenses of taking longer to achieve the system goal that unifies the organisational participants. In turn, we link the fast-tracked approach to a choice to exploit institutional voids to speed up the achievement of the unifying goal at the expenses of a risk of disarray if institutional void exploitation backfires. Our main contribution is to theorise how this exploit-or-avoid duality explains variation in organisation design and performance in emergent markets and link this duality to differing forms of navigating institutional voids.

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DII-2018-051

Socio-Economic Benefits of the Development of Nuclear Science and Technology for Zambia

Dr Lubinda Haabazoka[1]

Abstract

It is difficult to overstate the importance of nuclear science and technology. The first peaceful nuclear programs were launched in the United States in the mid-1960s and later in Europe in the early 1970s. Concerns about fossil fuel depletion and the desire of several countries to reduce their energy dependency resulted in the development of nuclear power plants across the globe especially during the 1970s. With advancements in nuclear science, many developed countries started using nuclear technology not only in the energy sector but also in the agriculture, health and other important sectors of the economy.

Unfortunately, Zambia like many developing countries around the world did not utilise the opportunity provided by nuclear technology to enhance its own national economic development agenda. The Zambian government has however announced plans to establish a Center for Nuclear Science and Technology with intentions of building a Nuclear Power Plant in the near future. This paper therefore seeks to establish the potential socio-economic benefits of nuclear science and technology for Zambia. It seeks to look at capacity building activities that Zambia might need to do in order to enhance peaceful nuclear infrastructure development in Zambia.

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DII-2018-052

Technological Development and Skills Transfer in the Lusaka South Multi Facility Economic Zone

Mr Maxwell Zulu[1]

Abstract

The Lusaka South Multi Facility Economic Zone (LS-MFEZ) is a real estate development focusing on promoting industrialization and diversification of the Zambian economy. The country has been heavily dependent on the export of raw materials mainly copper and other resources. The objectives of establishing LS-MFEZ were to promote manufacturing and stimulate export activities, technological, skill transfer, wealth and job creation in Zambia. The Zambian employment labour market is currently dominated by 70 percent employment in the informal sector and 30 percent in the formal sector and more than 80 percent of the labour force has no skills. The development of LS-MFEZ requires skilled and semi-skilled labour that will be employed in the various categories of industries in the Zone. There are industries that will set up in the zone; new in the country and in Africa, and they may require different skilled labour to those already available. Some industries may require upgrading available skilled manpower in technology, construction technology, ICT and many other professionals such as technologist, managers, architects, engineers, pharmacists, experts in marketing and advertising to mention a few. The required human resources for LS-MFEZ assumes that LS-MFEZ will require skills for manufacturing, research and development as well as management/administration, depending on investment. The zone therefore provides opportunities for skills improvement and development in a wide range of professions namely management and administration, engineering, financial management, ICT, research and development and many others. There are other specific skills that will be required in specific industries, which have no offered training in their fields such as designing of products, computer chip and software development, specialised medical services, and plant operation for some plants. The Zone will also require skilled consultants in other professions such as risks and financial auditing, engineering, branding and marketing. Opportunities for skills transfer will be available especially high technological companies and in available skills in order to manage the high-tech equipment that will come with the developments. Therefore, this paper seeks to explore technological development and skills transfer in the Lusaka South Multi Facility Economic Zone in order to promote and deliver infrastructure locally.

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SCIENTIFIC PAPERS

SUSTAINABILITY AND DEVELOPMENT GOALS IN INFRASTRUCTURE DEVELOPMENT

DII-2018-003

Implementation of Environmental Management Plans: Key Role Players' Challenges in South Africa

Primrose Tariro Nyamazana[1], Aghaegbuna Obinna Ozumba[2]

Abstract

The study reported in this paper was purposed to identify the responsibilities and attendant challenges of key project participants who influence implementation of Environmental Management Plans (EMPs) in the execution of construction projects. A pilot study was carried out to investigate the challenges faced by key role players when executing their environmental management roles in implementing EMPs in construction projects. An online questionnaire was used to gather data on the key role players' perceptions of EMPs and attendant implementation challenges. A sample of 10 various professionals was selected using convenience sampling. An in-depth review of purposively selected literature guided the collection and analysis of the empirical material. Findings from this pilot survey show that varying perceptions of key role players on EMPs largely influence the implementation of EMPs in construction projects. Establishing the challenges faced by key role players in executing EMPs contributes to the enhancing environmental practices in construction projects. The preliminary findings reported in this paper form a strong basis for exploring the topic further to the benefit of Project managers, environmental management personnel and other key project participants who are involved in the implementation of EMPs during the execution of construction projects. The findings will be particularly beneficial to the built environment in developing countries.

Keywords: construction projects, environmental management plans, South Africa

1. Introduction

Environmental management objectives in the construction industry are implemented through various instruments such as governmental policies, incentives for construction firms to adopt 'green' features and environmental management systems (EMS) (Zhang et al., 2015). The EMP is a document prepared during the environmental management (EIA) process guides impact mitigation and management throughout the entire project life cycle which is from commissioning to decommissioning (Baby, 2011). EIA is a technique, process and regulation enable the construction sector to evaluate the environmental consequences of construction projects in many countries (Uttam et al., 2012). Environmental impact assessment has the potential to promote sustainable development

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(Campion and Essel, 2013) by disconnecting economic growth from environmental degradation in a developing country such as South Africa (Patel and Giordano, 2014). EMP documents aim to address all the basic phases of a project namely: planning, construction, operation and decommissioning (Aucamp, 2009, p. 91). An EMP document must provide the following: a summary of the negative environmental impacts identified; a description of mitigation measures proposed; a description of the proposed monitoring programme; a description of the proposed monitoring programme; the legal framework for environmental protection (Aucamp, 2009, p.91). The environmental legislation establishes minimal environmental management requirements for construction site activities (Teriö et al., 2014). Thus, the EMP is a monitoring tool for managing impacts identified during the EIA process (Patel and Giordano, 2014). Hence, an EMP is deemed to be a practical link between EIA and environmental management systems (EMS) (Glasson and Therivel, 2012, p. 338).

It has been argued that environmental performance of construction projects faces many challenges due to the complex nature of projects, uncertainties and the need for high-level coordination among stakeholders (Uttam et al., 2012). It has been revealed that the perceptions of environmental assessment practitioners strongly influence EIA quality performance and implementation (Kågström, 2016). Kågström (2016) argued that interests, interrelations, norms, and subjective informed judgments and use of discretion EIA practice and implementation. In the UK, Jha-Thakur and Fischer (2016) identified multiplicity of key stakeholder perceptions of EIA effectiveness, lack of understanding of EIA and the relevant legalities, and a tendency of resistance and disownment among responsible persons. Stakeholder perceptions of EMPs as an environmental protection tool for major developments have been detailed in a UK study by Bennett et al. (2016). Following the notion that construction projects are more about people and the influence they bring to the construction process, to determine project outcomes (Seymour et al., in Murphy and Nahod, 2017). It is necessary to understand stakeholder perceptions and experiences in every aspect of construction. This is assertion is even more relevant in the current scheme of things, with increased need for sustainability in projects and the emergence of regulations to achieve sustainability in projects. However, around EIA and EMP in projects, while a limited amount of studies exists in advanced countries, there is a scarcity of literature on challenges to EMP implementation in projects, and particularly in developing countries such as South Africa. Hence, this paper articulates some of the identifiable challenges encountered in the implementation of construction EMPs, using the perceptions of key role players.

2. Methodology

A survey pilot study was carried out using online questionnaires. Survey questions were designed on the basis of purposively selected literature, in order to establish clarity, completeness, and user-friendliness of the questionnaire (Bennett et al., 2016; Ling and Li, 2012). An online questionnaire was designed using Qualtrics software package. This pilot questionnaire survey was distributed to a sample of 16 professionals involved in managing environmental management practices in construction projects. Participants were identified using purposive sampling technique (Saunders et al., 2012, p. 287). A total of 20 invitations were sent to potential participants using email. This was followed with telephone calls. The Qualtrics survey link was sent to sixteen individuals who agreed to participate in this pilot. Responses were collected over a period of three weeks. Out of the 16 participants, 10 completed the survey. Both closed and open-ended questions were used for this mixed method study. Data were analysed using Microsoft Excel and Qualtrics software package. Descriptive statistics of the data is presented in this paper.

3. Results

The sample was made up of 5 clients' project managers, three contractors' project managers, one client's environmental control officer (ECO) and one contractor's ECO. Participants were from five out of South Africa's nine provinces. Four of the respondents are currently working in the Gauteng while two are working in the Western Cape, 2 in Mpumalanga, 1 in the Eastern Cape and 1in the Free State province. The highest academic qualifications of participants for this study range from certificate to master's degree. One participnt holds a certificate, 1 has a diploma, 2 have bachelors, 3 have honours while three masters' degrees. A proportion of 70% of participants had more than five years' experience in the SA construction industry, while 20% had more than 16 years' experience. Only 10% of the sample had less than two years in the SA construction industry. Table 1 below summarises the demographic data.

Table 1: Demographic data

Professional titles	Clients' project managers	5
	Contractors' project managers	3
	Client's ECO	1
	Contractors' ECO	1
Academic qualifications	Certificate	1
	Diploma	1
	Bachelors	2
	Honours	3
	Masters	3
Geographic location	Gauteng	4
	Western Cape	2
	Mpumalanga	2
	Eastern Cape	1
	Free State	1

Survey participants were asked their opinions on whether EMPs were too rigid or not. More than half, 60% of respondents stated that the EMPs are sometimes too rigid, 30% were of the opinion that EMPs are not too rigid, and 10% stated that EMPs were too rigid, as illustrated in Figure 1. Participants were also asked to explain further their responses to the rigidity of EMPs. Some participants argued that EMPs were clear, specific and aimed at reducing adverse environmental impacts of construction projects. On the other hand, other respondents argued that some EMPs were too generic and copied from other projects. Other respondents raised concerns on the issue of making formal applications for major changes to projects. Another concern was the impact of EMP implementation on scheduling and design requirements of projects. One participant highlighted that sometimes EMPs are presented using technical words which may be difficult to understand for those who are supposed to implement. Another participant stated that there is room for improvement on rigidness of construction EMPs in South Africa.

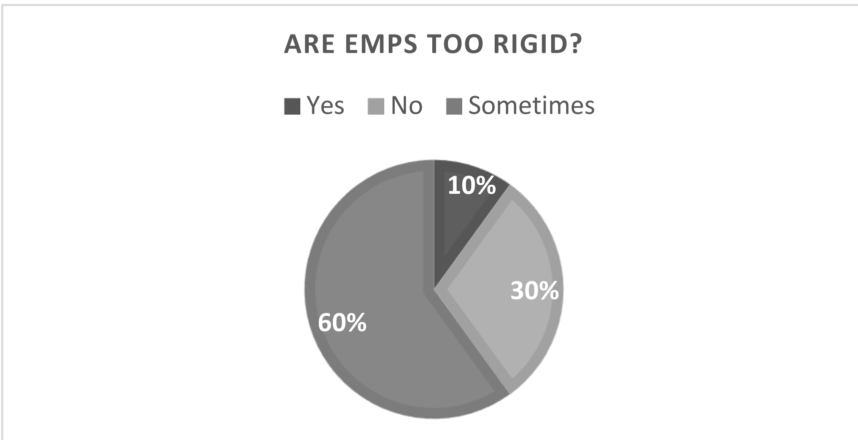

Figure 1: Rigidity of the EMP

The questionnaire survey also explored perceptions of respondents on nature of EMPs with regards to summarising impacts, 40% of respondents rated this aspect as average. While 50% rated it as 'good', and 10% stated that it was very good. On the aspect of describing the monitoring program, 40% of participants stated that EMPs were good. While half of the participants rated EMPs average, and one participant rated the EMP were poor in describing monitoring programs. Various perceptions were also recorded with regards to EMPs regarding describing responsibilities for mitigation and monitoring procedures, describing the implementation schedule and reporting procedures, addressing impacts of the construction project. Responses ranged from 'poor' to 'very good'. However, most responses were 'average', and 'good' while a few respondents selected 'poor' and 'very good'. The aspect of describing cost estimates for implementing mitigation measures received the most unfavourable responses. Figure 2 below gives a summary of these perceptions. Hence it can be said that EMPs are okay though there is room for improvement on these aspects so that key role players feel encouraged to implement EMPs to manage environmental impacts. On the issue of the effectiveness of, most respondents stated that EMPs were somewhat effective in construction projects.

Almost all respondents stated that there are very positive attitudes and commitment towards EMP implementation among clients' project managers and clients' environmental control officers. On the other hand, the attitude and commitment of contractors' project managers, ECOs, site management, and senior management were rated from 'very poor' to 'good'. There were also various perceptions on the attitude and commitment of government environmental inspectors.

The participants were also asked whether understood how EMPs are supposed to be implemented in construction projects. 70% were very positive that they understood, while 20 % stated that they did not understand, while one participant was not very sure. However, 60% of participants stated that they need more training on EMP implementation.

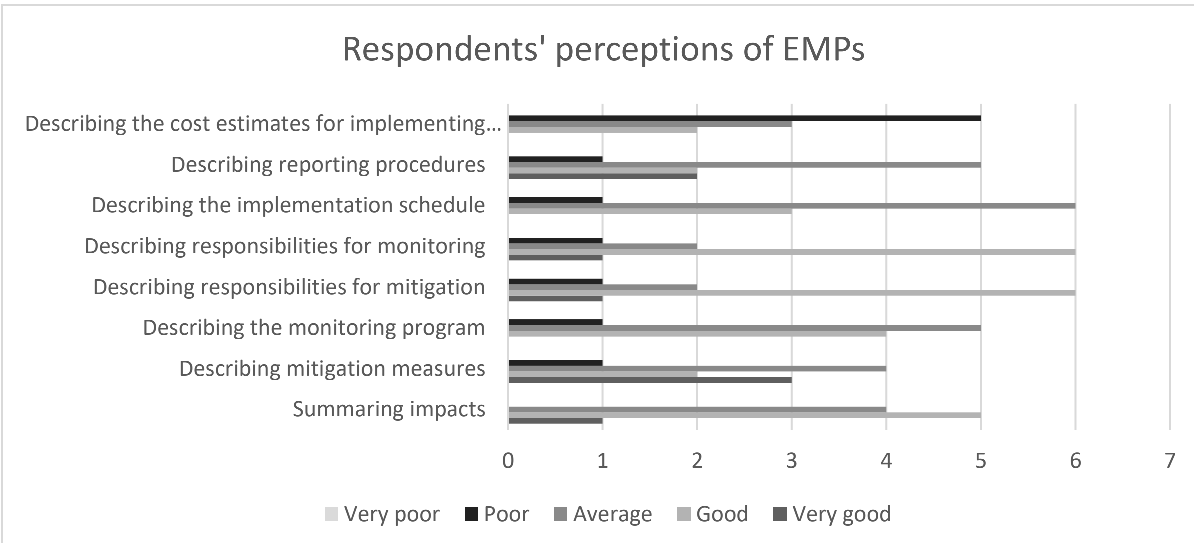

Figure 2: Perceptions of EMP characteristics

Most of the participants indicated that the level of enforcement of EMPs by regulatory authorities was average and there is a need for communities and non-governmental environmental groups to be more involved in monitoring the implementation of EMPs. However, they acknowledge that pressure from government inspectors compel them to implement EMPs. In the survey respondents were also asked if developers/clients emphasised the need for compliance with environmental management during construction. Half of the respondents responded 'yes' while the other half responded 'sometimes'. Similarly, respondents had divided opinions on whether corruption was affecting EMP implementation. Financial dependence of ECOs and environmental assessment practitioners (EAPs) on clients was also deemed a challenge to EMP implementation.

A majority of respondents also highlighted that environmental management systems' certification sometimes helps organizations perform better in managing impacts. Issues of knowledge and attitude were stated as barriers to proper environmental management practices. The majority of respondents also recognised project time and cost constraints as factors that affect optimal implementation of EMPs. Similarly, poor subcontractor cooperation, poor supplier cooperation and lack of adequate training to site management personnel and site operatives are some of the most agreed challenges to EMP implementation in construction projects. Various perceptions were revealed on the aspects of environmental compliance monitoring and auditing practices by clients and contractors. Most responses ranged from ‘very poor’ to ‘very good’.

4. Conclusion

Findings currently lead to the conjecture that there are various perceptions of the nature and effectiveness of construction EMPs among key role players in South Africa. Thus far there is a strong indication that knowledge and attitudes of key role players, possibly play a crucial role in the implementation of EMPs. While preliminary at this stage, the findings are similar to those of Bennett et al. (2016) and Jha-Thakur and Fischer (2016). It is also arguable that most challenges to EMP implementation emanate from weaknesses and threats to EIA systems. While this remains to be supported further in the current context of South Africa, Jha-Thakur and Fischer (2016) stated that practitioners must address weaknesses and threats to EIA systems for EIA to achieve its purposes. On the other hand, contractors may play a critical role in implementing EMPs in construction projects. Windapo and Goulding (2015) also suggested that knowledge and attitude of contractors towards sustainable construction influences their practices on construction sites. Therefore, it is arguable that on the basis of current findings, contractors need continuous increase in knowledge. In the same vein there is need to cultivate positive attitudes to EIA and EMP amongst project participants. The current study is a pilot that is purposed to create the basis for a nationwide survey. As such it is limited in scope, sample size, numerical strength and variety in ample population. Therefore, there is need to conduct South Africa-wide survey to derive substantial empirical evidence on the challenges involved in the implementation of construction EMPs, based on perceptions of key role players.

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An Assessment of the Adequacy of Maintenance Activities in Public Higher Learning Institutions: A Case Study of the Copperbelt University

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Abstract

Maintenance activities enhance the life span of facilities and improve the wellbeing, health and safety of occupants in higher learning institutions. Higher learning institutions like the Copperbelt University have maintenance demands placed due to the constantly growing population of students and staff. This in turn places pressure on the building which creates a need to ensure that the environment is conducive for its occupants. The research made use of primary and secondary data. Secondary data was obtained from literature available on maintenance activities and health and safety practices for learning institutions. Primary data was obtained using questionnaires administered to students, hall wardens and the University maintenance team. The findings indicate that Copperbelt University has a reactive maintenance system that has resulted in inadequate maintenance activity leading to the reduction of the structural and non-structural integrity of buildings. This in turn has affected the life span of buildings, their aesthetic quality and the wellbeing and health and safety of occupants and disturbance in academic calendar. By taking an interest in maintenance activities, public learning institutions can enhance the life span of their buildings and the health and safety of occupants and avoid disturbances to the academic calendar. Inadequate maintenance activity leads to the reduction of the structural and non-structural integrity of buildings thus compromising health, safety and life span of buildings.

Keywords: defects, maintenance activities, maintenance programs, planning

1. Introduction

Higher institutions of learning are corporate bodies of academicians and students that provide facilities for teaching, learning, research offered to undergraduate and graduate programs and bestow degrees (Azaury, et al., 2014). Universities create value by providing the knowledge needed to arrive at effective solutions and to prepare highly educated people to carry them out (Crow, 2014). Knowledge creation produces social and economic change and plays a very crucial role in preserving the cultural and social continuity of the democratic system. However, public higher institutions of learning such as the Copperbelt University (CBU) need to come to terms

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with their dual identity of providing noble services of social, cultural and economic change through academic activity and operating like a business to survive. Unlike products, service quality is evaluated by customers not only by the core service but also by the service experience (Zeithham and Parasuraman, 2004). Owino (2013) asserts that corporate image has a strong influence on customer satisfaction. Maintenance activities play a cardinal role in enhancing occupant well-being, health and safety. Managing and maintaining healthy building conditions is crucial to reducing occupational hazards and sustaining organization operations. Additionally, unhealthy buildings can lead to increased employee absenteeism, a decrease in productivity, and eventually, in some extreme cases, to a shut-down in operations (Owino, 2013). Therefore, the condition of a building is paramount to the continuity and profitability of business operations.

This research is an assessment of the adequacy of maintenance activities in public higher learning institutions based on a case study of the Copperbelt University.

2. Literature Review

The CBU is one of the top public learning institutions in Zambia that was founded in 1987, has over 15,000 students and 930 members of staff (UNCTAD, 2017). The institution is composed of a majority of old infrastructure (1980's) and fairly newly (2000's) constructed infrastructure (CBU, 2017). Due to the key role of the organization, maintenance activities are cardinal for continued operations and value creation to the society at large. According to Olagunju (2012), buildings cannot remain new throughout their entire life, maintenance problems start to creep in once building projects are completed. Maintenance needs to be carried out on them to sustain the performance of the buildings and keep them in good condition (Panchdhari, 2006). Building maintenance is work undertaken to keep, restore or improve the components, services and surrounds of a building or facility to an acceptable standard and to sustain the utility and value of the building (Panchdhari, 2006).

2.1 Causes of defects in buildings

A defect is the deterioration of a building feature which can either be structural or and non-structural (Nurul and Azreel, 2014). A non-structural defect is a flaw on a non-structural element for a building such as dampness or peeling paint work (Ibid). A structural defect on the other hand can be referred to as actual physical damage to a load bearing component of a building which affects its load bearing functions and makes it unsafe for occupants. A building structure includes retaining walls, columns, beams and flat slabs (Neha and Shruti, 2015). Most defects can be discovered in their early stages through visible or detectable symptoms. If not promptly rectified, minor defects can develop into structural defects, causing failure or sudden collapse thus endangering lives and may become costlier to rectify. Defects are common problems in any built structures.

According to Danielle (2014), the diagnosis and repair of structural defects is important due to their adverse impacts on occupants or operations, non-structural defects such as cracking and peeling of finishes or fungal growth on walls are often overlooked due to their unknown impacts on occupant health and productivity. Very often rectification of non-structural defects is neglected or delayed due to financial constraints or other maintenance priorities imposed on building owners. Such delays or failure to repair non-structural defects at an early stage often leads to higher maintenance costs in future or affects the health of occupants thereby having an impact on productivity as it may result in higher levels of absenteeism in an organization. It has been proven that dilapidated and unhealthy buildings illustrate a poor environment that has a very low quality of life and encourage incidences of anti-social behaviour (Panchdhari, 2006).

Sick Building Syndrome (SBS) is a term used to illustrate a certain experience in relation to a building and its occupant's health or wellbeing and cannot be referred to as an illness (HSE, 1995). Despite vast research being done, the cause of SBS can be attributed to a combination of factors such as physical/environmental factors and job factors. Physical factors include building/office design, building services, indoor environment and air quality (Ibid). According to National Health Service (NHS, 2014), the symptoms of sick building (SBS) include headaches and nausea, aches and pains, fatigue, poor concentration, shortness of breath, eye or throat irritation among many others. The symptoms of SBS can occur on their own or in combination with each other, and they may vary from day to day. SBS seems to be associated with certain types of buildings such as buildings that are occupied by lots of people such as open plan offices, schools, Libraries or museums. It is important to note that the symptoms are common in everyday life which makes it hard to link. Indoor air pollution for example can be caused by volatile organic compounds in cleaning agents, perfumes, asbestos, dampness leading to mould or overcrowding. The effects of this include respiratory illness, organ failure and allergic reactions. Maintenance activities should comprise care to the building that should pour benefits to occupants' wellbeing, health and safety (NHS, 2014).

2.2 Types of maintenance

The types of maintenance programmes determine the communication system, procedure of conducting maintenance and the financial aspect of these maintenance activities. Maintenance programs include preventive maintenance (PM), reactive (breakdown/corrective) maintenance and predictive maintenance.

2.2.1 Preventive maintenance

This can be referred to as planned maintenance aimed at minimising costs by managing buildings and their components before major issues ever occurring (Danielle, 2014). Preventive maintenance requires consistent inspections and routine servicing or remedy of works. This type of program allows for budgeting for works and reduces the amount of pending works available (O'Brien, 2014). The maintenance can be planned and unscheduled for example a plan to fix a light bulb with a replacement when it stops working. Planned but unscheduled maintenance occurs in situations where the maintenance plan for an asset is to wait for breakdown before performing maintenance. This means that the resources such as parts, supplies and personnel are ready and available to use so that the repair can be made within a reasonable time (O'Brien, 2014).

2.2.2 Reactive (breakdown/corrective) maintenance

This is the most widely utilized maintenance approach (Mobley, 2008; Ahlmann, 1998). It is the process of reacting to failed, ineffective or damaged equipment and repairing or replacing it in order for the intended function to be achieved. Essentially, reactive maintenance ignores any preventative measures and simply deals with a problem or issue when it is reported. Not having a maintenance strategy is the simplest "strategy" to have for asset maintenance and eliminates the need to plan ahead for maintenance (Danielle, 2014). Breakdown maintenance cost 3 to 9 times more than planned repairs because shutdowns happen during production runs (O'Brien, 2014).

The main advantage of running a reactive maintenance system is that it does not require an initial cost involved in investing in systems, procedures, pre-planning and organization and consequential reduced maintenance cost because servicing and routine checks are not incorporated. The approach requires few staff to manage. However, unpredictability of defects occurrence results in either labour or materials being unavailable immediately and therefore delay the time taken for a repair, increasing equipment downtime, inefficient use of employee time, affecting budgets and cost planning (O'Brien, 2014). Furthermore, out of hours or emergency visits by contractors to fix an issue can result in unnecessarily expensive charges that may have been avoided (Sullivan et al., 2004). Reactive maintenance doesn't protect or look after equipment and therefore reduces the lifespan of the unit and the potential revenues (Mobley, 2008; Ahlmann, 1998).

2.2.3 Predictive maintenance

This maintenance strategy is based on monitoring and measuring the condition of the assets to determine whether they will fail during some future period and then taking appropriate action to avoid the consequences of that failure. When the condition gets to a predetermined unacceptable level, the equipment is shut down to repair or replace damaged components so as to prevent a costlier failure from occurring (O'Brien, 2014). This approach offers cost savings over time because tasks are performed only when warranted (Gioventu, 2011). This brings several cost savings by minimizing the time the equipment is being maintained, minimizing the production hours lost to maintenance, and minimizing the cost of spare parts and supplies. The skill level and experience required to accurately interpret condition monitoring data is also high and has a high upfront cost. Judgment should be exercised when deciding if predictive maintenance is best for a particular asset (O'Brien, 2014).

2.3 Maintenance practices of higher learning institutions

Institutions of higher learning face pressure of preserving existing building facilities within the campuses to address growing demands of an increasing influx of students and academic activities. According to Akinsola et al. (2012), plumbing, vandalism, electrical problems, and lack of maintenance culture are most peculiar to tertiary institutional buildings in South-western university buildings. Lateef et al. (2010) concluded that most Malaysian universities adopt corrective and cyclical maintenance management systems which led to an accumulation of maintenance backlogs. The buildings of higher learning in Nigeria only receive top management attention when there is a problem (Ofide et al., 2015).

Most of building problems in institutions of higher learning are management-related problems, user misuse of building facilities and faulty workmanship (Azaury et al., 2014). Hostel buildings are given lesser maintenance priorities than offices and lecture halls. The majority of the users use hostel spaces more than other building types. Since these hostel facilities are in poor condition, students may face health challenges, which could result in them not being productive in the poor environment. The poor condition of buildings in this environment has a direct relationship on performance of users of these facilities provided by the institutions (Odife, 2015). Since challenges abound in maintenance management practices of educational institutions as highlighted above, and the growing intake of students has weakened building facilities. In most cases, maintenance activities are under the authority of the maintenance supervisor or manager, and these must monitor the work progress daily, weekly or monthly depending on the nature of the situation and the potential impact of a service breakdown to the users. Diseases related to inadequate water, sanitation and hygiene are a huge burden in developing countries (Adams et. al, 2009).

According to Gioventu (2010), during the life of every building, building owners are regularly confronted with decisions regarding the expenditure of money to look after their buildings. The various types of costs associated with the assets can be distributed into three general categories such as keep-up costs, catch up costs and get-ahead costs. Keep up costs are costs associated with annual maintenance of the assets and operations of the building. Catch up costs are costs to correct any accumulated backlog of deferred maintenance. Get ahead costs are costs associated with adaptation of the building to counter the forces of different forms of obsolescence such as functional obsolescence, legal obsolescence and style obsolescence. Unfortunately, many buildings find themselves having to deal with catch-up costs that have accumulated over the years either because of inadequate maintenance of the assets or inadequate allocation to the reserve fund (Odife, 2015). Maintenance policies and practices play a significant role in maintaining and prolonging the durability of building components. Frequent routine inspection and cleaning will detect symptoms of defects allowing early rectifications to be carried out to prevent further deterioration and the need for a complete replacement (Gioventu, 2010).

According to Pedro (1998), a University maintenance program is an organizational activity carried out to prolong the life expectancy of school buildings, its furniture and equipment. The school maintenance program should be systematic and proactive to prevent the need for repairs. It should have a sufficient staff and budget for proper maintenance. A University maintenance program should ensure that the university building can function at its designed level always, function during the normal life span of the school building and resist the effects of an extreme natural event like disease outbreaks, hurricanes, floods, and earthquakes, provided that the original design, construction, and materials were satisfactory for these demands (Pedro, 1998).

The maintenance of the school building is a daily activity of the institution and its personnel. It is an important factor in the delivery of education. Usually, the education officer and the public works department are responsible for the maintenance of all school buildings and the physical plant. Besides that, the school community (administrative staff, teachers, students, and parents) should institute its own school maintenance program (Pedro, 1998), the maintenance programme should comprise of three basic components that include an organization structure, inspection, and a maintenance plan.

3. Methodology

The data for the research study was collected from a target group of students, members of staff and the University maintenance team that included hall wardens, maintenance officers at CBU. The study used a researcher administered data collection strategy and the collection point was CBU. The nature of this research is that of a case study, hence the needs to consider the aspects of a case study research. A case study offers the chance to study a subject involving an organization or a group of people, and usually involves gathering and analysing information (Zainal, 2007). The information is both qualitative and quantitative. The main data collection tool were survey questionnaires, they were handed out, completed and returned. This tool was further supplemented using an observation template for 22 buildings and interviews. Interviews were carried out with maintenance officers and the resident engineer's office and analysed using content analysis. These methods were chosen because they are an inexpensive and provide an efficient way of reaching a large percentage of respondents and obtaining data. The questionnaire and interviews assured participants of anonymity and that the data collected was purely for academic purposes. The study administered one hundred and fifty-one (151) questionnaires to the respondents and 119 were usable, yielding a response rate of 79%.

4. Results and Discusion

4.1 Types of maintenance

According to the findings from the interviews, the type of maintenance used at the Copperbelt University is reactive maintenance. This is a fix only when broken type of maintenance system. While this system may be the most widely used due to its lower start-up cost and limited personnel requirements, it tends to ignore the root cause of a defect and results in repeat work leading to additional cost. Additionally, it interferes with planned work and result inefficient use of what is supposed to be productive time due to the unpredictable occurrence of defects (O'Brien 2014). The consequential result of this is a backlog of maintenance works. The questionnaires showed that most reported works take generally weeks and months (54.5%) to be attended to; with the least time being days (9%) and 16.8 % of reported defects are still unattended to. These can also be attributed to the procedure used where all information and details concerning defects are processed through two offices, the administration officers and the hostel hall wardens referred to as the 'maintenance unit'. The academic office oversees administration and academic blocks such as the schools and departments and the hostel hall wardens oversee hostel blocks respectively. From the findings, the current report system is effective in that it enables easy tracking of maintenance work but there is a slow response rate in terms of time taken to attend to maintenance due to the procedure nature of the reporting system that requires constant follow ups from those affected and the length process of having to procure required items. Once a defect occurs it is reported to the maintenance unit either by the hall warden, administration officer or student. The maintenance unit then diagnose the defect and if need be, attaches a request for materials with a job card and sends it to the procurement office. The procurement office then procures the materials and hands it over to maintenance unit. The maintenance unit then engages the necessary personnel to do the works, and once the works are complete feedback is given to the hall wardens or admin officers.

The research sought to find out the existence of a strategic plan, policy or programs that the maintenance unit uses in line with carrying out maintenance activities within the Copperbelt University. 82% of the maintenance team declined to the availability of a strategic maintenance plan, policy or program. This result supports the theory that a reactive maintenance system is used.

4.2 Occurrence of defects

Defects have been categorised as non-structural and structural of which 63% and 37% amounted non-structural and structural defects respectively. The frequency of defects was computed using the Relative Importance Index (RII), this identified the defects and the frequency of the type of defects that are found within buildings at the Copperbelt University as can be seen in figure 1.

Non-structural defects include broken/missing door handles, water penetration, broken shelves, and louvers, fly screens and the like, leaking/damaged pipes, faulty sockets (safety), worn out gutters. Given the slow reaction time to remedy defects, occupants resort to replacing fittings like door handles and light fittings on their own for security reasons such as to feel safe and to protect their belongings as cases of theft are common. From figure 1, it can be concluded that the overall percentage of defect occurrence was above average, and this has affected the performance of buildings at the Copperbelt University. Defects such as damaged/ faulty sockets (84.8%), dirty and worn out walls (78.4%), leaking pipes (78.4%), and worn out roof sheets allowing water penetration are some of the most prevalent. Out of service ablution (68%) and damaged and damaged/Missing taps (78%) are also a common prevalent. The institution has a total of 56 ablutions blocks that where built for a population of 2,000 users but currently housing a population of over 10,000 students. This is in contrast of the guidelines of 1: 25 for girls and 1: 30 for boys (Gacheiya and Mutua, 2009). Recommendations are surpassed by at least a common factor of 3. This has largely contributed to the current closure of the institution to stop the spread of the cholera pandemic of January 2018. It is estimated that 88% of diarrhoeal disease is caused by unsafe water supply, and inadequate sanitation and hygiene (WHO, 2004). School's sanitation and hygiene have received the least attention in the allocations of monetary resources usually accompanied by a backlog of maintenance activities and maintenance costs (Gacheiya and Mutua, 2009). The current estimated backlog of maintenance cost towards sanitation is close to ZMW 1,000,000 (Lusaka Times, 2018).

Figure 1: Defect occurrence

One severe case of structural defects can be seen on a building in the school of Built Environment (SBE) which has currently been condemned as subject to possible failure because of movement in the foundation. This movement was caused by settlement because of termite mounds underneath the building that over time has resulted into serious cracks within the building. Inspections where only done after defects of serious cracks were reported by concerned occupants. The building was declared unfit for use and its occupants were asked to relocate but have not done so due to limited office spaces. It was also highlighted that there has been no maintenance works done to the structural components of the said building.

The indoor air quality (IAQ) test to determine air quality is not carried out because analysis of air samples often fails to detect high concentrations of specific contaminants in the air. However, given the rate of overcrowding, cooking in hostel rooms and state office blocks, the lack of air-conditioning units in student hostels, classrooms and most offices, the evidence of dampness in walls, use of old office furniture and the existence of asbestos on most buildings, the chances of SBS to occupants is high. 80% of the respondents had exhibited symptoms of sick building at different points in time such as headaches, aches and pains, fatigue, poor concentration, shortness of breath, eye or throat irritation. It is important to disclaim that these symptoms may be caused by other factors and may not be because of poor air quality or dilapidated facilities. Health and comfort however can be affected by these factors which are highly prevalent in the institution. Environmental stressors such as overcrowding, noise, improper lighting and job-related factors such as stress can produce similar symptoms as those related to poor air quality and living conditions. It was observed that indoor plants are not common in hostels as well as offices to encourage cleaning of the air. This can be attributed to the lack of knowledge of SBS by occupants.

4.3 Challenges faced in implementing maintenance activities

Maintenance policies and practices play a significant role in maintaining and prolonging the durability of building components and ensuring a good wellbeing and ensure health and safety of occupants. Having a reactive maintenance system, the maintenance unit is only able to accommodate and deal with defects as they come. The aspect of planning is forgone. The most urgent defects are attended to whilst the 'non-urgent' defects are often neglected or pushed to the bottom. With reference to figure to above, the lack of resources ranked 2nd, this is an after effect of planning as can be seen with personnel (3rd) and time (4th). Resource requirements can be estimated before reports are made however, this is not the case. From the data collected, availability of resources in some cases was a major drawback in that if the materials are not available the maintenance works come to a standstill. There is a shortage of man power within the department as most personnel after retirement or death are not replaced. This has affected personnel and sadly reduced the capacity of effectiveness in carrying out maintenance works within the institution. In some cases, the personnel in charge of attending to the works have to be pushed in order for them to have the works done. Frequent routine inspection and cleaning will detect symptoms of defects allowing early rectifications to be carried out to prevent further deterioration and the need for a complete replacement. In most cases failure in maintenance activities may be attributed to failure to carry out daily or routine inspection of building components, poor planning and budgeting or inadequate allocation of resources to finance maintenance activities, negative attitude of maintenance managers towards planned maintenance and heavy reliance on corrective and emergency maintenance and insufficient measures taken to prevent vandalism.

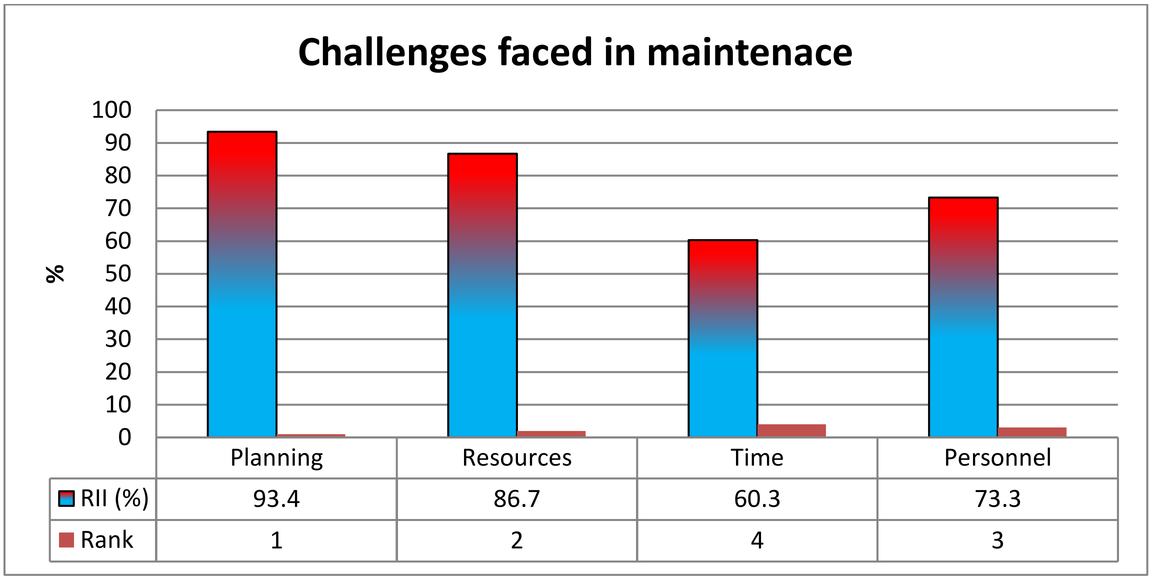

Figure 2: Chart illustrating the challenges in implementing maintenance activities

5. Conclusion

Using a reactive maintenance system to rectify defects gives slow results, interferences with planned work and leads to inefficient use of time caused by following up on defects rectification progress. The institution faces a significant backlog of structural and non-structural defects that affect the structural integrity of the building, the quality of life of occupants, affect productivity and perceptions of the public of the institution. Maintenance activities are not adequate given the current of maintenance activities backlog, lack of planning, low staffing and lack of resources. The unavailability of a maintenance plan entails that key resources such as materials, labour and equipment are not readily available when they are needed. This may result in occupants taking matters into their own hands to feel safe and secure within the buildings. There is need for frequent inspection especially where structural defects are concerned to prevent fatal accidents from occurring. This will require adding to the current staffing to meet this demand. There is need for awareness of defects that may pose a danger to the safety and health of occupants as this system is based on report then fix basis. Reactive maintenance does not consider the wellbeing of occupants, their health and safety and the preservation of a building for its maximum use.

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The Sacrifice of Groundwater by Urbanization: A Glance at Ngwerere Catchment

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Abstract

Ngwerere catchment is an inter-district catchment with the head waters in Lusaka District and tail waters in Chongwe District (Zambia). The people who live in the catchment heavily depend on groundwater for their water supply for domestic, agricultural and industrial activities. The catchment has seen both planned and unplanned infrastructure development and has, of late, reported drying of some groundwater wells and this has been attributed to climate change. To highlight the root cause of the decrease in groundwater within the catchment a comparative analysis of groundwater levels, rainfall data and satellite images together with population data was carried out. The trends in groundwater levels were analysed using Maximum Depth of Ground Water per Hydrological Year (MDGWHY). The analysis revealed an average decrease of water table of 0.233m per hydrological year. This decrease could not be attributed to rainfall as for the same period (2011 to 2015), total rainfall increased at a rate of 0.132m per hydrological year. Landsat satellite images for Ngwerere Catchment were processed so as to quantify impervious surface resulting from urbanization. The analysis revealed that impervious surface for the catchment increased, from 2011 to 2014, by over 300%. Urbanization has increased impervious surface, which blocks natural groundwater recharge and as such a large amount of water is lost by runoff. If not guided, urbanization can seriously impair groundwater recharge. To control the increase of impervious surface, it is therefore being proposed that a fee be charged on any land developer who exceeds a defined threshold of impervious surface for any land parcel within the catchment, and that the monies realised be used to set up artificial groundwater recharge zones. Increase in groundwater abstraction due to population growth also contributes to the decline in groundwater table for the catchment but the impact is negligible because most of the households within the catchment use on-site sanitation.

Keywords: groundwater, impervious surface, Ngwerere catchment, on-site sanitation, rainfall, urbanization

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1. Introduction

Infrastructure development and growth of any country depend on water resources development (UNOSD & UNU, 2013). But infrastructure development increases impervious surfaces which affect water resources (Leopold, 1968; Brabec, et al., 2002; Zha, et al., 2003; and Xu, 2007). The increase in impermeable surfaces can alter the spatial and temporal availability of groundwater (Keller, 2012; Subramanya, 2010; USGS, 1983; and USGS, 1998) and affect water supply for domestic, agricultural and industrial use. Further, groundwater abstraction should not exceed groundwater recharge; else this can lead to drying up of wells and springs and increase the cost of abstraction due to lowering of water table (Brassington, 2007 and Thomas, et al., 1998). Lowering of water table can also lead to subsidence of land.

In Zambia groundwater forms an irreplaceable contribution to domestic water supply. And in recognition to the irreplaceable contribution of groundwater, the government of Zambia has been and is still spending a lot of money on borehole drilling. According to the Six National Development Plan (2011 – 2015) of Zambia, 7,000 bore holes were to be constructed over a period of five (5) years (MFNP, 2011). In addition, local people and NGOs especially in un-serviced residential areas dig wells for domestic water supply. This clearly shows that groundwater is of fundamental importance in meeting water requirements in Zambia.

In Lusaka Province of Zambia households that are partially and wholly not serviced by the Lusaka Water and Sewerage Company obtain water from hand dug wells or boreholes. Apart from being close to the ground surface, the water is safe and fit for domestic use and generally does not require expensive treatment. Unfortunately, in recent years groundwater has been declining at an alarming rate and some wells have been reported dry.

The decline of groundwater table could be because of increase in abstraction rates, increase in impervious surface or decrease in rainfall. But in this catchment the decline of groundwater table has been, in most cases, attributed to decrease in rainfall due to climate change. In this paper rainfall, population, impervious surface area and groundwater levels data for Ngwerere catchment are analysed with respect to the period 2011 and 2015 to give insight on groundwater decrease. Methods of addressing the decrease in groundwater are then proposed.

2. Methods

2.1 Study area

Ngwerere catchment (fig. 1) spans over an area of about 28,000ha, of which 40% is in Lusaka District and 60% in Chongwe District. The elevation ranges from about 1200m, South-west, to around 1100m, North-east of the catchment. The catchment has seen planned and unplanned settlement development. The people living within the catchment heavily depend on groundwater for their water supply, which accounts for more than 50% of water supply.

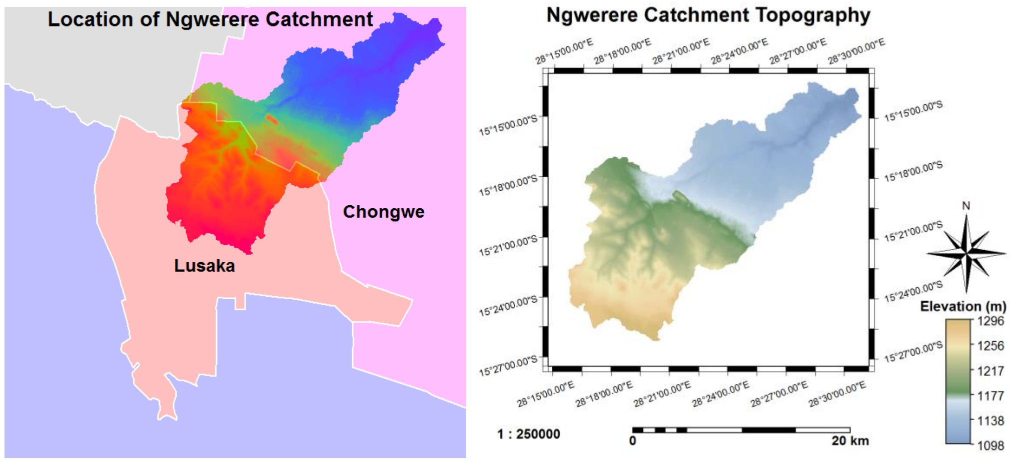

Figure 1: Location & Topography of Ngwerere Catchment

2.2 Materials and methods

Elevation Data: The Digital Elevation Model (DEM) for the project area was acquired from Global Data Explorer, a United States Geological Survey (USGS) online Data Pool. Integrated Land and Water Information System (ILWIS) software was used to analyse the DEM and create the catchment boundary for Ngwerere Catchment.

Groundwater data: Data on groundwater levels were measured and recorded from September 2011 to March 2015. A steel tape was used to measure the depth of the water table from thirteen (13) domestic wells. The decrease of groundwater was quantified by analyzing the maximum depth of groundwater table per hydrological year using the equation 1.

$$D = Y_2 - Y_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where,

D = Decrease in groundwater table, Y_1 = Maximum depth of groundwater table for first hydrological year, and Y_2 = Maximum depth of groundwater table for the second hydrological year

Rainfall data: Rainfall data was collected from the Zambia Meteorological Department Department. The rainfall data for Kenneth Kaunda International Airport was considered for the period 2011 to 2015 (Table 1). Monthly rainfall data was aggregated to give totals for hydrological years to establish the trend of rain input for the catchment.

Table 1: Total Rainfall data for Kenneth Kaunda International Airport

Total Rainfall(mm)	
Hydrological year	**Kenneth Kaunda Int' Airport**
2011/2012	623.2
2012/2013	733.7
2013/2014	834.8
2014/2015	1031.0

Landuse/Landover Data: Landuse/Landcover images were acquired from the NASA/USGS Landstat program. Level 1 Product Landsat data, of zero percent cloud cover and spectral bands of spatial resolution 30m, were downloaded from "Earth Explorer", a USGS website. The images include a Landsat 5 Thematic Mapper image captured on 30th May, 2011 and Landsat 8 OLI_TIRS image captured on 7th June, 2014. (**OLI** means: Operational Land Imager and **TIRS** means: Thermal Infrared Sensor)

Satellite image classification: Image classification was implemented in ILWIS software. Identifiable landcover themes included water, forest, cropland, shrubs, savannas, grassland and built-up area. The classification was adapted from International Geosphere and Biosphere Programme (IGBP) DISCover Data Set Land Cover Classification System (Loveland & Belward, 2000). Representative cells for each Landcover theme were selected and used as a basis for the classification. Classified images were validated by crossing with independent data themes for each satellite image. Summary statistics, from the above operations, were extracted and interpreted. The nature of transition was identified by generation of a landcover conversion matrix.

Impervious surface: Impervious surfaces are anthropogenic features through which water can hardly infiltrate. These can be indirectly quantified using Built-up area extracted from satellite images and include rooftops, roads, driveways, sidewalks, parking lots, etc. Increase in impervious area from 2011 to 2014 was quantified by generating statistics of Built-up areas from classified images. Increase in impervious surface is proportional to increase built-up area which can be defined by equation (2).

$$Increase\ in\ Built\_up\ Area = \frac{Total\ Built\_up\ Area\ (2014) - Total\ Built\_up\ Area\ (2011)}{Total\ Built\_up\ Area\ (2011)} x100\% \ldots .(2)$$

Population Data: Population data was gathered from Central Statistics Office (CSO), Zambia report (CSO, 2011). Population projections were adopted from (MCC, 2011). The population for Ngwerere Catchment was estimated using proportional coverage of the catchment in the shared districts.

3. Results and Discussion

Catchment boundary: The Ngwerere Catchment boundary traverses Lusaka and Chongwe Districts. The high elevations are found in Lusaka District and the low elevation in Chongwe District. The catchment area demonstrates that water resources go beyond district administrative boundaries and requires the districts involved to take active role in the protection of the catchment.
Groundwater: Groundwater levels (fig. 2) were analysed using Maximum Depth of Groundwater per Hydrological Year (MDGWHY). The analysis revealed an average decrease of water table of 0.233m per hydrological year.

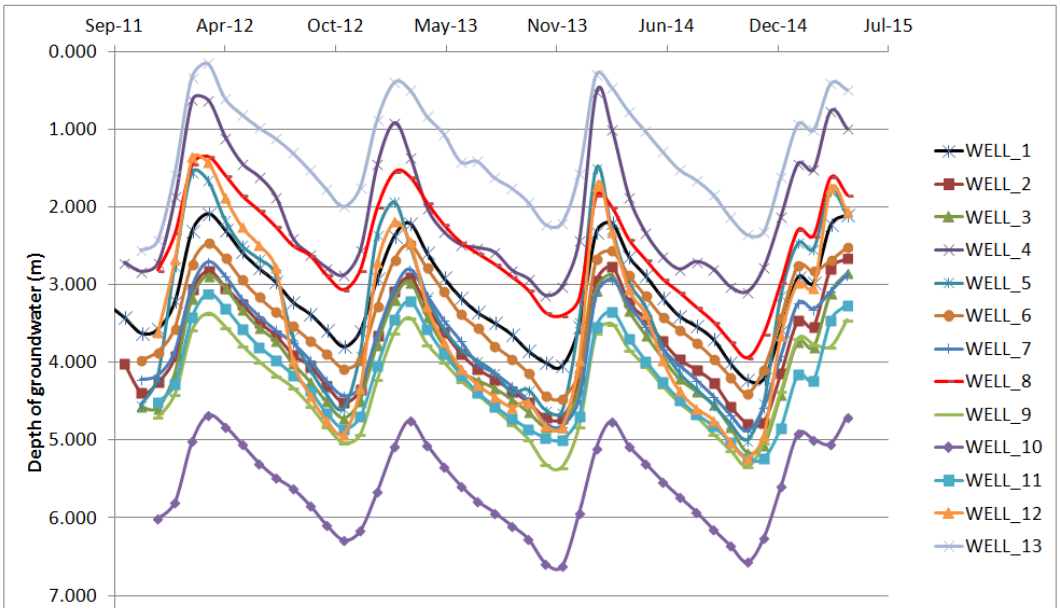

Figure 2: Depth of groundwater table for Ngwerere Catchment

From the maximum depth analysis of groundwater table, the decrease in groundwater table was calculated (table 2). The decrease in groundwater was calculated using equation 2.

The average annual decreases in groundwater table for different years are tabulated in table 2. From the table it can be deduced that for the period under consideration the average rate of decrease is **0.223m** per hydrological-year. The maximum decrease recorded was **1.309m** per hydrological year. The decline in groundwater levels means that residents will have to dig or drill deeper to meet their water demands. Thus, the cost of abstracting water from the ground is increasing.

Rainfall: Total Rainfall amount per hydrological year was plotted (fig. 3) to display the trend of rainfall in the catchment.

Table 2: Decrease of water table in observational wells

	Decrease in Groundwater level [m]			
	Period			
Observation Well	2011/12 to 2012/13	2012/13 to 2013/14	2013/14 to 2014/15	Overall Average [m]
WELL_1	0.173	0.251	0.179	0.223
WELL_2	0.126	0.196	0.071	
WELL_3	0.129	0.120	0.320	
WELL_4	0.045	0.264	0.000	
WELL_5	0.051	0.044	0.360	
WELL_6	0.108	0.387	0.000	
WELL_7	0.207	0.392	0.065	
WELL_8	0.254	0.334	0.545	
WELL_9	0.333	0.309	0.000	
WELL_10	0.278	0.337	0.000	
WELL_11	0.348	0.137	0.245	
WELL_12	1.309	0.000	0.401	
WELL_13	0.000	0.228	0.134	
Average decrease [m]	**0.259**	**0.231**	**0.178**	
Max Decrease [m]	**1.309**	**0.392**	**0.545**	

From fig. 3, it is clear that rain has been increasing at a rate of **0.132m** per hydrological year for the period under consideration. This situation should have led to increase in groundwater recharge, but it hasn't. What has been observed for the groundwater levels is a decrease. This decrease could not be attributed to rainfall. When you have an increase in rainfall you expect to have a corresponding increase in groundwater for a phreatic aquifer, but this was not the case. So, rainfall was ruled out.

Landcover/Landuse: To quantify Landcover/Landuse change Landsat satellite images were classified (see figures 4 and 5). Change detection was done by crossing the classified images, so as to generate a conversion matrix.

The analysis reviewed that Built-up area increased (fig. 4) from about 1,400ha in 2011 to over 6,500ha in 2014. The Built-area expansion is concentrated so much on the South-west region, the area located within or near Lusaka City. This is due to population growth of Lusaka City which has resulted in the high demand of land, especially, for shelter. Population increase is confirmed by the data collected from the Central Statistics Office of Zambia (CSO, 2011). Land parcel variations in terms of percentage are displayed in figure 6 below.

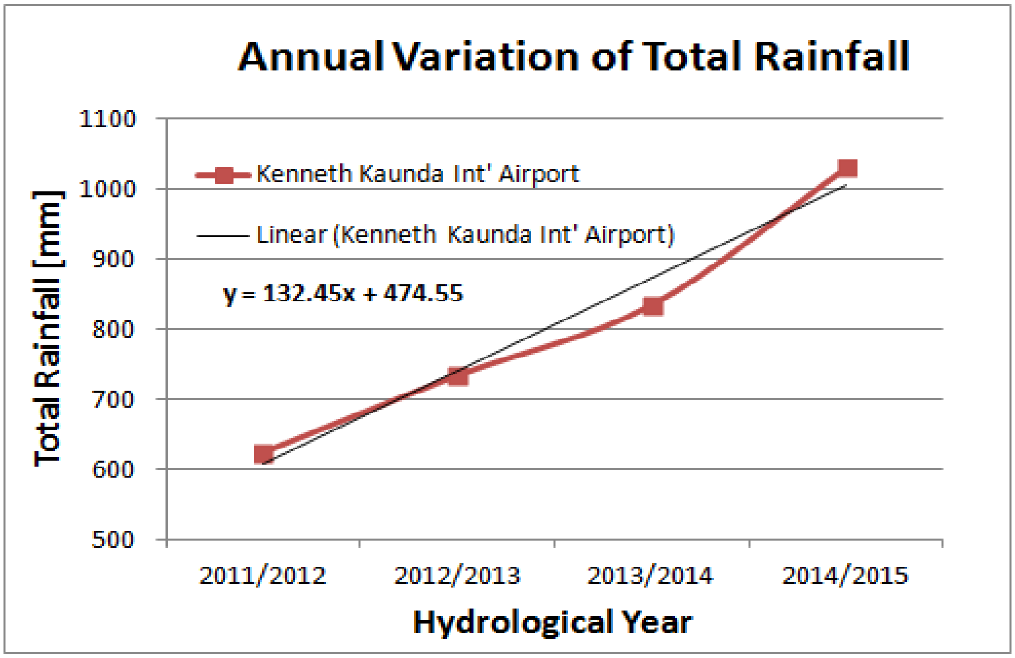

Figure 3: Annual Rainfall for Kenneth Kaunda International Airport

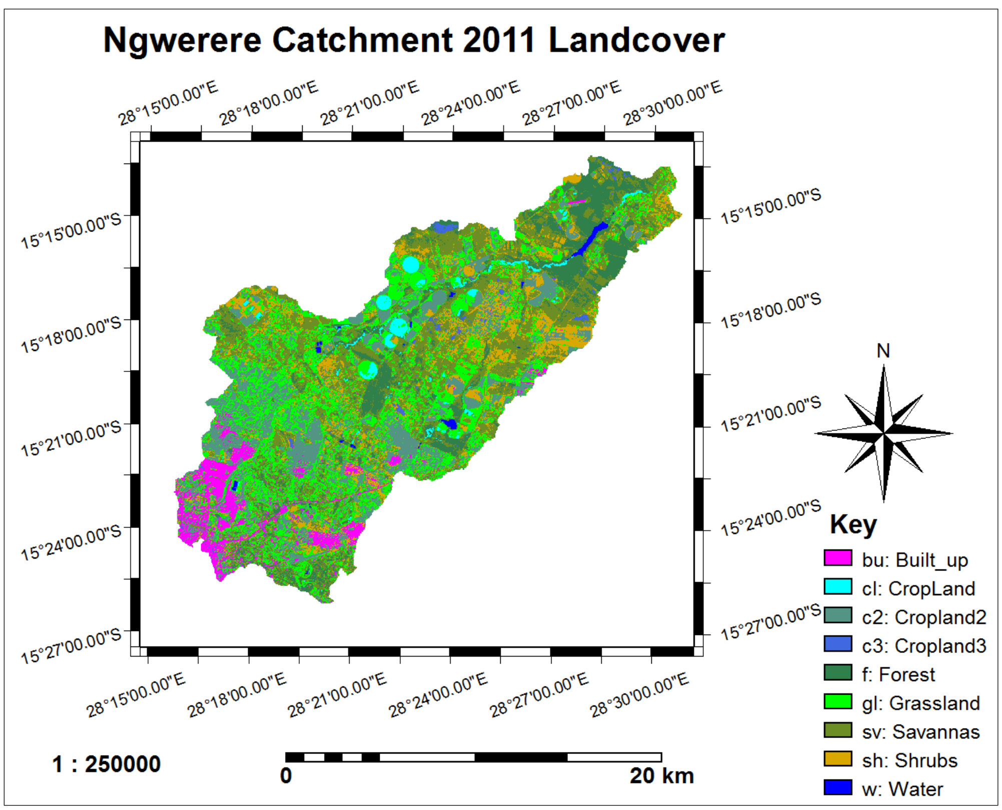

Figure 4: Ngwerere landcover maps for 2011

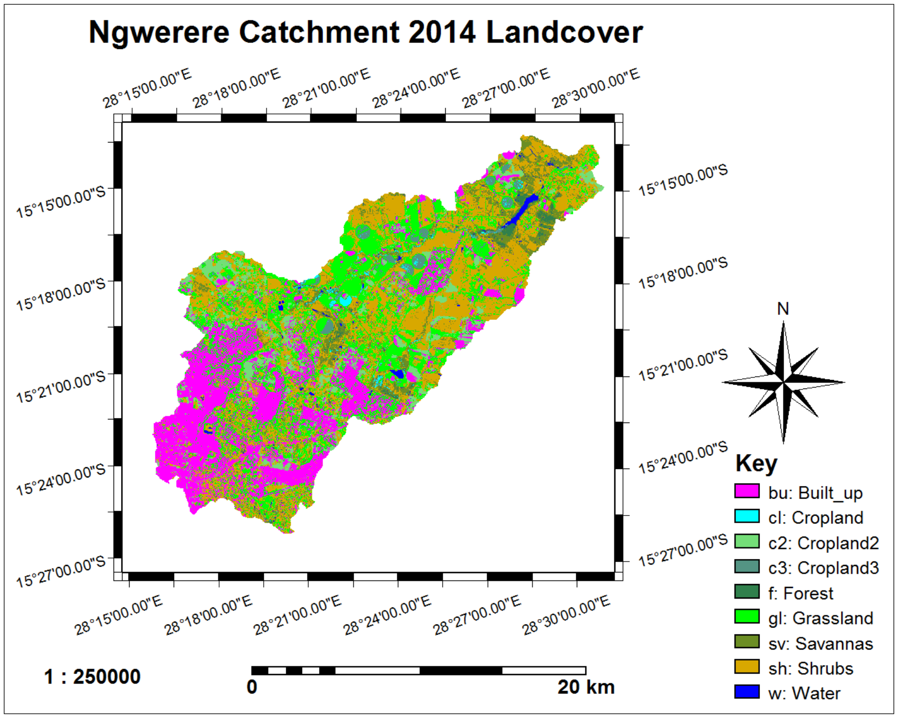

Figure 5: Ngwerere landcover maps for 2014

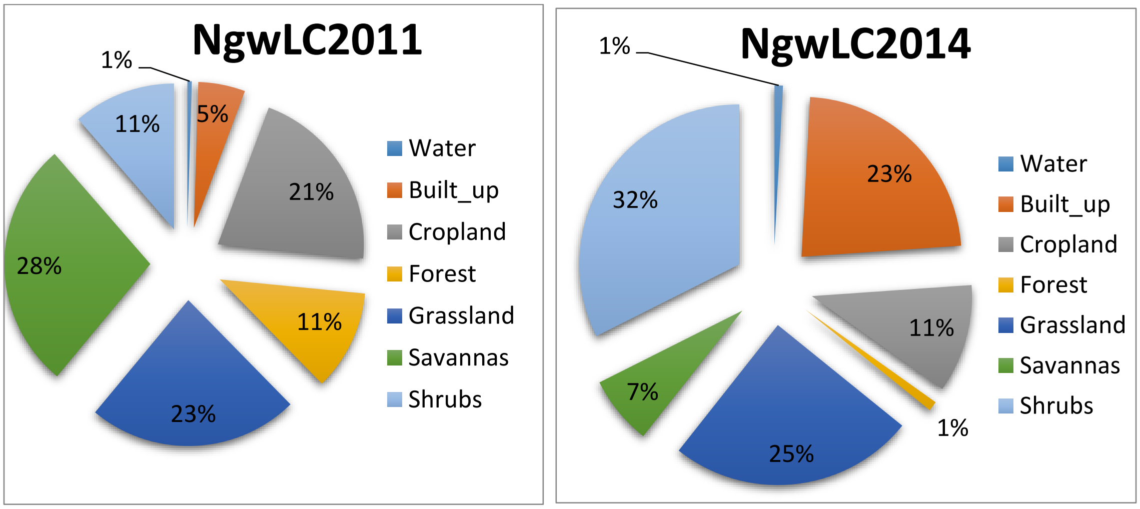

Figure 6: Ngwerere Landcover – A comparison for 2011 and 2014

From figure 6 above, it is evident that the spatial coverage of Built-up area increased from below 5% (in 2011) to above 23% (in 2014) of the total area of the catchment. Forest area, cropland and savannas decreased for the period under consideration. Increase Built-up area means increase in impervious surface which in turn reduce infiltration, thereby increasing the volume, duration and intensity of surface runoff. Unconfined aquifers overlain by areas with uncontrolled increase of impervious cover will eventually have a reduction in groundwater as the recharge is reduced.

As mentioned earlier, change detection was done by crossing the classified images. Table 3 shows the details of Landcover/Landuse change. It clearly shows that from 2011 to 2014, built-up area increased by over 300%. Cropland, forest and Savannas decreased by 47%, 91% and 74%, respectively. The major contributing landcover to built-up are cropland (2,841ha) and grassland (1,267ha).

Increase in built-up area is because of urbanization due to increase of population which has created a high demand of accommodation, trading areas and communication facilities. Urbanization increases impervious surfaces which include rooftops, roads, driveways, sidewalks, parking lots, etc. The increase of impervious cover leads to the increase in the volume, duration, and intensity of urban runoff (Brassington, 2007; Keller, 2012 and Thomas, et al., 1998). Ngwerere Catchment has seen increase in impervious cover which has led to overall decrease of groundwater recharge and baseflow.

Table 3: Ngwerere Catchment Landcover/Landuse conversion matrix – 2011 to 2014

		NgwLC2014 Area (Hectares)							
		Water	**Built_up**	**Cropland**	**Forest**	**Grassland**	**Savannas**	**Shrubs**	**Total**
NgwLC2011 Area (Ha)	**Water**	125.91	0.09	0.27	0.63	0.27	0.63	9.09	**136.89**
	Built_up	0.00	1,406.34	17.55	0.00	14.40	28.35	0.00	**1,466.64**
	Cropland	2.88	2,841.48	806.76	2.70	1,750.68	11.07	472.14	**5,887.71**
	Forest	100.71	16.47	162.90	270.81	80.37	1,535.67	969.30	**3,136.23**
	Grassland	3.87	1,267.38	797.31	0.09	3,331.80	6.93	1,184.13	**6,591.51**
	Savannas	5.94	364.32	568.26	2.07	1,134.27	376.65	5,331.87	**7,783.38**
	Shrubs	0.27	605.61	737.73	0.00	688.23	1.98	1,179.00	**3,212.82**
	Total	**239.58**	**6,501.69**	**3,090.78**	**276.30**	**7,000.02**	**1,961.28**	**9,145.53**	
									28,215.18
	Growth	**75.02%**	**343.31%**	***-47.50%***	***-91.19%***	**6.20%**	***-74.80%***	**184.66%**	

Population: Population data shows that the population, for Lusaka and Chongwe Districts, is increasing. For 2015, population was estimated at 2,214,000 for Lusaka District and at 50,000 for Chongwe District (fig. 7). The population for Ngwerere Catchment was estimated using proportional coverage of the catchment in the shared districts.

Increase in population activates an increase in demand of water and infrastructure development in terms of shelter, trading areas and communication. Increase in demand for water triggers an increase in groundwater abstraction which can contribute to the decline in groundwater table for the catchment, but the impact is negligible because most of the households use on-site sanitation, mainly septic system. Increase in demand for infrastructure development leading to the construction of shelter, trading areas and communication facilities create impervious surface which subsequently decrease infiltration and consequently decrease groundwater recharge.

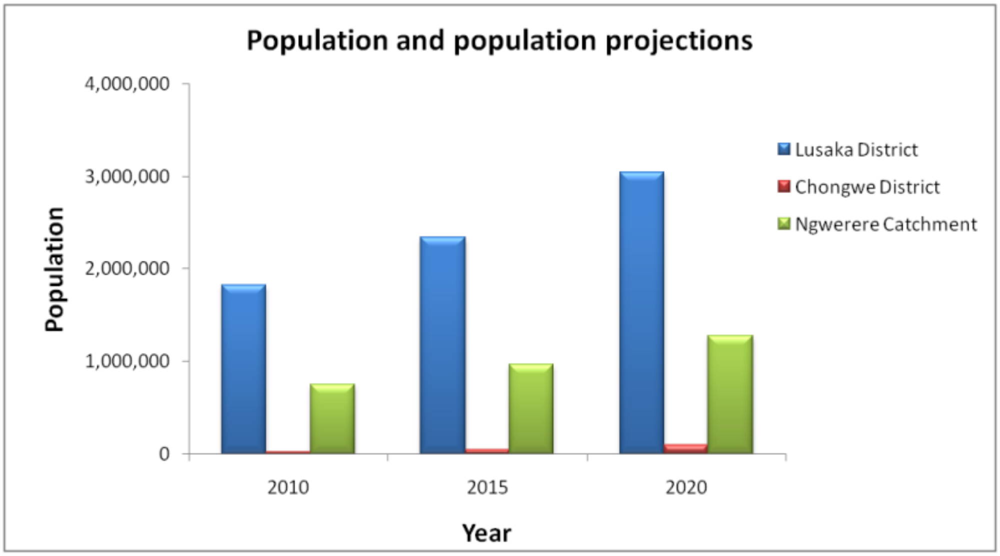

Figure 7: Population for Lusaka District, Chongwe District and Ngwerere Catchment

Impervious surface: Urbanization creates impervious surface which block natural groundwater recharge and as such a large amount of water is lost by runoff (Leopold, 1968; Subramanya, 2010 and Thomas, et al., 1998). If not guided, Urbanization can seriously impair groundwater recharge as is the case in Ngwerere Catchment. To control the increase of impervious surface, it is therefore being proposed that a fee be charged on any land developer who exceed a certain threshold of impervious surface for any land parcel within the catchment, and that the monies realized be used to set up artificial groundwater recharge zones. The fee should be higher for critical recharge areas. Charging land developers for exceeding a defined threshold prevents developer from unnecessarily sealing the ground and compels them to support groundwater recharge. Additionally, controlling impervious surface does not only encourage groundwater recharge but also reduces flooding potential of streams and rivers, protects ecosystem and enhances stream water quality. Just like when one wants to block stream-flow he/she has to apply for a permit, those who want to block groundwater recharge must apply for a permit. Sheet for determining impervious surface for land parcel is shown in Appendix A. The sheet has been adapted from Wisconsin Shoreland Zoning Revision, NR 115 Guidebook (WCCA, 2011).

4. Conclusion

A comparative analysis of Groundwater levels, rainfall data and satellite images together with population data shows that the decrease in groundwater in Ngwerere Catchment is not due to change in rainfall pattern. Using the Maximum Depth of Groundwater per Hydrological Year (MDGWHY), an average decrease of groundwater table of 0.233m per hydrological year was registered. This decrease could not be attributed to rainfall as for the same period total rainfall showed an increased trend at a rate of 0.132m per hydrological year. When you have an increase in rainfall you expect to have a corresponding increase in groundwater for a phreatic aquifer, but this was not the case. Satellite – image analysis revealed that there was an increase in impervious surface for the catchment of over 300% for the period 2011 to 2014. This is the reason why groundwater is decreasing despite having an increase in rainfall.

Increase in impervious surface is because of urbanization due to increase of population which has created a high demand of accommodation, trading areas and communication facilities. This enlarges the impervious surface which blocks natural groundwater recharge and as such a large amount of water is lost by runoff. If not guided, urbanization can seriously impair groundwater recharge. It is therefore being proposed that a fee be charged on any land developer who exceeds a defined threshold of impervious surface for any land parcel within the catchment, and that the monies realized be used to set up artificial groundwater recharge zones.

Increase in groundwater abstraction due to population growth also contributes to the decline in groundwater table for the catchment but the impact is negligible because most of the households use on-site sanitation, mainly by septic system.

5. Acknowledgement

Level 1 Product Landsat data were downloaded from "Earth Explorer", a USGS website (http://earthexplorer.usgs.gov/). The DEM was retrieved from the online Data Pool, courtesy of the NASA Land Processes Distributed Active Archive Center (LP DAAC), USGS/Earth Resources Observation and Science (EROS) Center, Sioux Falls, South Dakota, https://lpdaac.usgs.gov/data_access/data_pool." I thank USGS and NASA for a free policy which allows free download of satellite images.

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Appendix A

Table A1: Sheet for determining impervious surface for land parcel

Sheet for determining impervious surface for land parcel		
Impervious Surface Item	**Dimensions**	**Area (square meters)**
Existing main Building		
Existing accessory building/garage		
Existing sidewalk/s, Patio/s and Deck/s		
Existing covered Porch (es), Driveway and Other structures		
Total		
a. Total area in square metres of lot area	....	
b. Total area of existing impervious surface	....	
c. Percentage of impervious area : 100*b/a	....	
If the percentage impervious surface area is greater than 15% mitigation is required		
Date:		
Inspector:		
Comments:		

Adapted from Wisconsin Shoreland Zoning Revision, NR 115 Guidebook (WCCA, 2011)

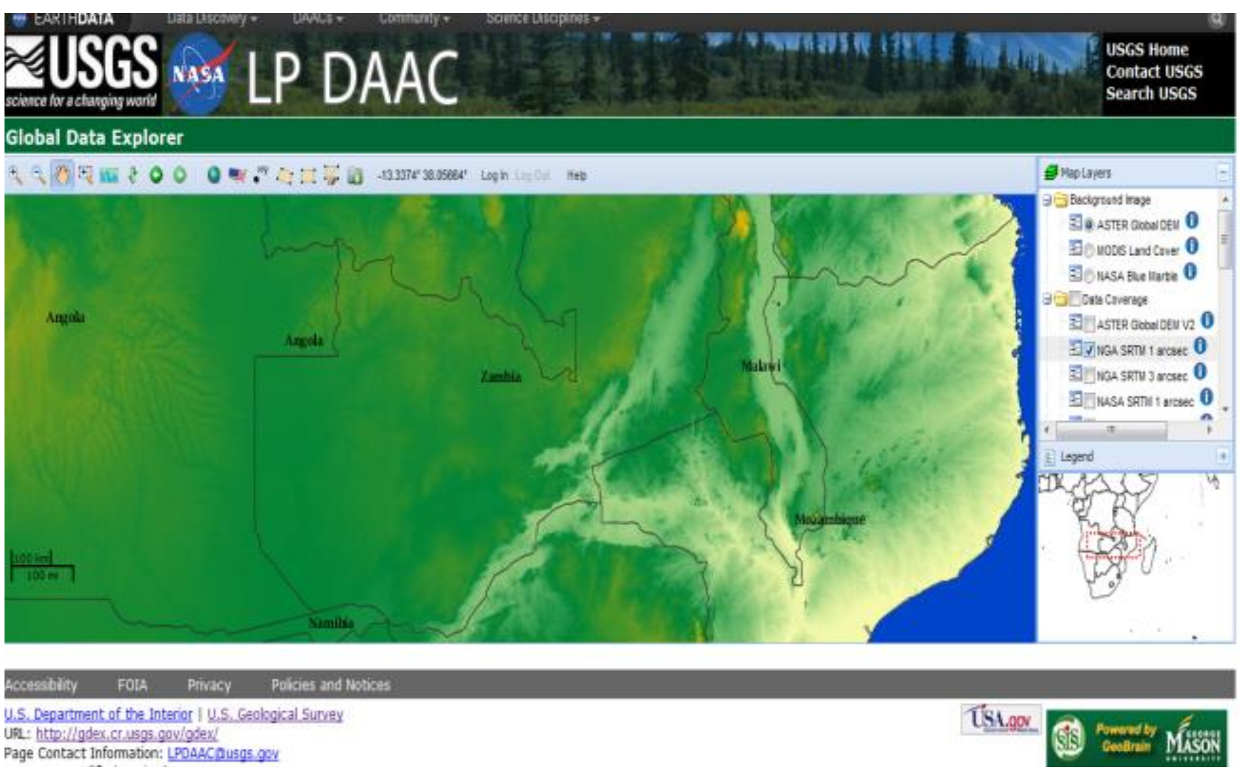

Figure A1: Global Data Explorer website, source for elevation data window

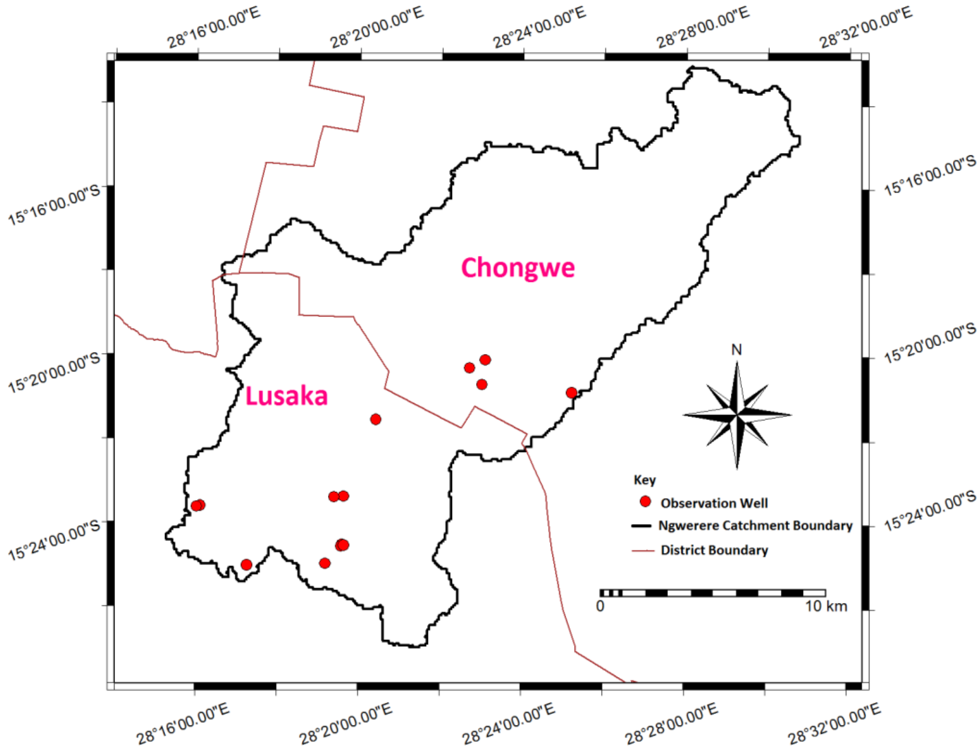

Figure A2: Location of Observation Wells

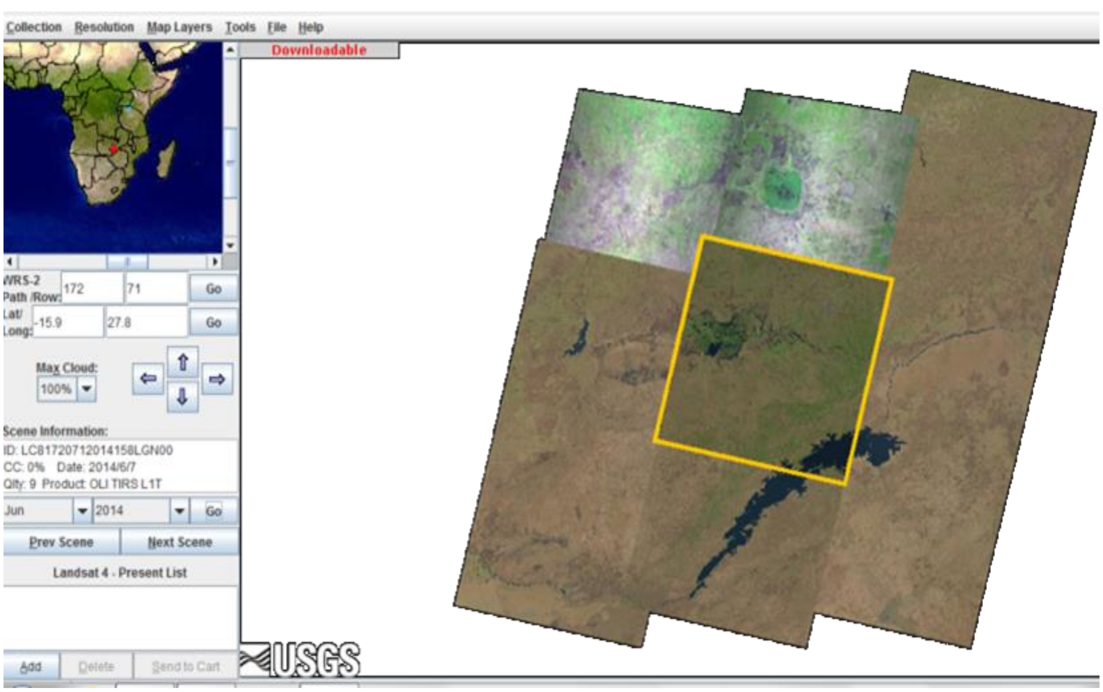

Figure A3: Earth Explorer, USGS website for Landcover/Landuse data window

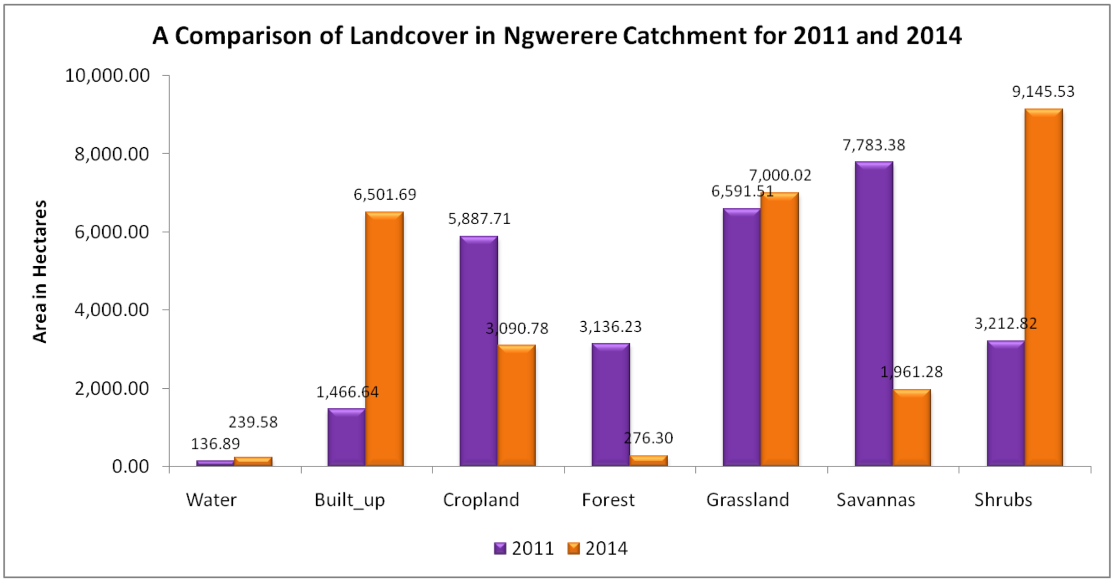

Figure A4: Ngwerere Landcover – a comparison for 2011 and 2014

DII-2018-016

Critical Factors influencing Success of Infrastructure Projects

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Abstract

Infrastructure projects that do not meet organizations' goals and objectives can have a negative impact on organizations, stakeholders and end–users. Studies have been conducted by various researchers to identify critical success factors (CSFs) that influence the successful outcomes of infrastructure projects. The main objective of the study discussed in this paper was to identify critical factors influencing project success. Questionnaires were devised from literature review and administered to construction industry professionals which included project team members, line managers and project managers. Based on the findings, political influence, adequate planning, project manager competence and adequate funding were ranked the highest critical success factors. The research findings are focused to assist industry professionals gain better understanding on key areas based on prioritised success factors to improve performance in project delivery.

Keywords: construction industry, critical success factors, project success, infrastructure projects

1. Introduction

Infrastructure projects have an important part to play in the development of countries and most importantly contribute significantly to the economic growth and sustainable development of a country (Nijaki and Worrel, 2012). The construction industry plays a role in the economy of every country (Mashwama, Aigbavboa and Thwala, 2016). As much as the construction industry is improving, the industry still faces challenges like rise in costs (Windapo and Cattell, 2013; Subramanyam and Haridharan, 2017). Project failure can result in, financial loss to the business environment, stakeholders, creditors and investors (Castillo, 2010).

Project success has eluded the construction industry to the point whereby keeping existing clients has become a struggle. Infrastructure projects are becoming more difficult to successfully complete

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(Garbharran, 2012). There isn't a single definition of project success mainly because project teams find themselves in different situations, which that the definition will be different from that of a different project team. The topic of project success if frequently discussed, however they haven't been an agreement of a specific meaning (Al-Tmeemy, 2010; Yong, Mustaffa, 2013). Nguyen (2013) believes that once the term of project success has been defined, infrastructure projects will be easier to manage, control and to plan for. The success of organizations is affected by every project and the performance (Zavadskas, 2012, 2014). They have been several interest from researchers to study which factors influence project success and what criteria to use to measure project success.

The role of the project manager is important to project success, this has been echoed by several researchers (Yang, 2011; Nixon, 2012; Hwang, Ng, 2013). It is then very important for the project manager to come up with an effective strategy of increasing the likelihood of achieving project success. Project Managers must possess essential managerial and leadership knowledge, competencies, skills and characteristics which ensure successful projects by making the correct decisions at the correct time and involving the correct people in the right places (Ahmed, 2013). According to Ibrahim (2013), successful projects are the results of the well put together team.

The question of how to manage infrastructure projects successfully still needs to be asked and this has attracted a significant amount of research in the past couple of years. Even though much research has been conducted in the field already (Toor and Ogunlana, 2009; Davies, 2014), critical success factors that are most important for effective project management are still uncertain (Ika, 2009). Toor and Ogunlana (2009) investigated other studies of critical success factors in infrastructure projects and state that those studies are context specific. With this discovery the researchers believe that research on critical success factors is only limited to countries, cultures, markets and environments whereby the study is being conducted. The authors believed that more research should be done in other countries so that it accounts for the nature and structure of local infrastructure projects, the level of maturity for organizations being in charge, the procurement strategies put in place by the organizations, the scale of the infrastructure project and the local norms, values and culture. This is because of the ever-changing environment in which constructions companies are operating in and with globalization of the industry has brought along many other challenges to the relevant stakeholders that are involved in infrastructure projects (Nunnenmacher, 2011).

1.1 Study objective

Given the above introduction, the main aim of this study was to investigate to critical success factors which influence project success in infrastructure projects with the South African construction industry and the Limpopo Province. The objective of the study was therefore to identify critical factors that influence success of infrastructure projects.

2. Literature Review

The first researcher to use the terminology of CSFs was (Rockart, 1982). The terminology "critical success factors" means that certain phases that are important, vital and contribute to the ultimate project success. In this case to be able to achieve success on construction projects, Project managers, along with organizations must determine the critical success factors that influence project success and cause ultimate failure on projects. The research of critical success factors has not only been conducted in the construction industry, but also in other industries including Information technology (IT), production industry and medicine. There have been an increase in studies to investigate critical success factors in the past two decades (Rockart, 1982).

Cooke-Davies (2002) says that project success is a simple concept in the field of project management. They also argue that the traditional definition which investigates the golden triangle is not adequate at all. Using the golden triangle as a method to measure project success cannot be an objective measurement of success on construction project because using the golden triangle is difficult and can be ambiguous.

Project success can mean something different to different parties (Toor and Ogunlana, 2009) and individuals. Achieving the organizations objectives can be considered a success on infrastructure projects and this can be done through project management systems, by allocating the required resources to complete the tasks. Kerzner (2013) says that a project is considered successful when the project is finished according to detailed specifications of the project from the beginning till the end date, within the provided budget and set quality. To accomplish the objectives of a project, it is important that critical success factors are identified and this process plays an important role during the phases of design and execution during infrastructure projects. Available research that has already been produced shows that existing literature has identified critical success factors ranging from 4-43 CSFs identified by researchers.

Some CSFs are categorized or grouped ranging from Human-related factors, Project-related factors, External environment-related factors, Project Procedure-related factors and Project Management-related factors. Existing literature that is available does show that the study of critical success factors in infrastructure projects has been conducted in other countries as well such as Nigeria, Vietnam, Lithuania, Malaysia, Spain, Hong Kong, Ghana and Tanzania.

From the early 1960s-1980s project success was seen when the initial objectives and aims of the project have been met, and this was from the viewpoint of the golden triangle (Lim and Mohammed, 1999), (Kerzner, 2013) and (Jugdev and Muller, 2005). Much of the focus from the 1960s to 1980s was more on the importance of the end-user satisfaction. However, things have changed in this day and age whereby CSFs are identified but these CSFs are not grouped. Project success took centre stage and frameworks for project success were created and integrated (Jugdev and Muller, 2005). The researchers understood that project success was more from the viewpoint of stakeholders.

Davies (2014) has determined that research on project success has significantly shifted between the 1960s -1980s when the technical aspect on infrastructure project was the main focuses on projects. Nunnenmacher (2011) believed that the definition of project success will be based on the type of project that is taking place and also the set goals an objective of the project. Ultimately project success is defined as when the project meets the budget, timorously completion, specific quality standards and inherently functionality.

However, the 21st century researchers understand that defining the concept of project success is difficult, complex and ambiguous because many researchers understand and define project success in their own ways. Ensuring project success on infrastructure projects some researchers state that key stakeholders must be involved on the project throughout the project to ensure the project is delivered successfully. Successful project management requires commitment and planning so that the project can be completed successfully.

2.1 Project success

Project success is an abstract concept and determining whether a project is successful is subjective and extremely complex (Sanvido, Grobler, Parfitt, Guvens, and Coyle, 1992; Chan, Scott, and Chan, 2004). Project success can be categorized into groups one being hard and objective; measureable and tangible while on the other hand subjective, soft, and less measurable and intangible (Chan, Scott, and Chan, 2004). However, the criteria of measuring success, the golden triangle, is not enough to measure project success.

There has not been a distinct answer as to how to take control of construction projects which are unique and dynamic by their nature (Nguyen, Ogunlana, and Lan, 2004). This is an environment that constantly changes and brings challenges with lots of activity, unplanned and those that are planned during the project life–cycle (Sanvido, Grobler, Parfitt, Guvens, and Coyle, 1992). The parties that are involved on the project strive to try and minimize the unknowns and uncertainties for the sake of attaining project success (Josephson, and Bjorkman, 2011; De Wit, 1988).

Studies have been conducted to define what project success is and researchers such as (Sanvido, Grobler, Parfitt, Guvens, and Coyle, 1992; Nguyen, Ogunlana, and Lan, 2004) state a project is a success when the main goals and objectives of the project have been achieved; only then a project is considered successful. Sanvido, Grobler, Parfitt, Guvens, and Coyle (1992) argues that several Project Managers often agree to that; however, they also acknowledge that this definition is by far the only definition for project success. The definition of project success differs because of the view that success will depend on which criteria are chosen to evaluate project success (Sanvido, Grobler, Parfitt, Guvens, and Coyle, 1992).

2.2 Critical success factors

The term CSFs comes from the field of management information systems. The first researcher to use the term in his study was (Rockart, 1982). Rockart (1982) defines CSFs as those few areas that the organizations top management and the Project Manager should focus their attention to these areas are very important for the goals and objectives to be ultimately achieved. Rockart (1982) emphases that the key to obtaining success is by the Project Manager focusing the resources on the issues that are important between obtaining ultimate success or project failure. Cooke-Davies (2002), and Sanvido, Grobler, Parfitt, Guvens, and Coyle (1992) also define critical success factors as factors that are important for the project team participant to ultimately achieving their objectives.

Rockart (1982) takes it a step further and states that critical success factors relate to the certain factors and conditions of a sector. Identified critical success factors on projects often will change because the industry changing, the organization repositioning within the industry or because of arising business opportunities for the industry. It is therefore important that the organization and Project Manager understand what critical success factors are.

3. Research Methodology

A questionnaire was designed based upon literature and current construction practice to obtain information on the critical success factors perceived by participants on the projects. The questionnaires dealt with critical success factors for infrastructure projects. The targeted respondents were project manager, line manager and project team members who were directly involved in the projects. The project managers comprised of managers of the organization and line managers reporting to the Project Manager and finally the project team members who were also available and working on site during the construction phase. The questionnaires were distributed to conveniently selected construction sites. However, only 10 questionnaires were returned and therefore used for the analysis. The respondents included one project manager, two-line managers and seven project team members.

4. Results and Discussion

In the structured part of the questionnaire, the respondents were asked to rank the degree of significance of 16 critical success factors drawn from literature. Furthermore, the respondents were asked to add other success factors that they perceive as being necessary. However, they did not make significant additions. Table 2 shows the ranking of 16 critical success factors by project members involved in the projects. Four critical success factors namely, political influence, adequate planning, project manager competence and adequate funding were ranked highest by the respondents. Therefore, the four critical success factors are considered as been critical.

Table 2: Ranking of critical success factors

S/No.	Critical Success Factors	Number of respondents	Rank
1	Political influence	10	1
2	Adequate planning	10	1
3	Project manager competence	10	1
4	Adequate funding	9	4
5	Owners involvement	8	5
6	Relationship between project team and contractor	8	5
7	Realistic goals and objectives	8	5
8	Labour unrest	7	8
9	Project team competence	6	9
10	Interpretation of specification	4	10
11	Ability to carry out meetings	4	10
12	Roster strategy	3	12
13	Adequate plans and Specification	3	12
14	Community Involvement	3	12
15	Availability of Stakeholders	3	12
16	Buy in of Local Chieftaincies	2	16

4.1 Political influence

Political influence was the highest ranked critical success factor. This finding was consistent with other studies (Hwang and Lim, 2012; McCabe, 2003). Political influence can have a negative and a positive impact on the project. When political power is in support of an infrastructure project, the Project Manager can ensure that all goes according to plan and all is effective when it comes to planning, the execution of goals and motivating the project team to deliver the project in the required time. The negative impact on the other hand is that people get appointed in positions that they are not qualified for and have no experience. This can lead to projects to have delays because of the Project Manager not knowing how to manage infrastructure projects. People within projects are often unwilling to conform to an imposed standard (Clarke, 1999). Thus, very clear project objectives and scope will eliminate this symptom. People should be informed to know the project direction, expected project outcome, and especially their roles. Clear responsibility and accountability are necessary to sweep away what Clarke (1999) called the "counter-productive effects of individualism". It has been recognized as one of the most critical factors for the successful completion of projects in numerous studies (White and Fortune, 2002; Sanchez and Perez, 2002).

4.2 Adequate planning

The primary aim of the organizations and project managers is to make sure that they execute the goals and objectives of the project. The Project Manager on the project must make sure that all the required resources and information are available on site always to be able to execute the scope. Adequate planning was ranked third most important critical success factor. This was consistent with other studies (Garbharram, Govender and Msani, 2012). Proper project planning and control require project teams to utilize appropriate project management techniques and tools. The involvement of many parties is a dominant characteristic of construction projects. If one of the parties is not capable to act within his/her role, the project is likely to fail. It is, therefore, essential to ensure that the bidding process can help single out the right designers, contractors and other parties to effectively transform project ideas into reality. A recent study (Long, 2003) conducted in Vietnam found that problems responsible by designers/consultants and contractors had very high frequency and influence on large construction projects

4.3 Project manager competence

The second highest ranked critical success factor was Project Manager competence. This finding is consistent with other studies (Garbharram, 2012; Baker, 1983). The role of the Project Manager is considered as one of the most important critical success factors on infrastructure projects. Single headedly the incompetence of the Project Manager can terminate the project prematurely when they do not have the necessary skills and knowledge that are required. When the Project Manager has strong skills this eventually rubs of the project team in a good way. Leadership is also a crucial aspect in project management. Caudron (1999) noted three different kinds of competencies required in leadership: leadership competencies such as the ability to lead change, functional competencies such as technical and human resource management skills, and personal skills such as high achievement motivation and persistence. Large construction projects need certain kinds of technology, but selecting the right technology may be problematic, especially when the project team is incompetent. Technology transfer has often been the focus of discussions, yet developing countries still use obsolete technology. Possession of modern technology is a critical factor for success and sustenance in today’s business environment. A serious challenge to construction industries in developing countries is their inability to adopt or adapt established best practices already working in other countries (Ngowi, 2002).

4.4 Adequate funding

The Owners of the project, before taking on a project, must have the required funds available and funds aside for rising cost in materials. The Project Manager and the organization will conduct a forecast to see where they will be required to spend money on up-to-date technology. Adequate funding was the fourth most important critical success factor. This was consistent with other studies (Ram and Corkindale, 2014). This component emphasizes that successful projects are implemented in comfort. That is, money, resources, efforts and leadership should always be available throughout the project’s life. They ensure that construction projects run smoothly. Money and other resources in terms of adequate funding until project completion and availability of resources are obvious imperatives to carry out projects. Availability of funds/resources has also been ranked highest in recent researches (Belassi and Tukel, 1996; White and Fortune, 2002).

Clearly, most of the CSFs are human-related factors. This implies that people play a decisive role regarding the success or failure of a project. It is not surprising since they are responsible for creating, managing, operating and utilising the project and are invariably affected by it. Depending on their needs, different participants in construction may have divergent interests in the project but they must have an agreement, in principle, about project objectives and critical success factors that can help to achieve those objectives. It is argued that each of these plays an important role in project success or failure.

5. Conclusion

The success of large construction projects, especially infrastructure projects, is very important for all project participants as well as the community and the nation to sustain national development. However, various factors affect whether a project is completed successfully or not. The primary objective of the paper was to identify critical success factors for infrastructure projects. Four CSFs were identified as being important. These included political influence, project manager competence, adequate planning and funding.

The study has a major limitation, which is the number of responses received. The researcher faced difficulties about non-responsiveness of potential participants. The findings may be different if a larger sample was used.

Nevertheless, the findings are focused to assist construction industry stakeholders and professionals in delivering infrastructure, with and understanding of fundamental areas which contribute to the success/performance of a subject venture.

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A Conceptual Model of the Socio-Technical Systems of Carbon Emissions within the South African Housing Sector

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Abstract

South Africa is one of the signatories to the Copenhagen Accord and has committed to cut carbon emissions by 34% the year 2020, and 42% by the year 2025 through the "intended nationally determined contribution" plan. Reduction of energy consumption within the housing sector is one of the targeted areas where to cut the emissions. Few studies have been conducted in carbon emission reductions within the South African housing sector especially on the complex nature of carbon emissions from dwellings. The issue of carbon emissions in dwellings is seen as a socio-technical problem. As such, the purpose of this paper is to develop a conceptual framework for modelling the socio-technical systems of carbon emissions within the housing sector of South Africa. The study uses the system dynamics approach as both the methodology and tool for modelling, which takes its philosophical foundation on the pragmatist research paradigm. The findings from the study indicate that there is a population of variables influencing carbon emissions in South African dwellings. The findings further suggest that those variables seamlessly work together and interact in a complex way. In conclusion, findings in the current study have been used to develop a high-level conceptual model which at this stage has not been validated. Therefore, generalization of these findings is limited.

Keywords: carbon emissions, housing sector, socio-technical systems, South Africa, system dynamics

1. Introduction

Governments at different levels around the globe are urgently seeking solutions to the problem of climate change due to unsustainable use of energy in all spheres of economy. Sustainability issues in dwellings have been a major concern generally due to the amount of energy consumption and carbon emissions being generated. For example, the United Nations Department of Economic and Social Affairs (UNDESA) (2010) reports that the use of fossil fuels in dwellings alone can be attributed to about 30% of carbon emissions in all sectors. This amount is huge and that is why the

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whole world is continually finding means to reduce energy use and carbon emissions in dwellings because of the threat posed to the entire planet. As such, a consensus was reached within the world's governments to significantly reduce what the carbon emissions will be in this 21st century. This is reflected in the Rio summit of 1992 where the United Nations Framework Convention on Climate Change (UNFCCC) was signed committing developed and some developing nations to significantly reduce their carbon emissions profiles. Subsequently, there were series of follow ups regarding the UNFCCC agreement of 1992 and ratified in 1993. For example, the World Climate Conference of 1997 in Kyoto, Japan and that of Copenhagen summit in 2009 and most recently, the Paris agreement of 2015. At Kyoto conference, a legally binding agreement was reached to cut carbon emissions. This agreement has kept several countries on their toes to drastically reduce their carbon footprints.

South Africa is one of the signatories to the Copenhagen Accord, and as such it is committed to cutting out emissions by 34% in 2020, and by 42% in 2025 through the "intended nationally determined contribution" plan. Reduction of the energy consumption patterns in dwellings is one of the targets to cut the emissions. While many high-level studies have been conducted within the South African energy sector as demonstrated by the works of ERC (2011), Musango (2014), amongst others, there is limited evidence to suggest that much studies have been conducted in the area of carbon emissions reductions within the housing sector, especially formal and informal dwellings. For example, one of the reasons for the Green Building Council of South Africa is because of these ambitious targets. It is necessary to note that this area of research has been demonstrated to be an important field within the energy studies in housing. The objective of this paper is therefore to develop a conceptual model for the socio-technical systems of carbon emissions in housing. This is with a view to adding to the understanding of complex nature of carbon emissions in dwelling and proposing a novel approach for testing different strategies and interventions for reducing energy consumption and carbon emissions in dwellings.

1.1 The socio-technical systems theory

The study is hinged on the concept of socio-technical systems (STS) theory. Dwyer (2011) argues that the STS theory emerged as a new field of academic discipline for those specialising in sociology of technology. The theory is premised on the notion that engineers/technologists tend to ignore the significance of some socio issues relating to certain aspects of their work, while also the social scientists, often, know little about the issues of technology and may hence not eager to consider the artificial reality of technical objects. Bringing these two divides together, the STS theory then emerged, and it has since taken prominence in the research circles.

To gain a more understanding of how the STS works, Dwyer (2011) demonstrates this by using a generic model depicted in Figure 1. The diagram in Figure 1 suggests that the STS contains components that are referred to as social structures, and artefacts that are termed technical elements, which contribute directly or through other components to a common system goal. It was shown that both the components and artefacts interact with each other with system goal guiding the overall behaviour of the system.

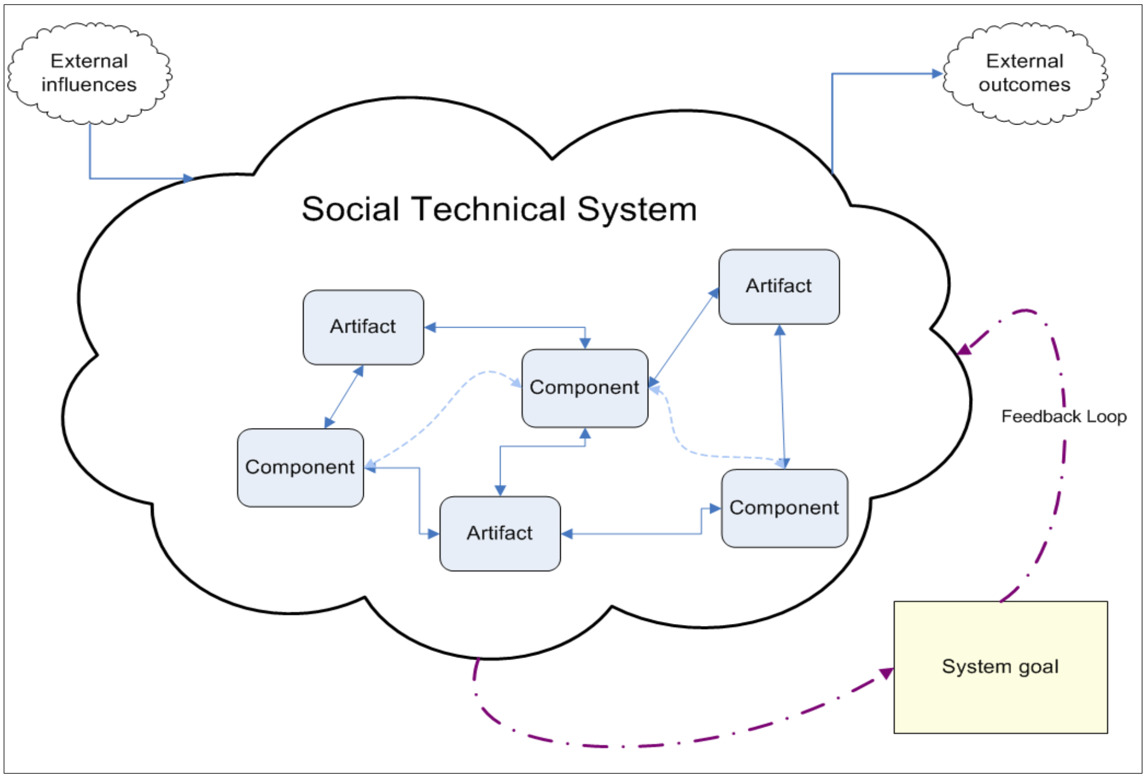

Figure 1: A model of a socio-technical system (Adapted from Dwyer, 2011)

There is a feedback loop that allows the system's actual output to be compared with the system goal. Errors are then detected by this feedback loop and appropriate corrective measure are to improve the system performance (Hughes, 2000).

Based on the above, the STS theory, therefore, serves as the theoretical lens for the issues surrounding energy consumption and carbon emissions within the housing sector of the economy, which is the focal point of this paper.

2. Review of Related Literature

There are quite many studies that have considered the variables influencing the sociotechnical systems of housing energy consumption and carbon emissions. Among those studies is the work of Hitchcock (1993). The study considered the housing as a system consisting of both the physical and socio systems. Hitchcock (1993) argued that the physical system deals with the issues of forms, materials and devices that made up a dwelling, while the socio system depicts issues surrounding the occupants living in the dwelling. The study further contended that the two systems interact and interrelate and their interaction shape energy consumption patterns within a dwelling with influence from another system called the environment system. Further, the studies of Moll *et al.* (2005), Bartiaux and Gram-Hanssen (2005), Bin and Dowlatabadi (2005), Yun and Steemers (2011), Abrahamse and Steg (2011), Kelly (2011), Tweed et al. (2014), Motawa and Oladokun (2015) have all explored the sociotechnical interactions regarding housing energy consumption and carbon emissions. Specifically, the studies cover issues surrounding the identification of variables and interrelationships existing among those variables. For example, the work of Motawa and Oladokun (2015) provides a comprehensive list of variables influencing the sociotechnical systems of housing energy consumption and carbon emissions. The study categorised the variables into endogenous, exogenous and excluded variables as given in Table 1.

Table 1: Variables influencing the sociotechnical systems of housing energy consumption

Endogenous Variables	**Exogenous Variables/Parameters**	**Excluded Variables**
heat losses	total floor area	Some variables relating to occupants' behaviour e.g.:
dwelling heat gain (dhg) due to cooking	area of opening	- occupants' social class influence
dhg due to no of people	solar flux	- occupants' social group influence
dhg due to appliances less cooking	solar transmittance factor for glazing	- occupants' cultural influence
dhg due to artificial lighting	frame factor	- occupants' personal influence
average effect of solar gains	average solar access factor	Some variables relating to dwellings physical parameters e.g.:
total dwelling heat gains	pi	- dwelling exposure
natural heat transfer	dhg due to water heating	- dwelling orientation
artificial heat transfer	insulation factor	- air changes
dwelling internal heat	setpoint temperature	Some variables relating to external environment such as:
discrepancy in internal and external temperature	temperature conversion factor	- political uncertainties
dwelling internal temperature	growth in occupant's activity level	- energy securities
discrepancy in internal and setpoint temperature	external air temperature	
humidex value	relative humidity	
occupants' activity level	SAP rating	
occupants' metabolic buildup	average annual gas bill	
perceived dwelling temperature	average annual electricity bill	
occupants' comfort	energy to carbon conversion factor	
probability of window opening	carbon depletion factor	
probability of putting on clothing	demand for cooking energy	
effect of energy efficiency standard improvement on dwelling energy efficiency	lighting energy demand	
effect of fabric insulation on energy efficiency	appliances energy demand	
effect of combined fabric insulation and energy efficiency standard on dwelling energy efficiency	population equilibrium time	

Endogenous Variables	**Exogenous Variables/Parameters**	**Excluded Variables**
effect of energy efficiency standard on cooking energy	reproductive time	
effect of energy efficiency standard on lighting energy	average life expectancy	
effect of energy efficiency on hot water energy	occupants behaviour	
effect of energy efficiency on space heating energy		
effect of dwelling energy efficiency on energy bills		
effect of energy bills on energy consumption		
climatic effects on international energy price		
climatic effects		
average annual energy bills		
space heating demand		
space heating energy rate		
space heating energy consumption		
energy to carbon conversion		
space heating carbon emissions		
carbon depletion		
rate of hot water energy usage		
hot water energy usage demand		
hot water energy consumption		
carbon emissions due to hot water usage		
cooking energy rate		
cooking energy consumption		
carbon emissions due to cooking energy		
rate of lighting energy usage		
lighting energy consumption		
carbon emissions due to lighting energy		
appliances' energy consumption		
rate of appliances energy usage		
carbon emissions due to appliances' energy		
average annual energy consumption per household		
total annual household energy consumption		
average annual carbon emissions per household		
total annual household carbon emissions		
population		
births		
deaths		
mortality		
households household size		

Source: Motawa and Oladokun (2015)

3. Research Methods

It is important to state that the research being reported in this paper is a part of an enlarged postdoctoral study. As such, the research methodology for this study takes its philosophical foundation on the pragmatist research paradigm. This research paradigm ensures the triangulation of two or more research strategies to solve the research problem posed by the study. This is premised on the need to align the methodology with the theoretical underpinning as explained in Section 2 above. The purpose of this research as enunciated in Section 1 above is to develop a conceptual framework for modelling and testing a range of possible future profiles regarding carbon emissions within the housing sector. The modelling platform being considered for this purpose is the system dynamics modelling approach. The system dynamics approach, on its own merit, is hinged on a pluralistic method that considers both the qualitative and quantitative approaches to modelling (Pruyt, 2006). This then informed the choice of the research design and method for this study.

Specifically, the study conducted a literature review to identify and classify the variables influencing the sociotechnical systems of housing energy consumption and carbon emissions. This is mainly to provide the basis for the conceptual model being developed by this study. Importantly, the conceptual model was first developed based on the evidence from the literature and the authors' mental knowledge. The conceptual model was then subjected to experts review through the experts' knowledge elicitation approach. The knowledge elicitation of the experts was in form of focus group where the conceptual model was shown to them for their input. The session started by a brief description of the problem being investigated with a summary of the outcome from the extant literature. The philosophy and logic behind the development of the conceptual model were discussed and this was followed by the interaction and discussion with the participants. The participants offer useful insights into the conceptual model being developed and the final model was developed based on the input from the participants.

4. Results and Discussion

Based on the outcome of the literature review that was first conducted, Figure 2 was then emanated. In Figure 2, the main variables that are being considered for modelling the interrelationships among the variables influencing the sociotechnical systems of housing energy and carbon emissions was shown. This by implication indicates the dynamics of energy consumption and carbon emissions within the housing sector, especially formal residential dwellings. The STS of energy consumption and carbon emissions in housing sector shows that there are basically three systems moderating energy consumption and carbon emissions. These systems are the dwelling system, occupants' system and environment system. All the three systems interact and work seamlessly to account for energy consumption and carbon emissions, considering the demand side of emissions. Among the variables considered for the dwelling system in terms of dwellings' physical properties are space heating, lighting, and ventilation. Also, dwellings' dynamic variables like temperature setting/regulator are being considered under the dwelling system. Additionally, variables related to the occupants' system in terms of occupants' biophysical variables; behavioural variables as well as dwellings' household characteristics are included. Furthermore, the model included variables related to the environment system in terms of climatic and economic variables. The interaction among the variables indicates the complexity involved.

Figure 2 then forms the basis for the conceptual model developed in this study. As such, the outcome of this study evolves the conceptual model for modelling the dynamics of energy consumption and carbon emissions within the housing sector as shown in Figure 3. The conceptual model/framework disaggregates the dynamics of energy consumption and carbon emissions in formal residential dwellings into six main sectors premised on the three systems identified in Figure 2. These sectors include the population/household sector, the dwelling internal heat sector, the occupants' thermal comfort sector, the climatic-economic-energy efficiency interaction sector, the household energy consumption sector, and the household carbon emissions sector. The six sectors work together seamlessly to give the "cause and effect" interactions among them. For example, the causal loops demonstrate the complexity involved in modelling this kind of a system.

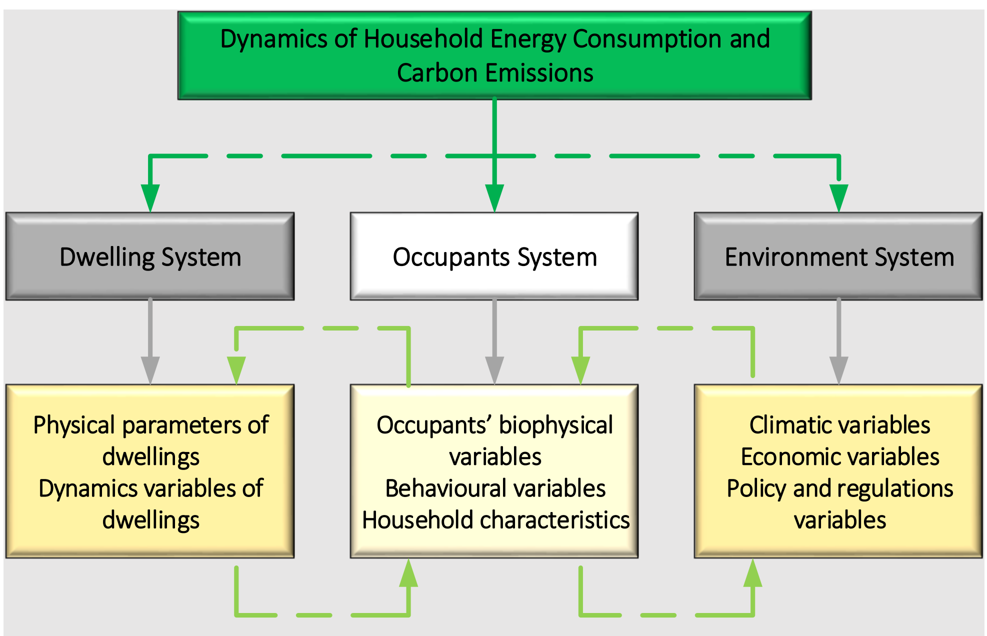

Figure 2: Interrelationships among the model variables

In Figure 3, three important feedback loops are identified. The first loop being the behaviour feedback loop. The behaviour loop indicates how the thermodynamics of dwelling internal heat influence occupants' thermal comfort and vice-versa. This loop generates insights in terms of the occupants' choices, for example, their lifestyles and the effects they have in terms of space and water heating, the use of air-conditioning system, amongst others. The consumption feedback loop shows the resulting interactions between the climatic-economic-energy efficiency sector and household energy consumption sector with the occupants' thermal comfort sector acting as external sector to the loop. The major insights from this loop is that there is the need to pay special attention to the variables within the loop. Similarly, the environment loop demonstrates the importance of external environmental system like external temperature, relative humidity, amongst others and their effects on dwelling internal heat and consequently on carbon emissions.

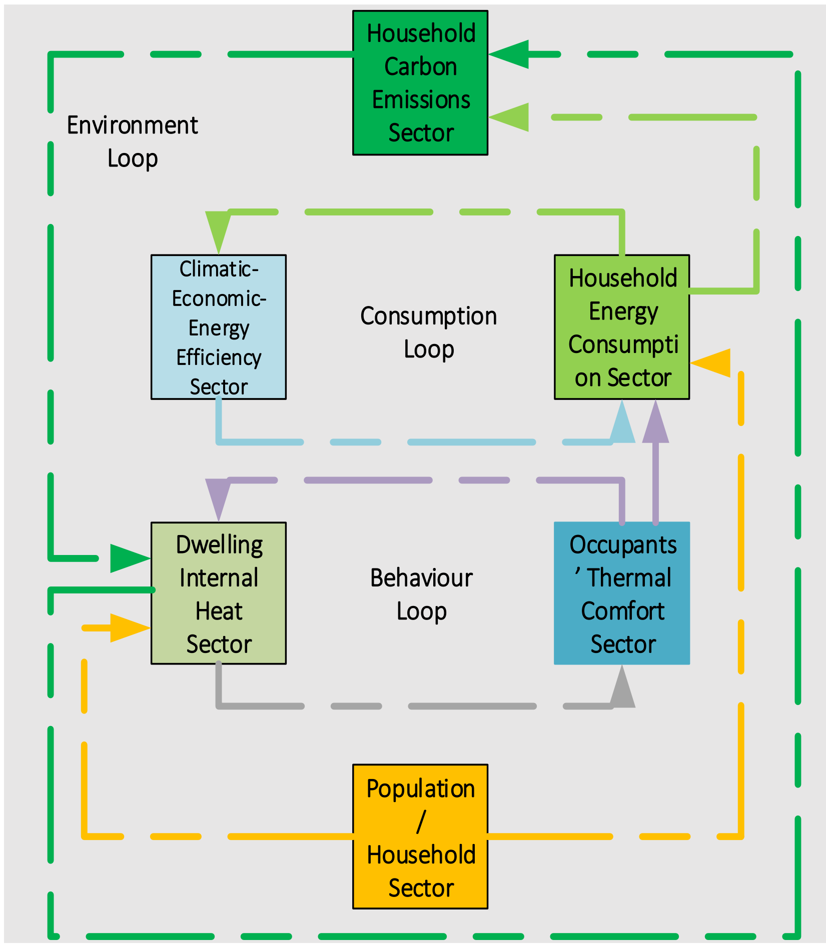

Figure 3: Conceptual framework/model

To further show some insights from the developed framework, a causal tree analysis of the model was explored as shown in Figure 4. The causal tree indicates how the high-level variables/modules are interrelated and interdependent from one another. This demonstrates the complexity involved in modelling this kind of a system. The variables within each of the sectors are further developed individually before integrating all of them together.

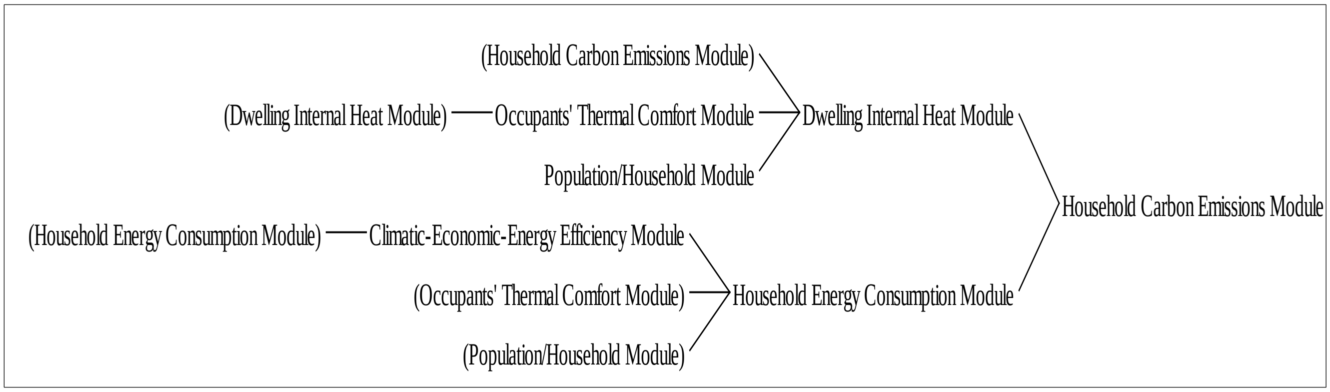

Figure 4: Causal tree of the preliminary high-level model

5. Research Implications and Value

As previously enunciated, this research is part of an enlarged postdoctoral study. As such, this research being reported in this paper is serving as a foundation study to the enlarged postdoctoral research. Specifically, this study has implications for further research by providing the conceptual model/framework capable of being used to develop models that will be used to solve the problem of carbon emissions attributed to the housing sector of the economy. The developed framework can then be used by other researchers as a guide towards modelling the sociotechnical systems of housing energy consumption and carbon emissions. This can as well spur further research activities within this research domain.

6. Conclusion

The paper has developed a conceptual framework for modelling the socio-technical systems of carbon emissions within the housing sector in South Africa. The conceptual model was developed targeting the low-income dwellings within the South African housing sector. The finding from the study indicates that there is a population of variables influencing energy consumption and carbon emissions in dwellings and these variables interact together in a complex way. In conclusion, this is a preliminary high level conceptual model/framework that is open to debate to validate same against the experts' experience. Further studies would involve developing the causal loop diagrams for other sectors and validate same with the energy experts and industry practitioners. After the actual system dynamics model would be developed by converting the CLDs to the stock and flow diagrams and then simulation. However, the conceptual model has some limitations. Firstly, the model only considered the demand side of energy consumption without considering the supply side. Secondly, the model considered only electricity as the main form of fuel for heating.

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Servitisation in Construction: An Identification of Drivers

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Abstract

Product (asset) delivery through projects remains a time-honoured legacy of the construction industry. However, increasing levels of client dissatisfaction concerning the non-functionality of these products has triggered an advocacy for a change within the industry's working practices. Servitisation has resulted from such agitations. Although relatively new to construction, servitisation has been extensively deployed across various economic sectors. This study seeks to identify the drivers for servitisation adoption in these sectors. Such understanding will assist in deciphering the probability of its adoption in the construction industry. A systematic review of relevant literature is utilised. The literature identified and reviewed was predicated on a set of pre-determined keywords considered analogous to the concept. Articles from a plurality of databases spanning 20 years (1988-2018) were utilised. Qualitative content analysis was used to categorise relevant excerpts from the articles in accordance with a combination of pre-set themes and sub-themes. Findings indicate that the quest for sustainability remain a salient driver for servitisation adoption. Notably, sustainability remains a critical driver for the ongoing transformation in the construction industry. Therefore, this study argues that it is only be a matter of time before the whole-of-industry transition towards servitisation is consummated. Accordingly, further studies are called for in this aspect. Suffice to state that this study holds dire implications for stakeholders in the contemporary construction industry vis-à-vis the quest for through-life functionality and utility of delivered assets.

Keywords: construction industry, product-service systems (PSS), South Africa, systematic review

1. Introduction

Servitisation has been identified as new business model which supports optimization and delivery of through-life value to customers (Johnstone et al. 2009). This is because of the merger of production and service offerings in this sector. Benefits accruing from this business model in

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different economic spheres like manufacturing (Baines and Lightfoot, 2011). However, it is obvious that construction business models are geared towards product delivery not delivery of services. This has resulted in the delivery of products that do not meet client specifications in terms of functionality and through-life value. Rather emphasis has been centred on the successful delivery of the products (building) as evident in the alignment of the iron triangle to project success criteria. Accordingly, the issue of client dissatisfaction has continued to confront the industry, especially in the need for intensive conservation of resources. Although the construction industry has been expending efforts towards resolving this, it appears that such efforts have not yielded the desired results. The fragmented nature of the industry has been blamed as a salient contributor towards this imbroglio as it seeks to dichotomize between the production and operational phases of the building produced.

In furtherance to this, it is believed that the turnover of stakeholders witnessed during the two phases makes sharing of relevant information between such parties for the client's benefit, improbable. Achieving optimal functionality in aspects like energy efficiency in buildings has become common place in contemporary construction discourse due to high energy costs and environmental concerns (Berardi, 2011). Improving energy efficiency in new commercial buildings and residential buildings is one of the most effortless and least cost choices to lessen a building's energy use, proprietor's operational expenses, and carbon footprint (Kneifel, 2010). Yet, the delivery of energy efficient structures remains low despite the expanding popularity of sustainability within the building sector, as buttressed by increasing quantities of sustainable and green building certificates and devices (Feigie et al., 2011).

It is worthy of note that the demands for provision of through-life value as depicted by functionality and durability of the delivered asset is not peculiar to construction industry clients. Similar demands are being made in other sectors. But, where other sectors have transformed their business models to cater to these demands, the construction industry seems behind in this endeavour. In the manufacturing sector for instance, the advent of servitized business models has largely provided value-in-use for customers (Wise and Baumgartner, 1999). Based on the foregoing, this study proposes that the traditional business model in the construction industry cannot support this transition and prescribes servitisation as a panacea instead. However, there is need to explore the applicability of servitisation in the construction industry, taking into consideration the industry's nature.

But the study being reported here, which happens to be an integral part of a larger study will only report on the probable drivers of servitisation in the South African construction industry. It is expected that such information will form the foundation of future studies into the concept's utility in the construction industry context.

2. Literature Review

2.1 Evolution on servitisation

Servitisation, the term invented by Vandermerwe and Rada (1988), is perceived as a way of creating value by adding services to products. Since the late 1980s, its appropriation as a competitive manufacturing technique has been considered by scholars who have particularly looked to comprehend the advancement and consequences of this idea (Wise and Baumgartner, 1999, Oliva and Kallenberg, 2003, Slack, 2005). A developing enthusiasm for this theme by the scholarly community, business and government has been buttressed (Hewitt, 2002). But a lot of this enthusiasm depends on the conviction that a move towards servitisation will create extra value-adding capacities for conventional manufacturers.

Within the aerospace sector, engine suppliers, for example, Rolls-Royce does not simply fabricate engines, but give through-life support to their engines and rent out the utilization of their engines based on a "Power by the hour" arrangement (Baines et al. 2007). While the applicability of cross-industry development must be treated with alert (Enkel and Gassmann, 2010), the construction of the Rolls-Royce Total Care Model, and comparable innovations from other engine manufacturers within the aerospace division, raise doubt as to the ability of the production network in building construction to play a more effective part in the operation and maintenance of building frameworks after delivery. Be that as it may, even before Rolls-Royce changed its plan of action, leading to the adoption of "power by the hour" arrangement, the firm used to offer product extras, repairs, and upgrade services (Waters, 2009).

In this manner, servitisation evolved from the notion that clients stand to benefit from products when they are complemented by services which ultimately deliver value-in-use (Vargo and Lusch, 2004, 2008). Clients are demanding for added value bothering on “Green” and “Sustainability” while on the other hand, the government and corporate clients are looking for ways to deliver buildings that are more energy efficient. However, these clients appear to be purchasing products that have no value-added services. Servitisation includes the construction of an association's abilities and procedures with the goal that it can better make common incentive through a move from selling product to offering Product-Service Systems. Hytönen (2005) argues that majority of products offered on the market consist of both products and services, with a greater emphasis on the product offered. Brax (2005) proposes that manufacturing companies incorporate services among their principle offers to increase the value of the primary chains.

Further, a few motivations for the incorporation of services into organization’s product offerings like the extension of association with clients, making open doors for construction in advanced markets, adjusting the monetary cycles with various money streams have been observed (Allen and Clarke, 2007). However, it remains to be seen how the South African construction industry can modify their product delivery approaches to attend to the growing demands of clients through the incorporation of services as is the case in manufacturing sector.

2.2 Transiting from product-based business model to a servitisation-based business model in construction industry

Traditionally, contractors have focused their consideration mainly on the design and construction of built assets. While they were typically required to provide services to an extent in relation to operation and sustenance facets, these service assurances were considered as backups to their design and construction obligations. There was a tendency to view these service practices as ordinary, responsive and scheduled; hence, organizations ignored the potential value they could offer their business (Johnstone et al. 2009). Organizations would offer added services (warranties, etc.) free just to secure a product deal or deliver layers of services that did not really address the client's needs (Anderson and Narus, 1995).

These changing attitudes towards product and services are embodied influentially in Vargo and Lusch (2004) challenge to scholars and experts to move towards a service-prevailing rationale, the idea of the contention being that suppliers must co-create value through-existence with their clients. Prahalad and Ramaswamy (2004) declare that the value co-creation process increasingly lies outside the suppliers' hierarchical limit, lying in the connections between a system of inner and outer on-screen characters. The driver for this developing rationale has been a recent pattern in product-orientated associations moving from product deliverance towards the establishment of incorporated blends of products and services that deliver value being used (Baines et al. 2007, Vasanthaa et al. 2011).

Possibilities for servitising within the construction and infrastructure subdivision exist in the form of integrated solutions which consolidate products and services to address a client's necessities over the life-cycle of the project. However, studies centered on the advancement of such integrated solutions focus on PPP/PFI projects within the construction context (Johnstone et al., 2009, Leiringer and Brochner, 2010).

3. Research Methodology

A systematic review of the servitisation literature was conducted to enable the identification of salient factors driving the adoption of the concept from a multi-sectoral perspective (Creswell, 2012). Serving as a research design, the systematic review facilitated the development of a publication selection criteria predicated on keyword(s) and a combination thereof, duration and relevant databases harbouring servitisation and servitisation related publications. Following a cursory search across various academic databases, it was discovered that first incidence of the term 'servitisation' in the literature occurred in 1988. However, after this singular mention, there was no other until 1994 when a flurry of incidences were noticed. Accordingly, the authors relied on dates starting from 1994-2017 during the search for articles. The search approach was developed by first selecting keywords and identifying the relevant databases, setting the time frame (in years) in which the research papers where published, and lastly identifying and analysing the papers by reading through the abstracts to narrow down the number of articles. Later after filtering the relevant articles, the entire articles were read to identify the patterns and themes to help prepare and present the findings (Figure 1).

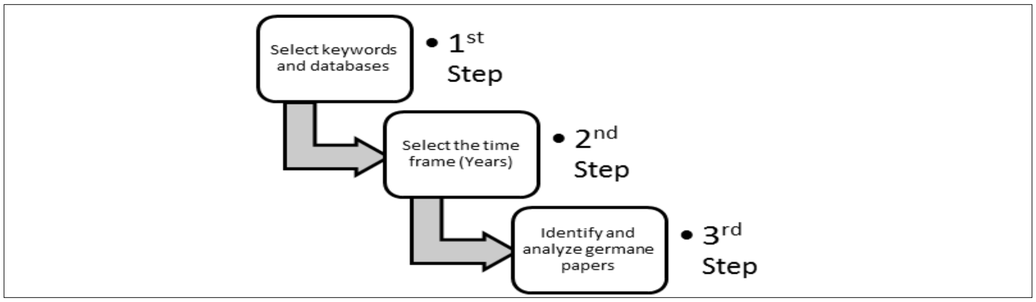

Figure 1: Procedure for Systematic Review of Literature

Initially a wide determination of major databases was identified to cover an assorted scope of publications (e.g.: journal articles, conference proceedings, and books). These databases included Compendex, Elsevier, Scopus, Springer link, ProQuest Central, ISI web of science, and EBSCOHost web. The publications for the literature reviewed in this study were accumulated in two parts. The first part gathered 237 full peer-reviewed scientific articles on the main keywords: such terms as Servitisation and Product-Service Systems. The second part gathered 63 articles based on the combinations of keywords like: sustainability, service design, servitized products, value-in-use, service-centred, and service-oriented. The reviewed papers of part one and part two amount to 300. However, not all the reviewed papers were relevant, only 161 of the reviewed papers were central to the study.

Many of these keywords were combined with 'construction industry' and 'South Africa' in various search instances to ensure relevance. This set was then expanded and refined as appropriate articles were identified. The abstracts of all the remaining articles were then considered and, unless thought inappropriate, the full paper was then read. The analysis itself was aided by applying mind-mapping techniques to capture and cluster the main themes and contributions. It is the analysis of these articles that forms the basis of the findings in this paper.

4. Presentation and Discussion of Preliminary Findings

The findings deriving from the reviewed literature of servitisation will be presented in this section in accordance to the designated categories.

4.1 Drivers of servitisation

The following drivers were identified from the articles sourced through the literature review which appear to be the major needs for transiting toward servitisation.

Table 2: Drivers of servitisation

Categories	Drivers	Number of articles	Authors
Sustainability	Sustainable structures Energy efficiency Diminishment of CO2 emissions	29	Robaina-Alves et al., 2015 Robichaud and Anantatmula, 2011 Baines et al. (2007)
Financial	Higher Profit Margins	12	Wise and Baumgartner, 1999; Gebauer et al., 2005 Slack (2005) Sawhney (2004)
Value Proposition	Service component Competitive advantage	26	Vandermerwe and Rada, 1988; Oliva and Kallenberg, 2003; Slack, 2005

The presented data shows that there is a ceaseless increment of the drivers towards servitisation. The academic scope of servitisation is normally eager and mirrors a developing attitude that the rationale of the contention for firms to servitize is becoming more persuading (Anonocopolou and Konstantinou, 2008). Baines et al., (2007) state that particularly as product driven servitisation where the supplementary service gave reflect the exceptional advantages product manufacturers have concerning contending in the aftermarket.

This is supported by Johnstone et al. (2009) when they explain the effective servitisation techniques of an engine supplier in the aerospace markets to highlight the role played by advances in digitalization, product reliability, monitoring of real-time product system performance and technological intelligence in transforming existing dynamics in the market for maintenance activities. Innovative advancements in product design and manufacture posits that the product supply chain is presently better situated to deliver supplementary maintenance than conventional maintenance and repair associations. Furthermore, the presented findings show that the expanding attention for increasing profit margins, service component, competitive advantages and mostly "sustainability" are driving the construction sector to build more sustainable structures.

The following drivers appear to influence the transition towards adoption of servitisation:

Category 1: Sustainability-related drivers

The results show gradual growth for the need of sustainability in construction and the public is becoming more mindful as well. Diminishment of carbon emissions from assorted industrial sectors is vital to endeavours to lessen carbon discharges because of the large material flows they process and to the large amounts of energy they utilize. If the energy is used inefficiently, this will prompt higher carbon discharge levels. It winds up noticeably important to base the economic, the energy and the environmental policies on the effective utilization of resources, specifically on energy efficiency (Robaina-Alves et al., 2015).

Since the public is becoming more mindful of the advantages of green construction and the built environment's effect on greenhouse gases emissions, there is a need develop ideas on how to reduce the carbon footprint in the construction industry and ways to deliver buildings that are more energy efficient (Robichaud and Anantatmula, 2011). Different elements, including higher energy costs, expanded costs of building materials, and regulatory incentives, are additionally pushing the green building business sector to develop and extend. It is quite clear that offering buildings that are more energy efficient can add value to clients as a service that accompanies a building as a product, and with no doubt that the required functionality, purpose and client's satisfaction will be met.

Category 2: Finance-related drivers

The financial drivers identified in the study are increased profit margins and constancy of income (Wise and Baumgartner, 1999). Wise and Baumgartner (1999) maintain that, in some sectors, service profits can be one or two orders of magnitude greater that new product sale. Slack (2005) agrees, and highlights that in these sectors higher return potential often exists. Similarly, Sawhney et al. (2004) identify companies that have enjoyed success with this approach and attained steady returns from services despite significant drops in sales like GE, IBM, Siemens and Hewlett Packard. These product-service combinations tend to be less sensitive to price based competition and so tends to provide higher levels of profitability in comparison to offering the physical product alone (Martinez et al. 2010).

Category 3: Value proposition-related

Marketing

The service component is notable to influence the acquiring choice and evaluating its significance has been an enduring convention in marketing literature (Storbacka, 2011). Reasons behind these are weights to make more adaptable firms, smaller meanings of centre skills and higher innovative multifaceted nature, and these regularly prompt expanding weights to outsource services (Lewis et al., 2004, Slack, 2005). Services are also claimed to create clients loyalty (Vandermerwe and Rada, 1988) to the point where the client can become dependent on the supplier. Services tend to induce repeat-sale and, by strengthening contact opportunities with the client, can put the supplier in the right position to offer other products or services.

Strategy-based drivers

Lastly strategy-based drivers refer to increasing competitive advantage. Competitive advantages accomplished through services are often more sustainable since, being less visible and more labour dependent, services are more difficult to imitate (Oliva and Kallenberg, 2003). Whilst examining these aspects, the authors reflect on the expanded commoditisation of the business sectors (markets), where differentiating strategies based on product innovation, innovative predominance or low prices, are becoming incredibly difficult to maintain. The value-add of services can improve the client value to the point, where, homogeneous physical products are seeming as customised.

5. Conclusion

The paper has used the servitisation literature to comprehensively explore the drivers associated with the adoption of servitisation across various economic facets in a bid ascertaining if these drivers can instigate wholesome adoption in the construction industry. Furthermore, the paper seeks to explore the applicability of the concept of servitisation in South African construction industry in assuring client value through delivering buildings that are more energy efficient. This paper highlights the need for a better understanding of how servitized business models can leverage upon functionality and satisfaction through offering coordinated blend products and services that deliver value in use. A systematic review of relevant literature is adopted as a research design for this study. The corpus of literature identified and reviewed was selected based on a set of pre-determined keywords considered conforming to the concept. The findings deriving from the reviewed literature of servitisation shows that sustainability, financial interests (profit margins and stable income) and value propositions appear to be the major needs for transiting toward servitisation. Hence, this study proposes that construction business models find ways of adding value by adding services to the product to satisfy client's needs and create awareness on concerns associated with servitisation. Accordingly, further exploratory studies are called for in this aspect. Suffice to state that this study holds dire implications for all stakeholders in the contemporary construction industry vis-à-vis the quest for through-life functionality and utility of delivered assets.

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Exploring the Concept of Value for Money Assessment in Sierra Leone

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Abstract

Value for money (VFM) is one of the fundamental principles of public procurement which ensures that resources generated by the state are judiciously expended to cater for the needs of the taxpayers without trading the ultimate benefits due to them. VFM assessment enables public officials to compare the acquisition of different project delivery methods and appraises the ability of potential bidders to significantly contribute value to projects. Unfortunately, in Sierra Leone, the expectations of the citizens have not been met in this regard, therefore, the aim of the research is to evaluate the methods used in value for money assessment in Sierra Leone. The choice of the research was mixed methods, and data was concurrently collated using questionnaire and interview. The respondents were drawn from the twenty-five (25) ministries in the public sector of Sierra Leone. The response data were analysed using the mixed methods approach. In this study, the survey data were analysed using SPSS and the interviews transcribed into a word processor. Further, data was analysed and presented using one-sample t-test. The study revealed that the methods mostly used in VFM assessments are prior review, post review, contract monitoring, audit, national competitive bidding, international competitive bidding, restricted bidding, limited international bidding and request for quotations. The study recommended that authorities should institutionalise the VFM assessment concept and adopt its methods, provide VFM assessment training to enhance the capacity of practitioners to contribute VFM to public contracts and include VFM assessment concept in the procurement Act.

Keywords: public procurement, Sierra Leone, value for money

1. Introduction

Most governments across the world are faced with the responsibility of providing the much needed infrastructure and services to stimulate economic growth. Achieving this task has resulted in countries increasing their debt stock. In the case of Sierra Leone, fixing this infrastructure gap and financing basic government functions have contributed to its debt stock of US$1.53 billion (International Monetary Fund and the World Bank, 2017, Ameyaw et al., 2015). Despite the strides

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made by the governments to meet these basic needs, efforts have not been made to achieve VFM (Raudla et al., 2016; Audit Service Sierra Leone, 2015). The VFM concept is inclusive and considers the whole life costs, benefits, risks, quality and quantity to achieve the business needs of the end-user. Evaluating VFM is a key consideration in public procurement, and it can be determined through a comparative analysis of potential bids by the procuring entity. The purpose of VFM assessment is to assist organizations in decision making by establishing the best option (among others) which contributes VFM to the public contract. Value for money assessment combines both the financial and non-financial aspects of the delivery method and the potential bidders (Barutha, 2016; Takim et al., 2011; 2009). Notwithstanding, the concept focuses on creating the right balance between economy, efficiency and effectiveness, and not solely restricted to the initial procurement cost (Jackson, 2012; Ameyaw et al. 2015). In contrast, Joaquim (2010) posits that VFM assessment is prone to manipulation by government authorities; and also practitioners have criticised the process on issues such as: lack of non-financial aspect; and the correctness of the risk calculation, presumption and discount rate applied in financial calculations (Lam and Gale, 2015; Ismail et al., 2012; Takim et al., 2011; Raymond, 2008). Also, practitioners have note that the absence of sufficient information (financial and non-financial) could derail the process and deny organizations of policy advice and the guidance needed to improve on VFM (Demirag 2017; Raudla et al., 2016; Lam and Gale, 2015; Jackson, 2012).

Practically, few sectors namely health, water, tourism, development and public private partnership are representative sectors applying the VFM assessment concept. Nevertheless, this concept precisely has not been applied in Sierra Leone. Although entities' procurement activities are audited as highlighted in the Audited Report of Sierra Leone (2015), the assessment of VFM at the ministry, department and agency levels are yet to be robust (Audit Service Sierra Leone, 2015; Fleming 2013; Holtgrave et al. 2013; Emerson and Cabaj, 2000; Weinstein et al. 1996). In practice, authorities in the public sector tend to apply legislated procurement procedures that ignore non-financial aspect, whole life cost and risk calculation. Owing to the lack of research on methods employed in VFM assessment in the public procurement, this study is purely based on VFM methods applied in other sectors. As a result, this study serves as reference on the methods that should be used for VFM assessments in Sierra Leone. Hence, this research aims to evaluate the methods used in value for money assessment in the public sector of Sierra Leone. In particular, the study seeks to identify the methods used in conducting value for money assessment. The contribution of the study is to enrich the understanding of the understanding of the impacts of value for money assessment on procuring entities.

The paper is structured as follows. Section 2 provides a review of the literature. Section 3 explains the research methodology. Section 4 presents the results and discussions. Section 5 provides the conclusion.

2. Review of Literature

2.1 Value for money

According to (Baker et al. 2013), Value for money has been in use in industries and trade sectors for some time and it is recently that some governments through the public financial management reforms (orchestrated by development partners) have begun using VFM concepts in their decision-making processes. Value for money is the optimum combination of whole-life cost and quality to meet the customers' requirements (Office of the Auditor General of Canada 2000). The objective of value for money is to secure a judicious, economic and efficient use of state resources in public procurement (McKevitt and Davis, 2016; Ameyaw et al., 2015). Similarly, Value for money (VFM) means providing enhanced public services at a realistic cost to the electorate (McKevitt, 2015; Siemiatycki and Farooqi, 2012). Building on the works of other authors, and for the purpose of this study the researcher has defined VFM as: the optimum combination of the whole life cost, benefits, risks, quantity and quality of the goods, works and services provided embracing the facilities management and environmental impact factors to achieve the desired outcome (Baker et al., 2013; Ismail et al., 2012; Takim et al., 2011; Takim et al., 2009).

2.1.1 Value for money assessment

In the wake of the austerity, the public authorities across the globe are calling for value for money assessment to determine the implications of public investments on the ordinary taxpayer (Bidne et al., 2012). Value for money assessment is a good management tool used to inform government's decision on whether to implement proposed projects as Public Private Partnership, or through Traditional Procurement (Barker et al., 2014; Baker et al. 2013). The process gives organizations opportunity to compare the procurement of different project delivery methods and assess the ability of potential bidders to significantly contribute value for money to public contracts. This assessment process combines both the financial and non-financial aspects of the delivery method and the potential bidders (Barutha, 2016; Takim et al., 2011)

2.1.2 Methods used in value for money assessment

There are various methods identified in literature to have been used in VFM assessment. Though many of them are not clearly defined and applied, three of these methods have been elaborated in this paper. These include cost-utility analysis, cost efficiency analysis and social return on investment analysis.

2.1.2.1 Cost-utility analysis

Cost Utility Analysis (CUA) is a distinct economic method which seeks to assess two or more choices by comparing their utility against a number of deliverables (Fleming 2013; Coons and

Kaplan, 2005). The aim of the CUA is to compare the cost-effectiveness of an activity with others so that decisions on spending and resource allocation can be made (Fitzgerald et al. 2017; Richardson 1994). CUA is mostly used in the health sector; and its unit of measurement is the quality-adjusted life-years (QALY) which merges quantity and quality-of-life outcomes in the economic assessments (Landa et al. 2017; Fitzgerald et al. 2017; Fleming 2013; Coons and Kaplan, 2005). The QALY is computed by valuing the total life years gained from a procedure and weighting each year to reflect the quality of life in that year' (Fleming, 2013). The pursuit to improve the quality of analysis and enhance comparability led to an endorsement of CUA by the Panel on Cost-Effectiveness in Health and Medicine (Holtgrave et al. 2013; Coons and Kaplan, 2005; Weinstein et al. 1996). CUA is more far-reaching than Cost effectiveness analysis in that it takes into account beneficiary or society perspectives in measuring utility and other outcomes which might be difficult to monetise (Fleming 2013; Weinstein et al. 1996).

2.1.2.2 Cost-efficiency analysis

Cost-efficiency analysis is an economic technique which focuses on the relationship between the administrative costs and the outputs of the project (Hsieh et al. 2014; White et al. 2013; Ansah-Adu et al., 2011). Whilst the analysis tries to avoid measuring costs that are private or non-administrative, for public procurement it is viewed as the number of business needs delivered to the beneficiaries without unnecessarily increasing the financial burden of the procurer (White et al. 2013; Kelly 1995). However, these broader costs and benefits should be considered in interpreting the findings, since high administrative cost-efficiency may cover weaknesses in the procurement function that negatively affect overall performance. Improving the match between the resources and the business needs requires a positive management of the procurement aspects of any intervention (Kelly 1995).

2.1.2.3 Social return on investment analysis

King (2014) discoursed that Social return on investment (SROI) derived from the concept of "economic value"; and is viewed as an "approach towards identifying and appreciating value created" (Arvidson et al 2013). In contrast, Klemelä et al (2016) opined that SROI has been criticised for overstating the relationship between monetised benefits and costs. The aim of the SROI is to both prove and improve interventions by reviewing the inputs, outputs, outcomes and impacts created with the support of various stakeholders and attach monetary value on the social, economic and environmental benefits and costs attained by the entity (Klemelä et al 2016; King 2014; Arvidson et al 2013). Others authors have stated that SROI is a method that assents to assess socio-economic values by comparing the net benefit of a project to the resources required to generate those benefits over a given time frame (Fleming 2013; Emerson and Cabaj, 2000). The net benefits comprise two cash flows, namely: net income and total net savings to the community and the financiers (Emerson and Cabaj, 2000). In calculating the SROI, the assessor adds up all the benefits, subtracts any negatives and compares the results to the investment (Fleming 2013; Emerson and Cabaj, 2000). Critical to maintaining the integrity of the SROI analysis is the establishment of an accurate discount rate by both the financiers and the organization (Arvidson et al. 2013; Emerson and Cabaj, 2000).

2.2 Conceptual framework for value for money methods

The conceptual framework explains the distinctive characteristics of each of the methods used for value for money assessment at the various ministries. In this study, cost-efficiency analysis is limited in nature as it only compares costs (unit and administrative) against the value obtained. Conversely, both the cost-utility analysis and the social return on investment analysis are unique in nature as their analysis go beyond merely comparing costs to the value achieved to include the social, economic and environmental cost and benefits, and beneficiary perspectives.

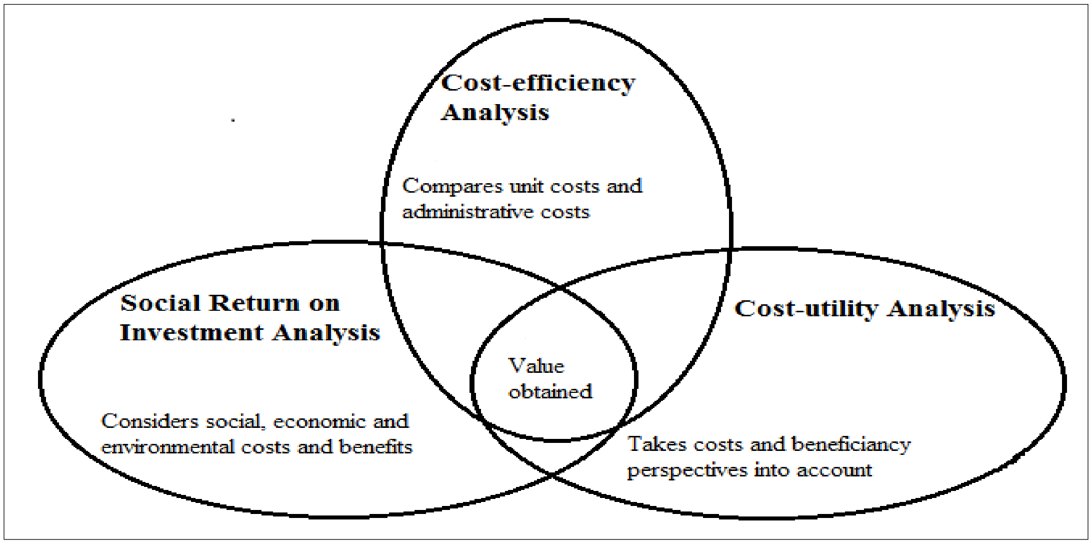

Figure 1: Conceptual framework

3. Research Methodology

The study used questionnaire and interview to concurrently collect data, and the analytical approach employed was mixed methods. Mixed methods comprise the gathering and analysing of both quantitative and qualitative data in a single research wherein data are concurrently collated embracing the fusion of data at various stages in the study process (Christensen et al., 2015; McClave et al., 2014). The snowball sampling technique was adopted to locate the experts for the interview; whereas, the sample size for these ministries was selected on census. Snowball sampling was useful since the experts were difficult to locate. A census is a type of survey which studies every unit in the population. The study was limited to the twenty-five (25) ministries sampled from the database received from the National Public Procurement Authority due to their volume of procurement. In this study, the survey data were analysed using SPSS and the interviews transcribed into a word processor. Further, the one-sample t-test was employed to analyse the data collected from the field.

The one-sample t-test analyses whether the mean score of a single variable differs from a specified constant value (Anderson et al., 2011). One sample t-test was carried out to identify the methods used in VFM assessment. The means were ranked to identify the methods used in VFM assessment. Variables with a mean score of 3.5 or greater were considered as the methods used in Sierra Leone. Colen (1992), set the significance level at 95% based on conventional risk levels (cited in Ahadzie et al., 2008). Prior to the t-test, a standard erro measure was performed. The standard error is a measure of how representative a sample is likely to be to the population, and it is the standard deviation of the sample means. A higher standard error indicates significant irregularity between the means of different samples; whilst a low standard error indicates that majority of the sample means are similar to the population mean.

4. Results

4.1 Results of survey

The survey results were analysed and discussed. The profile of the respondents was first analysed to confirm their suitability and by extension the validity of the data received from them.

4.1.1 Profile of decision makers

A total of 100 questionnaires were sent out to the 25 ministries. However, fifty (50) questionnaires representing 50% were retrieved. The sample size was determined using the list obtained from National Public Procurement Authority (NPPA). The high rate of response could be attributed to the persistent follow-up made by the researcher.

Table 1 indicated that amid the respondents covered in this study, eighteen (i.e. 36.0%) of the respondents were procurement officers; followed by Senior Procurement Officers with a representation of sixteen (i.e. 32.0%); three (i.e. 6.0%) of the respondents were Finance Directors; three (i.e. 6.0%) of the respondents were Accountants; two (i.e. 4.0%) served as Senior Accountants; two (i.e. 4.0%) of the respondents were Assistant Procurement Directors; two (i.e. 4.0%) held the position of Procurement Monitoring and Evaluation Officers; one (i.e. 2.0%) served as Senior Procurement Monitoring and Evaluation Officer; one (i.e. 2.0%) was an Assistant to the Senior Procurement Officer; and one (i.e. 2.0%) held the position of Assistant Finance Officer. The levels of authority represented in the study indicated that the respondents are in the position which it makes plausible for them to provide the needed information for the research; hence, the credibility of the data has been improved.

Table 1: Current position of respondents

Current Position	Frequency (N=50)	Percent (%)
Procurement Director	1	2.0
Finance Director	3	6.0
Assistant Procurement Director	2	4.0
Senior Procurement Officer	16	32.0
Senior Accountant	2	4.0
Procurement Officer	18	36.0
Accountant	3	6.0
Procurement Monitoring and Evaluation Officer	2	4.0
Senior Procurement Monitoring and Evaluation Officer	1	2.0
Assistant To Senior Procurement Officer	1	2.0
Assistant Finance Officer	1	2.0

Table 2 established that twenty-five (i.e. 50.0%) of the respondents had masters degree; eighteen (i.e. 36.0%) had first degree; four (i.e. 8.0%) of the participants recorded diploma; two (i.e. 4.0%) were Chartered Accountants; and one (i.e. 2.0%) had Higher National Diploma. These findings revealed that a greater number of the participants were qualified which gives them the comfort to provide the information required for the research.

Table 2: Educational level of the respondents

Educational Level	Frequency (N=50)	Percent (%)
Chartered Accountant	2	4.0
Masters Degree	25	50.0
First Degree	18	36.0
Diploma	4	8.0
Higher National Diploma	1	2.0

The study sought respondents' experiences on making procurement decisions in the various organizations surveyed for which findings are presented in Table 3. The table disclosed that twenty-seven (i.e. 54.0%) of the participants have had between 1 to 5 years buying decision-making experience. Twenty (i.e. 40.0%) had between 6 to 10 years' experience in procurement decision-making process. Out of 50 respondents, three (i.e. 6.0%) were between 11 to 15 years' experience. Experience brackets 16 to 20 years and above 20 years did not record any respondents. The result indicated that most of the practitioners who have been making procurement decisions fall between the experience brackets 1 to 5 years and 6 to 10 years; consequently, one would have no doubt in the credibility of the data collected.

Table 3: Respondents' decision-making experience

Procurement Decision-Making Experience	Frequency (N= 50)	Percent (%)
1 - 5 years	27	54.0
6 - 10 years	20	40.0
11 - 15 years	3	6.0
16 - 20 years	0	0
>20 years	0	0

4.1.2 Methods used in value for money assessment

Respondents surveyed were asked to indicate the methods used in conducting VFM assessments in the public sector of Sierra Leone and the findings are presented in Tables 4, 5, 6. Table 4 revealed that the standard error of all the means was comparatively close to zero, meaning the sample selected is a true representation of the population. Also, the standard deviation of all the means are above one (1.0) suggesting that the data deviates from the mean score and the disagreement among the respondents is high.

The t-test offers probable explanations for this situation. Table 5 displays a significance (i.e. p-value) which is two-tailed, indicating that the test has been plotted in two directions of the distribution. In order to test the likelihood of the association in one (1) direction, one-tailed test (i.e. $U > U_0$) was required. The main aim of this test is to examine whether the statistical significance of the rating is greater or less than 0.05.

Table 4: Results of t-test showing one-sample statistics

Variables	Mean	Std. Deviation	Std. Error Mean
Cost-Efficiency Analysis	3.40	1.143	.162
Cost-Utility Analysis	3.60	1.050	.148
Social Return On Investment Analysis	3.18	1.320	.187

Table 5: One-sample t-test results

Variables	Test Value = 3.5					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval the Difference	
					Lower	Upper
Cost-Efficiency Analysis	-.619	49	.539	-.100	-.42	.22
Cost-Utility Analysis	.674	49	.504	.100	-.20	.40
Social Return On Investment Analysis	-1.714	49	.093	-.320	-.70	.06

For this reason, Table 6 was created to help the researcher conclude on whether to reject or accept the null hypothesis (Anderson et al., 2011).

Table 6 shows that cost-utility analysis (CUA) which was ranked 1st emerged as non-significant with a p-value of 0.252>0.05. In effect, the findings indicated that the methods are entire new to practitioners, and have not been used in conducting value for money assessment in the public sector of Sierra Leone.

Table 6: Summary of t-test showing rankings

Variables	Mean	Std. Deviation	Ranking	Sig. (1-tailed)
Cost-Utility Analysis	3.60	1.050	1	.252
Cost-Efficiency Analysis	3.40	1.143	2	.270
Social Return On Investment Analysis	3.18	1.320	3	.047

4.2 Triangulation of data: Analysis of qualitative results

A second set of data was collected on similar issues discussed in the interview in order to confirm the results of the survey. These have been qualitatively analysed in the sections that follow.

4.2.1 Profile of respondents

This part of the study was conducted on eleven (11) procurement experts. The interviews involved 'informed persons' concerning their understanding of the value for money assessment concept; whereas, fifty (50) respondents participated in the survey. The purpose of the interview was meant to supplement the results of the survey. The content of the interviews was recorded and transcribed using word processor; while survey results were analysed using SPSS. The total response rate for this study was 61%. The high rate of response was credited to the persistent follow ups made by the researcher.

This interview focused only on procurement experts who make critical decisions on procurement in the public sector; whereas the survey covered all the procurement and finance practitioners in the ministries. Out of the 11 participants, one (1) held the position of Director, Procurement Monitoring and Evaluation, one (1) served as Director, Procurement Capacity Building, two (2) were Assistant Procurement Directors, one (1) was an Acting Procurement Director, One (1) Senior Procurement Specialist, three (3) procurement specialists and two (2) Procurement Officers; whereas, the current position of the respondents surveyed included procurement director, finance director, assistant procurement director, senior procurement officer, senior accountant, procurement officer, accountant, procurement monitoring and evaluation officer, senior procurement monitoring and evaluation officer, assistant to senior procurement officer, assistant finance officer. Both respondents represented a high level of authority, which makes it possible for them to freely provide the information required for the research; hence, the credibility of the data has been enhanced.

The data collected from the interviews revealed that ten (10) out of the eleven (11) participants had masters degree in various fields, and one (1) had first degree; whereas, the surveyed respondents' educational level included chartered accountant, masters degree, first degrees, diplomas and higher national diploma. The results revealed that the participants were highly educated and well informed to contribute to the research; therefore, the credibility of the data collected has been improved.

The result of the interviews revealed that one (1) participant had earned 23 years' experience (to his credit) in making buying decisions from both the private sector and the public sector. Another one (1) has been involved in making buying decisions for the past 20 years in both government and donor financed projects – serving in various sectors including the health and energy sectors. Three (3) had 15 years' experience. Another three (3) of the respondents had 10 years' experience in decision-making. One (1) had 14 years' experience. One (1) had 7 years' experience. One (1) recorded 6 years' experience. Whereas, the survey revealed twenty-seven (27) respondents had 1 to 5 years' experience, twenty (20) respondents had 6 to 10 years' experience and three (3) respondents had 11 to 15 years' experience. However, it should be noted that the experience brackets 16 to 20 years and above 20 years recorded zero (0). The result found that both respondents had wealth of experience in making procurement decisions which placed them in the position to contribute meaningfully to the study.

4.2.2 Methods used in value for money assessment

When experts were interviewed on the methods applied in conducting VFM assessment in their procuring entities, a different set of methods were mentioned. The interview results revealed that the experts did not use cost-utility analysis (CUA), cost-efficiency analysis (CEA) and social return on investment (SROI) analysis but rather they used contract monitoring, audit, prior review, post review, national competitive bidding, international competitive bidding, restricted bidding and request for quotations to conduct VFM assessments. Though the methods mentioned by the experts are not VFM methods but are rather processes which when effectively executed provide the information needed to support the VFM assessment process. The interview findings were supported by the results of the survey which indicated that CUA, CEA and SROI analysis are new to practitioners and have not been applied in conducting VFM assessments in the public sector of Sierra Leone.

5. Conclusion

Ideally, value for money assessment is conducted to ascertain whether the procurement decision has delivered best value. At the procurement level, the assessment of VFM should consider in more detail all the specific aspects and characteristics of the project (Ismail et al., 2012). VFM assessment starts at the pre-contract stage and is generated throughout to the post-contract stage. Thus, it is important that the VFM assessment process captures both financial and non-financial aspects. On this note, this research has revealed that the procurement officers and finance officers understood what VFM is all about. However, the evidence collected suggests that the concept of value for money assessment is new in the public sector's procurement environment, and not every procurement officer and finance officer can be assumed to be implementing it to the fullest. Currently, the methods used by practitioners are prior review, post review, audits, national competitive bidding, international competitive bidding, and restricted bidding.

Finally, these methods identified in literature (if adopted and applied) will ensure that the VFM contribution to public contract is enhanced, creating a stable financial base for governments to improve on the wellbeing of its citizens.

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A Conceptual Framework for Analysing Challenges to the Implementation of Environmental Management Plans in Construction Projects

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Abstract

Construction activities impact both positively and negatively all aspects of the environment namely biophysical, social and economic. The main goal of incorporating sustainability principles into the construction industry is to ensure that such impacts of development projects are dealt with accordingly in a well-balanced manner. Sustainability tools used for the environmental management of proposed development projects include Environmental management plans (EMPs). However, despite the existence of such tools, and specifically EMPs, the construction industry still struggles with managing the adverse impacts of its activities. This theoretical paper explores extant literature in order to propose a conceptual framework for understanding the attendant challenges in the implementation of EMPs on construction projects, using the South African context. The methodology used for this study was an integrative review of existing literature. Findings from the literature indicate that EMP implementation challenges emanate from problems associated with Environmental Impact Assessment (EIA) systems and environmental management systems in the construction industry. Furthermore, findings show that various construction project participants contribute to either the success or failure of EMP implementation. The proposed framework provides a background for understanding some of the major challenges encountered during the implementation of environmental management practices in construction projects, especially in developing countries. The proposed conceptual framework could be used to guide an empirical study.

Keywords: construction projects, EIA, environmental management plans, sustainability

1. Introduction

Construction activities are generally regarded as hazardous to the natural environment due to the production of undesirable impacts. Naturally, construction processes negatively impact the environment mainly due to pollution and consumption of natural resources (Irizarry et al., 2012;

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Yahaya and ZainulAbidin, 2013). Also, construction activities cause adverse social impacts such as displacement of residents and health risks due to pollution and socially disruptive effects of large active workforces in the communities (Celik and Budayan, 2016; Wang et al., 2016). Such undesirable impacts create negative perceptions from the general public (Tshiki, 2015).

Thus, construction companies are facing the challenge of ensuring efficient management of adverse environmental impacts of construction activities (Yahaya and ZainulAbidin, 2013). Proper environmental management practices can be achieved by ensuring that environmental impacts are kept within acceptable levels anticipated in the legal permits (Project Management Institute, 2003). Environmental management practices can be based on legislative requirements such as EIA or internal organizational policies such as formal environmental management systems such as ISO14001 (Bennett et al., 2016). On the other hand, an EMP aims to provide a continuous link or 'bridge' between the EIA process pre-consent and the EMS operated by project construction contractors in the post-consent stage of a project (IEMA, in Glasson et al., 2012).

However, failure to mitigate environmental impacts after the approval of projects has often been highlighted as one of the major shortcomings of the EIA process in many countries (Jha-Thakur and Fischer, 2016; Uttam et al., 2012). On the other hand, in developing countries, environmental consequences of construction activities are not comprehensively recorded due to lack of awareness, information and the required tools (Metin, 2016). Moreover, Osman et al., (2015) assert that environmental awareness among stakeholders is still considered to be low in developing countries despite the recent increase in attention given to environmental management practices. Also, project managers in the construction industry are blamed for focusing more on time, cost and quality while neglecting long-term adverse impacts of projects (Mishra et al., in (Wang et al., 2015). However, adverse environmental impacts from most construction activities result from actions by a project team from a construction firm; members of a project team include project owners, architects, engineers and contractors (Tyssen et al., in Yusof et al., 2016). Extant literature has however not addressed the causative factors from a holistic perspective, including all stakeholder perspectives in terms of regulation and implementation/compliance. In dealing with this gap Nyamazana and Ozumba (2017) explored the issue of challenges to implementing EMPs in construction projects, at a broader level, using the South African context. The deductions thus far highlighted the need for a conceptual framework to study "issues around EMP implementation" The current paper aims to propose a conceptual framework for identifying challenges affecting EMP implementation in construction projects in South Africa. It is designed as a further development from Nyamazana and Ozumba (2017). The current paper therefore suggests a framework for conceptualising the challenges of EMP implementation, in construction projects from both regulatory and compliance perspectives, with a focus on the South African context.

2. Background to the Study

Environmental impact assessment (EIA) has been identified as one of the tools which can play a role towards achieving sustainable development (Aucamp, 2009; Patel and Giordano, 2014). EIA can be described as a systematic process to identify, predict, evaluate and mitigate environmental (biophysical, socio-economic and cultural) impacts of a proposed activity and feasible alternatives (Aucamp, 2009; Glasson et al., 2012). The EIA process involves the drafting of an EMP which provides guidelines for mitigation and management of undesirable environmental impacts (Baby, 2011), essentially employed as a monitoring tool for managing identified impacts (Patel and Giordano, 2014). However, there are challenges facing the implementation of EIA systems around the world. A study by Jha-Thakur and Fischer (2016) revealed the lack understanding of EIA and its legal requirements among key stakeholders, after 25 years of EIA practice in the UK. The key stakeholders hold various perceptions on the effectiveness of EIA. There is also the tendency of resistance and disownment among responsible persons (Jha-Thakur and Fischer, 2016). In Asian countries, the implementation of EMP and social management, and monitoring plans has been identified as one of the challenges of EIA systems (Linter, 2016).

The challenge of low levels of environmental awareness among stakeholders has been highlighted as generally evident in African countries (Campion and Essel, 2013). In Tanzania, Low levels of awareness among project workers and lack of knowledge of environmental management plans amongst project managers are some of the challenges of EIA compliance (Nyihirani et al., 2014). In other related studies it has been argued that construction practitioners need to be aware of sustainable construction practices to significantly reduce the detrimental environmental impacts of construction activities (Abin in Irizarry et al., 2012). It has also been argued that construction companies can promote sustainable development by assuming their responsibility to minimise the negative impact of their activities on the environment and society, and maximise their economic contribution (Sustainable Construction Task Group, in Tan et al., 2011). Even so (Yahaya and ZainulAbidin (2013) essentially argue that commitment to implement environmental management rests on the levels of awareness, acceptance, and willingness to undertake such practices.

However there is limited focus on EMPs within academic literature, and the integration of EIA and EMS has received little attention in extant literature (Bennett et al., 2016). In addition their own study focused on stakeholder perceptions on EMPs in the UK, with more inclination to the regulatory perspective. It is arguable that the identified gap exists globally and locally in terms of the developing country context. As substantiated in Nyamzana and Ozumba (2017), there is a scarcity of studies looking at the issue of challenges from a holistic approach, especially in the local context.

2.1 The South African context

South Africa is a developing country with an established environmental assessment and management systems and is currently concentrating on the development of major infrastructure (Wood 2003, Presidential Infrastructure Coordinating Commission of South Africa in Wessels, 2015). However, like many developing countries of the world, South Africa is currently under pressure to address the much needed social and economic development while protecting the environment. One key impact is the gradual degradation in the quality and functioning of natural resources that sustain human activities (Department of Environmental Affairs (DEA), 2012a). This is arguably due to issues of non-compliance with environmental management regulations. Cases of non-compliance by elements within the South African construction industry were stated in the National Environmental Compliance and Enforcement Report (NECER) reports 2011-2015. Similarly, Chikezirim and Mwanaumo (2013) noted high production of construction waste and poor implementation of waste management plans adopted by contractors in Tshwane, South Africa. Another South African study by Windapo and Goulding (2015) identified a gap in compliance to green building or sustainable construction legislation, in the practices experienced during the construction project execution. Low levels of awareness of green building legislation and practices, and unfavourable attitudes among construction firms were highlighted (Windapo and Goulding, 2015).

Despite the preceding assertions, there is still a gap in knowledge with regards to a more comprehensive 'picture' of the challenges to the implementation of EMPs in construction projects. As deduced from Nyamazana and Ozumba (2017), there is a need for a framework to adequately conceptualise the said challenges from a research point of view. The sections hereunder present a research design, presentation and discussion of data analysis results, which lead to a proposed conceptual framework.

3. Methodology

An integrative literature review was done for this study. According to Saunders et al., (2016, p.74) an integrative review critiques and synthesises the representative literature on a topic in an integrative way to generate new frameworks and perspectives on a topic. A purposive sample of literature was used for this purpose. Sources include textbooks and electronic databases such as Science Direct, ASCE, Taylor and Francis, Sabinet, Emerald, and Scopus. Searches were also performed through Google Scholar. References to journal articles were also followed to widen the literature base for review. The major search keywords were: environmental management plans, environmental impact assessment environmental impacts, construction projects, and construction project management. Recent journal and conference publications were considered. In order to base the deductions on recent literature, it was decided to limit the review to articles published during the 2008-2018 period.

4. Findings and Discussion

From the review of extant literature, a thematic analysis led to the categorisation of information derived into a number of key themes. The themes are: Key role players in implementing EMPs in construction projects; and EMP implementation challenges in construction projects. The second theme is broken down into two sub-themes: EIA related challenges, and EMS related challenges. These findings are presented and discussed hereunder.

4.1 Key role players in implementing EMPs in construction projects

Various professionals from different professional backgrounds are involved in managing environmental management practices, including implementation of EMPs in construction projects (Yusof et al., 2016). Thus, in this paper, we argue that EMP implementation challenges should be viewed from perspectives of both compliance and enforcement or regulatory stakeholders. Development projects are monitored to check compliance or non-compliance with the required environmental regulations (Selvakumar, 2016), from an enforcement perspective. The South African Environmental Management Inspectorate (EMI) is a government enforcement body responsible for onsite industry inspections by the government (Wessels, 2013). The effective management of environmental impacts of a project is the responsibility of the client/ proponent. This task is usually outsourced to an environmental consultant mainly known as an environmental control officer (Patel and Giordano, 2014). Contractor organizations are regarded as the main actors who determine environmental management practices in construction projects (Griffith and Bhutto, 2008). Contractors' project managers oversee daily procedures and control the environmental impacts of project activities (Zutshi and Creed, 2015). Similarly, Yahaya and ZainulAbidin (2013) recognise the site manager as the contractor organization representative who plays a significant role of ensuring that the company's participation in the implementation of environmental management practices to achieve project environmental management goals. Similarly, Osman et al., (2015) assert that the project team and project manager play an important role in the implementation of environmental management practices in the construction industry Osman et al., (2015).

On the other hand, it has been argued that project managers and other participants do not have enough knowledge of the environmental impacts of construction (Irizarry et al., 2012). Furthermore, project managers tend to ignore issues such as environmental and cultural degradation caused by construction works (Irizarry et al., 2012). Similarly, Toor and Ofori (2008) challenge the traditional mindset of construction project management which intimately focuses on budget, schedule, and quality.

Organizations can benefit in various ways by making connections between EIA and EMS in development projects (Palframan, 2010). "While the goal of EIA is to anticipate and mitigate the environmental impacts of proposed new projects at the planning and design stages, an EMS can help organizations to manage the day-to-day environmental impacts arising during the construction effectively," (Palframan, 2010). Hence it can be argued that EMP implementation challenges can be traced from the EIA process up to environmental management systems in construction projects.

4.2 EMP implementation challenges in construction projects

Environmental management plans have several weaknesses according to perceptions for stakeholders (Bennett et al., 2016), these include Lack of monitoring during project implementation; Rigidity of EMPs; The generic nature or of EMPs; the Poor flow of information in projects; Poor management of environmental management knowledge in projects. Some of the reasons why EMPs are not properly implemented in most African countries, allocation of funds by proponents/developers, lack of government enforcement staff, lack of quality and reliable data, lack of government commitment to carry out monitoring and auditing activities due to competing for priorities (Kakonge, 2013). In addition, there is lack of monitoring and auditing reduces chances of getting feedback on the effectiveness of mitigation measures described in EMPs (Kosamu, 2011).

4.2.2 EIA related challenges

However, there are various challenges in EIA systems that can influence EMP implementation in construction projects. The main sources of EIA challenges are weaknesses of and threats to EIA systems (Jha-Thakur and Fischer, 2016). The supreme threats to EIA success in Africa include lack of strong institutions with adequate human resource capacity; rapid population growth; lack of direct investment in project communities; illiteracy and corruption (Campion and Essel, 2013). Furthermore, EIA in Africa is affected by lack of trained personnel, cost, and the belief that EIA might hinder development and lack of political will (Appiah-Opoku, Kakonge, in Glasson et al., 2012, p. 274); (Moja and Mnguni, 2014). A gap between EIA policy and its implementation was identified using the case of the construction of low-cost houses in Newcastle, South Africa (Moja and Mnguni, 2014).

Other challenges within the EIA system of South Africa include neglecting of socio-economic impacts in the EIA process; poor quality of EIA reports; lack of capacity to enforce compliance due to a shortage of staff at the regulatory departments. More so, there is lack of objectivity of environmental assessment practitioners (EAPs) and lack EAP independence; Also conflict between EIA and socio-economic development; lack of political will as politicians view EIA as a setback for development. Similarly, poor public participation also negatively affect the EIA process (Bowd et al., 2015; Campion and Essel, 2013; Moja and Mnguni, 2014; Sandham et al., 2013).

4.2.3 EMS related challenges

The challenges associated with EMS implementation in construction firms were identified by various authors (Dominguez et al., 2016; Owolana and Booth, 2016; Schmidt and Osebold, 2017; Zutshi and Creed, 2015). These include lack of knowledge about ISO 14001 in the construction industry; Lack of project specific training programs on environmental management; Resistance of senior management and other employees to change their habits and old ways of doing work. There is also low environmental awareness in the construction industry; Lack of trained and experienced staff; Lack of engagement and commitment to management; Disturbance of workflow. Furthermore, there is lack of client support; Lack of government enforcement and incentives; Lack of resources such as time and cost for the implementation of adequate environmental protection; Lack of cooperation of subcontractors due to lack of experience and familiarity. In addition to EMS standards not tailor-made for the construction industry, there is also lack of required technologies within organizations and monitoring of environmental performance.

Followingthe review of extant literature as presented in the preceding sections, it is arguable that the key issues emante from, and therefore should be viewed from both the regulation andncompliance perspectives. It is important to factor in the key role players, the issues related to EIA as a system, and the environmental management systyems. Their interplay and the dynamics of their relationships is required for a more comprehensive view of challenges to EMP in construction projects. The framework for conceptualising the said challenges, following the findings in the current study, is presented below.

5. Introduction of the Conceptual Framework

The proposed conceptual framework for understanding challenges hindering proper implementation of EMPs in construction projects is based on findings from review of extant literature. The study identified three main sources of challenges which are: the perceptions of key role players of construction EMPs, EIA system challenges, and EMS implementation challenges. Hence, the conceptual framework below shows three major sources of challenges as the constructs.

The independent variables are perceptions of contractors' representatives, clients' representatives, government environmental inspectors; weaknesses of EIA systems; threats to EIA systems; barriers to EMP implementation. The poor implementation of EMPs is the dependent variable. Thus the independent variables mainly influence poor implementation of EMPs in construction projects. The main key role players identified are contractors' representatives, clients' representatives, and government environmental inspectors. Challenges related to EIA are mainly weaknesses and threats to EIA systems. Similarly, EMS-related challenges are related to the barriers to EMS implementation in the construction industry. The proposed framework emphasises the need for a holistic approach to addressing the challenges to EMP implementation in construction projects.

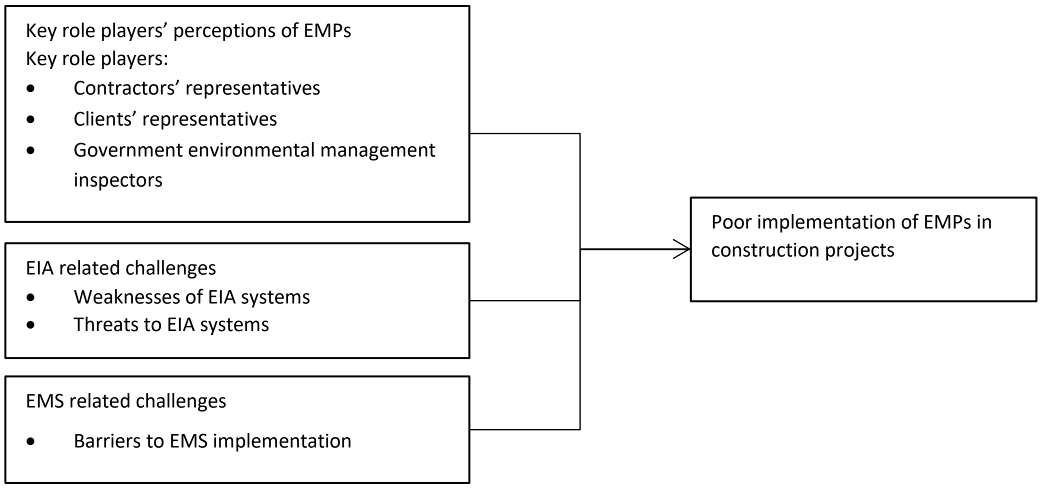

Figure 1: Conceptual framework for investigating EMP implementation challenges

6. Summary

This theoretical paper introduced a conceptual framework for identifying challenges to the implementation of EMPs in construction projects. The study has argues for a holistic approach to identifying and addressing challenges to the implementation of EMP in construction projects. Specifically it is proposed, that EMP implementation in construction projects should be explored from both regulatory and compliance perspectives. The deductions thus far and the future development of the study will be relevant to stakeholders involved in both ensuring and enforcing the implementation of EMPs in construction projects. However, considering the theoretical nature of the current study, it necessary to test the proposed conceptual framework and improve it in future studies.

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The Green Building Movement in Zambia

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Abstract

There is a worldwide movement towards sustainable development in all aspects of human development. This movement is also seen in the building industry. The players in this industry have realised the impact that buildings have had on the environment and how positive construction activities can reduce the negative impact of buildings. Building rating tools are a measure of how buildings are responding to reducing the negative impact on the environment. Zambia has not developed its own rating tools but the use of other rating tools has been going on for the last 10 years as can be seen by the number of rated buildings. This paper investigated the usage level of green building tools by Zambian architects and what has been the motivation behind the use of these tools. It also looks at the barriers in developing or using the existing rating tools in Zambia.

Keywords: green building technology, green building rating tools, sustainable construction

1. Introduction

In building construction it is no longer business as usual as the impact of buildings is being felt in every sector of the economy. Buildings are responsible for 30 percent of all greenhouse gas emissions, 65 percent of waste output, 70 percent of electrical consumption and 12 percent of water consumption and 65 percent of waste output (Lucon et al. 2014). Buildings which are not built in a sustainable way can affect the health, safety, comfort and productivity of the occupants (Isa et al., 2014). According to Environmental Protection (EPA) (Agency United Nations 2009) in the US, sustainable building construction is the "practice of creating structures and using processes that are environmentally responsive and resource-efficient throughout a building life-cycle from siting to design, construction, operation, maintenance, renovation, and deconstruction."
Green building rating tools are the measure as to how responsive buildings are to reducing their impact on the environment. Haapio and Viitaniemi (2008) state that green building rating tools are a yardstick for measuring environmental performance of buildings. Africa has not been left behind in this movement and the growth of sustainable buildings has increased in the last 10 years (Gibberd, 2002). In South Africa alone the movement has moved from being unknown to being the most publicized industry (Windapo, 2014). Sustainable buildings and green buildings will be used interchangeably in this paper.

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2. Background

An increase in the awareness of energy inefficiency and global climate change has significantly impacted the building sector since the oil embargo of 1973. More people are aware of the notion of going green as they incur huge energy bills and high building operational cost (Isa et al., 2014). Delivering sustainable construction requires action from all engaged in constructing and maintaining the structure including those providing design, consulting and construction services (WS Atkins Consultants, 2001).

There are many rating tools used all around the world, these include the American Leadership in Energy and Environmental Design Leaders (LEED) and the British BREEAM system. Others are Deutsche Gesellschaft für Nachhaltiges Bauen (DGNB), the Japanese Comprehensive Assessment System for Built Environment Efficiency (CASBEE) and the Green star of Australia and South Africa. According to Fenner and Ryce (2008) rating tool are divided into three main categories; Knowledge-based tools, Performance-based tools and Building rating tools. The knowledge based tools are meant to be guide for planning sustainable buildings and the performance –based tools are used as life cycle impact assessment and simulation tools to calculate aspects such as energy consumption, lighting and indoor air quality. While the building rating tools are for certifying buildings and to assist designers in identifying design criteria and documenting proposed design performance.

In Africa the trend has been the use of building rating tools that are developed from other countries. For example South Africa and Kenya has adopted the Green Star from Australia even though South Africa has developed its own sustainability tool, South Africa Building Technology (SBAT). Sharifi and Murayama (2013) have argued on the importance on having assessment tools that are regionally specific or that take into consideration adaptation to locality.

In Zambia, a lot of professionals in the building industry are taking on a leading role in promoting sustainable buildings. There are many drivers to the growth of sustainable buildings that have been identified in literature. (Darko and Chan, 2017; Windapo, 2014; Allouhi et al., 2015) identified rising energy costs, the industry's Green Star rating system, competitive advantages, legislation, the existence of green rating tools and government intervention and regulations that mandate building energy-efficient buildings.

Literature on barriers include (Häkkinen and Belloni,2006; Alsanad, 2015, Darko and Chan, 2017; Samari et al. 2013; Dahiru et al., 2014). In these studies some of the barriers stated were lack of awareness of green building practices that needed to be taking place in the industry, no enabling environment and economic constraints. According to Samari el al., (2013) several barriers were identified some of which were: lack of building codes and regulation, lack of incentives, higher investment cost, risk of investment, higher final price, lack of credit resources to cover up front cost, lack of public awareness, lack of demand and lack of strategy to promote sustainable buildings. When the studies were compared it seemed that government intervention influenced the development of green buildings.

The aim of this paper was to investigate whether architects are utilizing green building rating tools and if there are any drivers and barriers to the development of green building rating tools in the Zambian building industry. An online survey was conducted where a questionnaire was sent to all the architects on the Zambia Institute architects mailing list and thirty questionnaires were fully answered.

3. Research Methodology

This was descriptive cross sectional study using a mixed method design but it leaned more to the qualitative method design. The research type was adopted from three similar studies by Ali (2012), Windapo (2014) and Azouz and Kim (2015). A questionnaire was emailed to the participants with open and closed ended questions. The first section was for demographic data, the second section had questions dealing with knowledge of green building rating tools and the third section had open ended questions were the participants were explaining their experience with green building rating tools and rated projects. The qualitative section investigated the drivers and barriers. The total number of questionnaires sent out was 209 and of these 31 architects answered the questionnaire. This sample size was not representative of the architect's population, however since this was a mixed method study the information was detailed enough to represent the general population.

4. Data Analysis

The architects working experience table shows that the highest number of architects (n=17, 55%) had more than 20 years working experience followed by those between 10 -14 years (n=6, 19%).

Table 1: Working experience

		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	1-4	1	3.2	3.2	3.2
	5-9	3	9.7	9.7	12.9
	10-14	6	19.4	19.4	32.3
	15-19	4	12.9	12.9	45.2
	20+	17	54.8	54.8	100.0
	Total	31	100.0	100.0	

The study compared the working experience and the utilization of green building tools as shown in table 2. The results were significant looking at the p value of 0.014 which was lower than the Pearson Chi-Square at 0.05 degree of confidence. This shows that those who had more years of experience were more likely to be exposed to green building rating tools. These results show that information on green building rating tools is available with some of the experienced architects. According to (Alsanad, 2015, 2015; Samari et al. 2013) the lack of expertise's knowledge in green building development creates an environment that lengthens development time frame. The comparison between working experience and opportunity to train on green building rating tools was not significant with a P-Value of 0.484. This shows that even those who have not worked long in the industry had equal opportunity to train.

Table 2: The relationship between experience and utilization of green building tools

	Chi Square	**P Value**
Working experiences(3) to knowledge(8)	12.487	0.014
Working experience(3) to training received(11)	7.495	0.484
Building assessment tools (13) to possibility of Zambia to develop(24)	0.653	0.419
Building assessment tools (13) to Zambian expertise (28)	0.247	0.884

The comparison of the non-availability of green building rating tools in the market and the possibility for Zambia to develop one was insignificant with a p value of 0.419. It shows that whether the tools are available or not that would not determine whether a local tool can or cannot be developed. The comparison of the building assessment tools and the availability of the experts in Zambia was also insignificant a P-Value of 0.884. This may mean that the number of experts does not determine whether the tools are used or not. The factors affecting the use of the tools could be market or economic reason.

When the architects were asked if they were familiar with sustainability building principles, table 4 shows that (n=28, 90%) were familiar and (n= 3, 10%) were not familiar with these principles. The number of those who were familiar was high. However the ones who were familiar were quick to mention that they had not fully utilized sustainability principles in their designs due to the lack of interest by the developers. According to (Choi 2009; Dadzie 2014) the lack of expertise's knowledge in green building development creates an environment that lengthens development time frames and expert's knowledge is a key factor to promote sustainable buildings.

Table 3: Familiar with sustainable building principles

		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Very familiar	28	90.3	90.3	90.3
	Not familiar	3	9.7	9.7	100.0
	Total	31	100.0	100.0	

In this study it was clear that even though the number of participants that were familiar with sustainable building construction was high only (n=3, 13%) had actually worked on a building projects where sustainability principles were used.

Table 4: Awareness of green building rating tools

		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	yes	19	61.3	61.3	61.3
	no	12	38.7	38.7	100.0
	Total	31	100.0	100.0	

In table 5 it was seen that there were (no=19, 61%) participants that were aware of the different rating tools and (no=12, 39%) participants were not aware. In comparison with the number that were familiar with sustainability there were fewer that were aware of green building rating tools. When the participants were asked whether they had used the tools only (no= 12, 39%) of them had used these tools shown in table 6. The study showed that awareness did not mean knowledge to use the tools.

Table 5: Experience in green building rating tools

		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	yes	12	38.7	38.7	38.7
	no	19	61.3	61.3	100.0
	Total	31	100.0	100.0	

The factors that influenced the utilization of the tools was further discussed with the participants and the figure 1 below summarises these factors.

The highest number of the participants (n=8) mentioned that the rating tools were too expensive for developers to use. The second most popular reason was that most architects have not received training on the tools and could not be able to give sufficient information to the assessors. The number of participants who felt that the lack of the availability of these rating tools on the market had affected utilization was the same as those who thought that the long process of certification was the reason. Only two people felt that the lack of regulatory agencies and accredited lab facilities were the reason for the low utilization. Others mentioned low awareness and interest by clients in using rating tools.

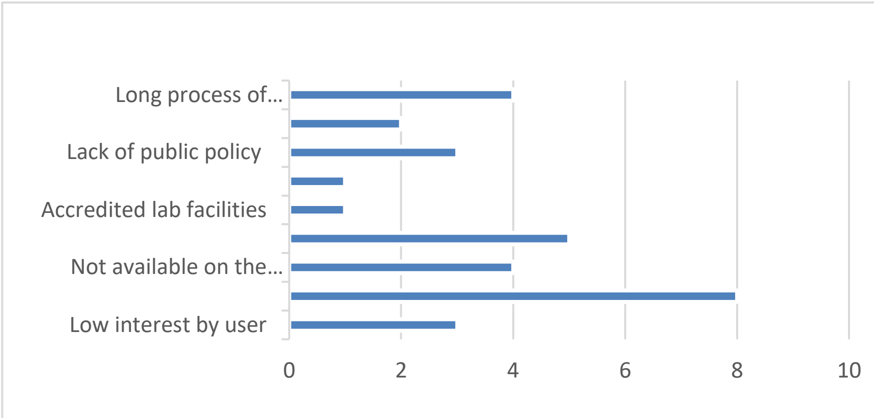

Figure 2: Reasons for the low utilization of rating tools

The lack of skills to rate buildings was a factor in poor utilization of tools as the study found very few architects who were certified assessors. Other architects mentioned that the lack of government regulations on sustainable building design laws and regulations had placed no obligation on professionals and developers to rate their buildings. Others mentioned that the lack of availability of rating tools locally has discouraged the rating of buildings. The long process of carrying out the evaluation of the buildings in preparation for rating was hindering their use.

Similar studies showed that the lack of buildings codes, regulations, awareness and knowledge were factors that could hinder the use of green buildings tools (Samari et al. 2013; Abidin and Powmya, 2014). In this study the above factors were not considered the biggest hindrance but market based factors were. However it was noted that the lack of regulations placed no obligation on the architects to build in a sustainable way and the factors that cause them to do so are market based. According to Dahiru etal., (2014) when professionals were interviewed as to what they considered a hindrance to green buildings development the main factor was lack of awareness by both the developers and professionals. In this study the majority were aware of what the rating tools were all about but had no opportunity to use them.

According to Samari et al. (2013) many experts believe that the role of governments in promoting green building is undeniable and effective. In the Ghanaian case according to Dadzie (2014) lack of demand for sustainable buildings, lack of strategy to promote sustainable construction, higher initial cost, lack of public awareness and lack of government support were the barriers. According to Alsanad (2015) the main barrier was lack of awareness on the benefits for the use of sustainable construction. When all the studies were compared it was seen that government regulations and awareness were factors that influenced the use of rating tools.

Table 6: Suitability of the existing rating tools for Zambia

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very suitable	10	32.3	32.3	32.3
	Not suitable	21	67.7	67.7	100.0
	Total	31	100.0	100.0	

Table 6 shows that (no=10, 32%) thought the current tools are suitable for Zambia while (no=21,68%) thought the tools would not be suitable. The reasons given for the unsuitability of the rating tools was that these tools had criteria that was not of priority to the Zambian market. They went further to mention that what would be of primary importance would be Cost-effective, Thorough guidelines for implementation, Quality assurance criteria, Energy rating and Sustainability plan. Social and economic factors were also mentioned. Others mentioned criteria that is already in existence in most of the existing rating tools.

5. Conclusion and Limitations

The study suggests that the challenge of low utilization of rating tools was not because the architects are not aware of their importance but that access to them was limited. Few had been trained or has been involved in the assessment of sustainable buildings. There is very little pressure to use the tools by developers due to the perceived cost of rating the buildings. Technical expertise is required by all architects if they are to be advocates for the use of these tools. Some of the challenges mentioned in this study were expenses to use the existing rating tools. This can be overcome by adopting a local tool that can be accessible to all architects. Cost has been a major factor for the use of rating tools and cheaper and more accessible tools is required on the market. Awareness of the benefits of these tools to the public is required as they are the beneficiaries of sustainable buildings. The government needs to step in to give policy guideline for the direction of sustainable building construction so that all the players know their obligations and responsibilities to create a more sustainable built environment. The development of the Sustainability Housing Guidelines by the Ministry of Local Government is a step in the right direction for the promotion of sustainable construction. However after the creation of these guidelines further development of the actual rating tools has to follow.

The limitation of this study was the low response to the questionnaire by the architects. However this was overcome by using both a qualitative and quantitative research method so that as much information could be gotten and analysed. This study was a snapshot of what is happening in the building industry and so further studies need to be carried out to capture all the players in the construction industry, together with government.

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Sustainability in Infrastructure Development: Overcoming the Challenges Pertaining to the Supply of Electricity in Nigeria

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Abstract

Electricity supply is an essential part of the infrastructure in any society. This study assessed the challenges encountered in the provision of electricity in Nigeria. A review of literature was conducted from various sources including journal articles, e-books, national and international organizations' reports and online news articles. Findings revealed that pricing, billing, revenue collection, generation constraints of gas and water supply as well as the cost of the infrastructure itself are prominent challenges faced in electricity provision in Nigeria. Further findings showed that upgrading the infrastructure to improve quality, smart-metered revenue collection, as well as decentralised remote locations by investing in green solutions could help to solve the identified challenges. These findings could assist in the development of strategies to ensure delivery of reliable, efficient and sustainable energy infrastructure in the country.

Keywords: electricity supply, infrastructure, Nigeria, sustainability

1. Introduction

For the context of this paper, electricity includes all sources of energy that can be channelled to power a device through the movement of charges. Electricity supply is an essential part of the infrastructure in any society. With constant power supply, the economy of a county would blossom. One of the United Nation's Sustainable Development Goals (SDGs) is to ensure access to affordable, reliable, sustainable and modern energy for all (Wu and Wu, 2014). These different dimensions are not mutually exclusive, but overlap (Loewe and Rippin, 2015). Affordable source of electricity will be entirely useless if it were not reliable and with the globalization and evolution of our societies, it has to be sustainable and reliable (Wu and Wu, 2014).

Meeting the above-stated criteria is a huge challenge for many countries around the world, especially with global urbanization and population growth. It is estimated that circa 600 million Africans do not have electricity supply; the demand grows at 6% per annum and will likely exceed GDP growth in many economies until 2040 (Traoré et al., 2017). Further, $300 billion will be needed for all of sub-Saharan Africa to have access to electricity in the next 15 years (Findt, 2015). Continued development in Africa is only possible when the continent is blessed with power

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resources and the infrastructure (Findt, ibid.). As global populations continue to rise, so will the demand for affordable energy and the need to meet this demand and ensure continued development is present (United Nations Development Programme (UNDP), 2018). Thus, the SDG Goal 7 is a concern for every country, but even more for the developing countries than the developed ones such as Nigeria.

Investing in infrastructure for electricity has several advantages including increasing job opportunities and productivity, as more time for work is created and micro-entrepreneurships are enabled (Traoré et al., 2017). This in turn increases the GDP of an economy as a whole. Thus the objective of this paper is to identify the challenges to constant electricity supply in Nigeria and their possible solutions. The paper examines the importance of electricity supply within the tenets of the definition by the United Nations which ensures that not only would electricity supply be reliable; it must be modern, affordable and its source, sustainable.

For the purposes of this paper, a review of literature on Nigeria's electricity supply as well as strategies to improve the status quo was undertaken. Various sources including journal articles, e-books, national and international organizations' reports and online news articles were consulted. The next sections present the status quo regarding electrification in Nigeria and suggestions to improve the situation. The paper thereafter concludes with recommendations.

2. Background of Electricity Provision in Nigeria

In Nigeria, power is usually represented by electricity, produced by the generation companies transmitted and distributed through a central grid (the Mains). Nigeria has an installed capacity of 12,522MW but due to several constraints, has an operational capacity of 3,879MW (Federal Republic of Nigeria, 2015).

Up until 2014, the generation and distribution of electricity was handled by the federal government. However, due to the inefficiencies in the supply of power and the high cost of maintenance, the federal government divested 100% its interest in six generating companies, and 60% of its interest in the distributing companies, while retaining control of the transmission to final consumer through the Transmission Company of Nigeria (Nigerian Electricity Regulatory Commission (NERC), 2018, online). The National Electic Power Authority (NEPA) was then unbundled and renamed Power Holding Company of Nigeria (PHCN). It was expected that the privatisation would assist in curbing and eventually eliminating the problems encountered in energy production and supply. The six generation companies and their respective privatisation levels under the PHCN are presented in Table 2.

Table 2: Generation companies in Nigeria under the PHCN

GenCo	Installed Capacity (MW)	Type	Privatisation Status
Afam Power Plc	776MW	Gas	100% Sold
Sapele Power Plc	414MW	Gas	51% Sold
Egbin Power Plc	1,020MW	Gas	100% Sold
Ughelli Power Plc	900MW	Gas	100% Sold
Kainji Power Plant	760MW	Hydro	Long Term Concession
Jebba Power Plant	578MW	Hydro	Long Term Concession
Shiroro Power Plc	600MW	Hydro	Long Term Concession

Source: NERC (2018, online)

The issues of electricity generation and supply prior to the privatisation exercise are still in existence. The provision of constant power supply is still a challenge. Considering both urban and rural areas, a total of 52% of the population have access to electricity as at 2010 estimates (International Atomic Energy Agency (IAEA), 2016). When considering the electricity deficits in different parts of the continent, Nigeria is ranked as the country with the largest electrification deficit among five African countries studied (ISI Consultants, 2015) (Table 1). The issues contributing to this status quo circle around a lack of infrastructure, insufficient meters, inadequate grid transmission network, poor maintenance of assets, the challenges of revenue collection and revenue loss, dodgy power grids, with frequent outages and brownouts in its urban areas, coupled with underinvestment in capacity increases, poor regulatory environment and corruption issues (ISI Consultants, 2015).

Table 1: Selected African countries with huge electricity provision deficits

Country	Deficit (number of people)	Rank
Nigeria	90 million	1st
Ethiopia	70 million	2nd
Democratic Republic of Congo	60 million	3rd
Tanzania	36 million	4th
Kenya	35 million	5th

Source: ISI Consultants (2015)

Daily losses of revenue due to different constraints in the power system amount to billions of Naira (millions of USD). For instance, on the 27 of March, 2018, the total revenue lost was NGN 1,084,000,000 ($3,013,520) stemming from losses in gas supply and distribution feeders (Nesistats, 2018). Such losses represent inefficiencies in the system which need to be resolved to improve the supply of electricity.

With the increased inconsistent power supply from the National Grid (even post privatisation), many firms and individuals have resorted to the independent provision of independent power through diesel or petrol powered generators and solar panels. It is now the norm for street nights to be powered by generators and for new real estate developments to provide for generator(s) to power their buildings. Apart from the cost of acquisition and maintenance of these generators, there is the added concern of the effect of pollution on the environment. These generators clearly do not meet the requirements of affordability and sustainability.

3. Challenges of Electricity Supply

3.1 Infrastructure issue

Infrastructure referred to here cuts across the generation, transmission and distribution sectors of electricity supply. The sector is riddled with poorly maintained, inadequate and obsolete infrastructure (ISI Consultants, 2015). Over the years, after the initial infrastructure was installed, no real investment by the government into the sector through the purchase of more modern equipment. This implies that with the increase in the country's population through the years, the installed infrastructure and equipment became inadequate for the sheer number of people, without taking into consideration the effect of poor maintenance of the existing facilities or its obsolescence. According to the 2016 International Atomic Energy Agency Report on Sustainable electricity supply scenarios for West Africa/which focused on the electricity supply in West Africa, the cost of electricity is one of the highest in the world, as supply of electricity is from centrally operated facilities which are over twenty years old in age with very low efficiencies. The installed transmission capacity can only wheel 50% - 60% of installed power capacity (United Capital, 2017).

Achieving sustainable supply of electricity from the existing infrastructure may not be possible as only circa 25% of the generated electricity reaches the final consumer (Federal Republic of Nigeria, 2015), amounting to the loss of millions of Naira (thousands of USD) on a daily basis as shown by the chart below. Substantial losses across the value chain, from generation through transmission to distribution can be attributed to technology limitations and outdated infrastructure (PWC, 2016).

3.2 Non-cost reflective pricing

The provision of electricity like other services must be properly priced to ensure that the service supply will be constant. Prior to the privatisation of the sector, the tariff charged customers covered only about 30% of the historical cost (PWC, 2014). It is no wonder that the sector was moribund and had to be privatised.

Regardless of privatisation exercise, the Nigerian Electricity Regulatory Commission is mandated to ensure that the prices charged to customers are fair, while allowing the different operators to finance their services and make some profit. Due to the stipulations of the NERC, the current cost of electricity to the consumer is within the range of NGN 26 - 38/kWh (FRN, 2015). The exact price each customer pays varies in accordance to the person's location, tariff class, tariff rate and quantity of energy consumed. The distribution companies have complained that the current pricing is not a true reflection of the cost of supply to the customers. The issue of appropriate pricing is a major source of contention between the power companies (those that acquired the generation and distribution companies from the government), the regulatory body of Nigeria Electric Regulatory Commission and the paying public. The distribution companies are unable to collect sufficient revenue to cover their costs which in turn leads to a shortfall of revenue for the Transmission Company of Nigeria, and generation companies and gas producers (FRN, 2015). This implies that the power companies (both generation and distribution companies) will operate at negative cashflows annually, and the cycle of inadequate electricity supply continues.

Generation constraints of Gas and water supply: The generating plants are either hydro or gas powered. There are huge challenges regarding the supply of gas despite the fact that Nigeria has the ninth largest gas deposits in the world (Duddu, 2013). The extraction and transportation of the gas is the main challenge as the existing gas gathering systems / pipes are inadequate and obsolete. Inadequate security across the existing pipelines exposes them to vandalization, which is also a huge problem. Militant groups recognise the impact of disruptions on the economy – as evident through rampant violence targeted at oil and gas pipelines in the north and south of Nigeria, which in turn impacts power generation (PWC, 2015).

The challenge of water on the other hand, is mainly seasonal. Nigeria experiences two seasons in a year- the rainy season and the dry season. Water constraint is usually an issue during the dry season, as against the rainy season. Revenue is lost due to insufficient gas and water during electricity generation (Figure 1) (Nesistats, 2018).

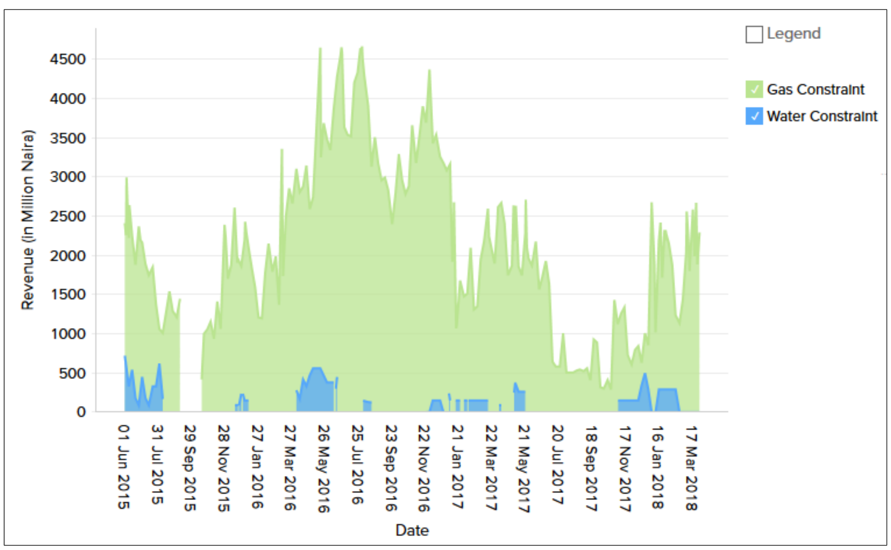

Figure 2: Revenue loss due to insufficient gas and water during electricity generation (Source: Nesistats, 2018)

3.3 Metering, billing and revenue collection

The metering system in Nigeria is two-fold: through analog or digital meters According to NERC, only circa 55% of the end users of electricity have meters. As a result of this the remaining 45% are subject to estimated billing system using the formula prescribed by NERC.

With the privatisation of the electricity sector came the introduction of the pre-paid metering system which should make billing and revenue collection easier since the users get value for the exact quantum of electricity purchased in advance. The challenge with the implementation of the pre-paid system stems from the cost of the meters and their availability. Until very recently, the NERC directed that electricity distribution companies were to bear the cost of the new meters and not the final user. This immediately created a scarcity of the pre-paid meters as the distribution companies could not afford to bear the acquisition costs of the meters. Hence, many customers were billed using the estimated billing system recommended by NERC. Despite the fact that the estimated bills are generated in accordance with the recommendations of NERC, many post-paid customers are reluctant to pay their bills as there is a general distrust of the cost stated. Consumers who claim they are overcharged due to estimation of bills would often want to pay back by passing or not paying bills (Utazi and Obuka, 2014).

Other associated problems with metering and revenue collection is the recurrent problem of energy theft on the part of the consumer who by-passes any form of accountability for the energy consumed and the electricity official who turns a blind eye to these occurrences as he has received some form of gift from the defaulter.

3.4 Cost of alternative solutions

An alternative to the reliance of electricity supply from the mains exists in the forms of individual generators mentioned above or greener technology which includes solar, wind or hydro energy for the generation of electricity. In Nigeria, the common alternative is the individual generating sets which serve as a backup solution for power outages from the Mains. The cost of electricity through these generating sets is about 62-94/kWh which is circa 138% higher than the cost of electricity from the grid (FRN, 2015). Apart from the financial costs, the generators serve as sources of pollution – noise, air and sometimes land and water – at a high cost to the environment and the planet at large.

Greener solutions are such as solar energy which is quite popular in the country, is expensive and not available to the average citizen. Other green solutions of hydro and wind power are largely unexplored and unpopular.

4. The Path to Sustainable Electricity Supply in Nigeria

4.1 Upgrade the existing infrastructure

As explained earlier, there were losses in revenue due to the inadequacy of the current electricity infrastructure. In February 2017, the World Bank approved a credit facility to Nigeria with respect to the upgrade of the electricity transmission and substations (World Bank, 2018). It is anticipated that the upgrade of the transmission system will lead to better supply of electricity by the distribution companies and will improve general private participation in improving power supply in the country.

On the generation side, PWC advocates for the Nigeria should target an increase in installed capacity by circa 45GW over a 10 year period (PWC, 2016), and this should serve to boost electricity generation by the respective power plants. While World Bank's credit facility is for circa 486 million dollars, it is estimated that an investment of 18- 20 billion dollars (Izuwah, 2017) is required for the infrastructure upgrade of the entire electricity sector spanning generation, transmission and distribution companies. There is therefore the need for increased Public Private Partnerships (PPPs) to help provide the funds needed.

4.2 Review the real cost of electricity

It should be understood that a major determination for the involvement of the private sector in the challenge of electricity provision is largely propelled by the quantum of profit realisable from the project. As stated above, a major problem affecting the success of the privatisation exercise is the determination of the real cost of electricity and the restrictions placed on the private companies on the price allocated to electricity supply without any form of subsidy from the Government. This stance makes the provision of electricity a major challenge as the private companies are unable to fund their operations.

The solution to this will be to review the cost of electricity as well as the restrictions on pricing as stipulated by NERC to ensure that the private sector is motivated to be involved in the provision of electricity and thereby introduce more investors into the sector. In order to match the need to ensure that the price of electricity remains affordable, the Government could introduce subsidies, more bailout funds or tax reliefs for the participating private companies.

4.3 Introduce smart meters, eliminate revenue losses

It is essential that the estimated billing system used in many parts of the country are removed and replaced with pre-paid meters. Pre-paid meters will ensure that the consumer's access to electricity is limited to the number of units he/she has purchased upfront. Pre-paid meters will help to reduce the challenge of revenue collection. Smart meters will have the pre-paid element, but are also capable of sending feedback to the distribution companies regarding possible energy losses along transmission points. A major concern for the deployment of smart meters is the cost, connectivity and project funding as explained by ESI Africa (2018).

4.4 Decentralise remote locations, invest in green solutions

Although the electricity supply in Nigeria is a central system, decentralizing remote locations may be worth considering. Decentralising these locations means that they are not on the Mains but will have rely on power generated from independent power plants in their respective locations.

As part of its 2030 vision, Nigeria has a 30:30:30 vision for electricity, with a target of 30% generation from grid-connected renewable energy technologies (The Nigerian Economic Summit Group and Heinrich Böll Stiftung Nigeria (2017). Solar energy is gradually gaining traction and this together with other sources of renewable energy may be the way out of the power crisis in Nigeria. It is expected that a range of partnerships, policies and financing initiatives in 2016 have laid the foundations for decentralised renewable energy market growth (Malo and Ehusani, 2017). They cited the 2016 partnerships of the International Finance Corporation (IFC), and the UK Department for International Development (DFID) to facilitate the deployment of off-grid and embedded solar systems in Nigeria's commercial and industrial sectors; the draft Mini-Grid regulation by the Nigerian Electricity Regulatory Commission; the a new bio-fuel policy by the Nigerian National Petroleum Corporation; amongst others as evidence of growth of the market.

5. Conclusion

Constant power remains a driving force for the growth of any economy as it serves as a catalyst for production. According to the PWC Power Report, 'the power sector facilitates high capital spending which promotes investment and builds economic competitiveness'. A lot has been mentioned above regarding the current state of power supply in the country and possible means to reduce if not totally eliminate the respective issues.

We note however, that all the solutions proffered above are linked to the need for a stable and viable power policy from the Government which will enable growth in the sector. While Nigeria remains listed as one of the countries in Africa with the lowest supply of electricity, it is interesting to note that with a few changes and injection of funds into the sector, the electricity supply status of the country could improve to mirror successes achieved in Mauritius, and the neighbouring countries of Cameroon and Ghana.

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Investigating Spatial Connectedness, Information Distribution and Scheduling: A Case Study of *A Re Yeng* and Gautrain in Tshwane, South Africa

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Abstract

The South African urban public transport system is facing several challenges. In response to concerns that have been raised by commuters, the three metropolitan cities within the Gauteng province introduced Bus Rapid Transit (BRT) systems and a speed train system, the Gautrain and Gaubus. The systems were introduced to provide a reliable and efficient formal urban public transport services. The state and level of integration of the province's innovative speed train system and the metropolitans' novel bus system has not been sufficiently studied and documented. This paper therefore investigates the state of spatial connectedness of the innovative urban public transport (train and bus systems) and aim to find possibilities to integrate the two systems with the use of an online application in the City of Tshwane. The study adopted qualitative research design that facilitated the gathering and analysis of spatial and qualitative data from the urban public transport (Gautrain/Gaubus and *A Re Yeng*) officials/authorities and commuters (Gautrain, Gaubus and *A Re Yeng*) in the city.

The study revealed that spatially, there are physical connections on several locations between the BRT and the Gautrain and Gaubus in the City of Tshwane. However, there is no integrated information that is provided to the commuters on the arrival and departures of the two systems leading to difficulties in switching between the two modes. Even the scheduling of the *A Re Yeng* and the Gautrain and Gaubus is not harmonised and synchronised. The study concluded that there are routes and places that are serviced by the *A Re Yeng* that are not included in the Gaubus systems but that the Gautrain commuters would want to reach, hence synchronising the system would benefit commuters at large. It is possible to schedule the Gautrain and BRT systems in such a way that they work together harmoniously, in terms of synchronising arrival and departure times and informing the commuters and connecting systems electronically.

The work recommends integrated application systems for Gautrain and Gaubus as well as *A Re Yeng* bus system in the quest to offer efficient and reliable transport systems, thus creating efficient cities were by people can move effectively from their homes to places of interest. Adopting intelligent urban public transport systems assist in the attainment of arrival and departure accuracy

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and helps to reduce delays on the part of commuters, thus assisting in providing efficient urban public transport systems that connect people to different places effectively and conveniently.

Keywords: big data, integration, intelligent transport systems, online information application, public transport

1. Introduction

Urban public transport provides a basic mobility service to various types of activities including employment, education, recreation and medical care (Browning 2013; Ndwandwe and Gumbo 2017). It also assists to reduce road congestion, excessive vehicle emissions and oil consumption – all of which benefit both riders and non-riders. Public transport also reduces some negative impacts on the road by irresponsible driving such as car accidents and other challenges. Pienaar et al. (2005) highlights that land and transport authorities have been trying to promote, encourage urban public transport and urban public transport need to be a first priority. South Africa has been undergoing a metamorphosis in its transport systems in response to competing forces and several demands (Musakwa and Gumbo, 2017). This has been particularly so for the country's urban public transport systems that have been facing pressure to improve reliability for commuters (Moswane and Gumbo, 2017). Among others, the need to keep pace with other international urban public transport has meant that local public transport systems introduce and apply recent and innovative methods of integrating urban public transport (Risimati and Gumbo 2018a). Government at all spheres- National, Provincial and Local has responded in the issues of lacking urban public transport by introducing public transport systems that are used in most developed countries. These public transport modes developed in South Africa are bus rapid transit systems and a speed train.

However, there seems to be a challenge of non-reliability in some cases. Urban public transport need to be connected and function as one system to fill the lacking element of non-reliability and non-effectiveness. *A re Yeng* commuters tend to use alternative informal public transport (Taxi's) as on some occasions buses take long to arrive at the stations, commuters become frustrated when buses are not at the station for pick up as per information distributed on the time tables (Ndwandwe and Gumbo 2017). Therefore, Public transport management need to adopt innovative tools to assist the public transport operations to be efficient, effective and reliable (Mostert, 2013). There is availability of good urban public transport in South Africa but it is high time that these public transport systems are taken to the next level. In support with the above mentioned, Intelligent Transport Systems (ITS) and Big data can be used as a technique to operate and manage urban public transport. The aim of this paper is to determine the state of integration of the *A re Yeng* and the Gautrain/ Gaubus in the City of Tshwane to establish if there are possibilities of integrating the systems with the online information application with compatible time tabling allowing commuters to know real time information of both modes.

2. Literature Review

Urban public transportation are systems that are available for use by all persons who pay the established fare. These systems make movement for all people to be easy regardless of the conditions as mostly are affordable. Encouraging individuals to use urban public transport is beneficial as it reduces negative effects such as air pollution and establish a sustainable, and efficient citizens traveling movement, and instantaneously with an encouraging effect in energy costs reductions (Gumbo and Moswane 2017). de Pablos et al., (2011), support the above by stating that urban public transport tackles the challenge of traffic congestion by transporting large numbers of people efficiently, and has a most important part to play in mitigating blockage and enhancing movement on the roads and cutting energy charges as urban public transport offers energy productive transport solutions. With the amount of journeys completed in cities set to rise exponentially in the years to come, governments will need to smarter mobility solutions. The planning of public transport systems plays a critical role in improving accessibility for all users. According to Gwilliam (2013), Transportation planning and design choices have a direct influence on development patterns, travel mode choices, infrastructure costs, redevelopment potential, the health of natural resources, and other community concerns.

Transport planning/evolution and demand usually respond to how communities function spatially (Holzer et al., 2003) and in some cases the transport planning can be used to force spatial change (Wegener & Fürst, 2004). Transportation assist to shape an area’s economic health and quality of life. Not only does the transportation system provide for the mobility of people and goods, it also influences patterns of growth and economic activity by providing access to land (Chen et al., 2014). Transportation planning is more than listing highway and transit projects. It requires developing strategies for operating, managing, maintaining, and financing the area’s transportation system to achieve the community’s long-term transportation goals (Dydkwoski, 2011). The type of a system can be referred as part of planning and the design element is being tied to a management plan as it will involve planning of routes and stops integrated with frequencies. In line with the above, at the strategic level of planning the public transport system, long-term stability of a high service quality is required for the public transport system to influence urban development and to create more sustainable transport patterns (Nielsen & Lange 2007). Schöbel (2016), states that planning a public transportation system is a multi-objective problem that includes among others of line planning, timetabling, and vehicle scheduling. For each of these planning stages, models are known and advanced solution techniques exist. Some of the models focus on costs, others on passengers’ convenience. Setting up a transportation system usually is done by optimizing each of these stages sequentially.

In the planning process, there is a need to find the current demand and the relationship of movement of different transport modes and environmental demands (Archarya and Morichi 2012). Then a need to formulate the plan, predicting the future travel demand and make a recommendation to full-fill challenges that might occur (Abu-Ayyash et al., 1986). Further, assessing whether the proposal made satisfactory demand and provide maximum benefit to the community. Monitoring existing conditions such as forecasting future population and employment growth, assessing projected land uses in the region and identifying major growth corridors; and identifying current and projected future transportation problems and needs as well as analysing, through detailed planning studies, various transportation improvement strategies to address those needs. In South Africa, Gauteng province, there has been development of innovative urban public transport in the past ten years (Musakwa and Gumbo 2017). Bus Rapid Transit and Gautrain are the formal urban public transport system implemented. However, commuters still face challenges of inefficient and unreliability urban public transport services.

2.1 Integrated urban public transport systems

Public Transport is not an isolated and independent phenomenon, as it involves a number of considerations. Inconsiderate development pattern may be reflected by the arising need to travel. Geographic location of residential developments in relation to other uses that residents need to travel to frequently is usually the core problem in public transportation issues (Moswane and Gumbo 2017). Transport related solution, innovation should not come only from the office of the transport department or experts in design for current needs and accommodating future transport need respond to existing and expanding patterns (Browning 2013; Ndwandwe and Gumbo 2017). The problem occurs when experts are instructed to solve or improve the travelling purely from the transport engineering point of view. Those types of solution are technically and easily achievable depending on the availability of resources. BRT and Gautrain/Gaubus infrastructure construction is a typical example where the budget was available and a design was authorised and implemented against most challenging, physical and legal obstacles (Mostert 2013; Musakwa and Gumbo 2017). Here, non-transport solution to what seem to be a transport problem needs exploration.

Nevertheless, there is a possibility of introducing a public transport system with the objective to solve problems such as efficiency, effectiveness, reliability of the public transport movement and arriving to stations as per the information distributed in timetabling. Literally, the transport planning and operations solution can address the transportation problem anywhere where the resources are not a problem. Gautrain/ Gaubus and *A re Yeng* (BRT) transport commuters into different locations and these two modes of Urban Public Transport (UPT) connect physically on some areas. With this, integrating the Gautrain/Gaubus and *A re Yeng* (BRT) could assist the movement to be more efficient and reliable as the switch in-between the two modes is convenient on such locations. The introduction of an online application that can combine Gautrain/Gaubus and A re yeng could be beneficial in such a way that these UPT systems work together harmoniously, in terms of synchronizing arrival and departure times.

Outcomes of the determination to resolve urban public transport challenges in urban areas in particular, the following approaches can be detected (Heres et al., 2013). Making use of available public infrastructure (build the problem away); Improved quantity and the quality of information (ITS) and Big data; connecting several modes of urban public transport; and make public transport more attractive (Kotchar 2016). The urban public transport system in the COT is disconnected and this affects the commuters, as they do not switch smoothly from one transport mode to the other. Gautrain/ Gaubus and *A re Yeng* are two different operators, scheduling of time tables does not correspond to one another to allow smooth switch in-between by commuters. Consequently, information to public transport users is not well distributed. Therefore, improving the information dissemination and other related challenges in urban public transport can attract more current private vehicle users, thus reducing congestion caused by more private vehicles in the roads. Using an online application for these urban public transport modes can improve integration/ connectivity of public transport in the COT. Gautrain/ Gaubus and *A re Yeng* commuters can use the online application to view real time information and the fastest alternative that can be taken for switching in-between the two modes of UPT. Determination should be made to enhance the efficient movement of Urban Public Transport. Technological innovations in the past increased the number of transport modes and facilities, which made it possible to offer a wide range of alternatives for diverse demands in the transport market (Archarya and Morichi 2012). Therefore, integrating UPT with the use of ITS and the big data might make the City of Tshwane public transportation effective, reliable, efficient and attract more commuters.

2.2 The use of big data in urban public transport systems

Big data signifies the information resources described by a High Variety, and the Velocity to involve particular technology and analytical approaches for its conversion into value. In line with the above, Ruiz et al. (2016), state that big data sources for transport planning applications include: GPS trace (smart phones, etc.), cell phones traces, transit smart card transactions, and other count and sensor data (including on-board vehicle sensors), online Social Media/Networks, credit card transactions (travel-related activities), RFID traces. Traffic congestion are a constant objection, and getting to work can be an inconveniency, even on the good days. With urbanization taking place, the issues of population explosion and inefficient urban public transportation only stand to become worse (Moswane and Gumbo 2017). Fortunately, the traditional techniques of handling urban public transportation could be on the verge of altering thanks to developments in big data. Although big data practice cases have been a fragment of the business domain for years now, urban planners and transport authorities are rapidly understanding how appreciated it can be when making developments to urban public transportation. Long travelling hours for commuters will be a less worry for urban public transport users (Burt 2014). According to Kotchar (2016), Big Data is changing the operations and management of the urban public transportation. Urban experts, who are responsible of UPT services, should consider leveraging big data.

Big data assist with planning as it produces more accurate information and understanding of the commuter's demand on different roads (Risimati and Gumbo 2018b). They can record commuter trips through various modes of urban public mobility; it can be trains or buses. All this data can help to enhance planning upcoming train/bus routes, frequency on current train/bus routes, and size of bus and trains (Chen et al., 2014). Through this method, commuter time waiting and walking could decrease, hence attract more users. Further, big data can predict the maintenance as it assists to detect the conditions of a certain public transport mode through the installed devices at a faster rate. Transport expects can manage to foresee errors that might emerge in future or a short period at the individual component levels e.g. Spring of rails, brakes fail etc. (Burt et al., 2014). Informed decisions, schedule maintenance of the equipment is likely to be prepared at the right time and authorities can have a close understanding of commuter trips, origin and destination involving trains, buses and even private modes of transportations. Big data also improves commuter safety and fulfilment, better equipment use and decrease operating costs. Understanding the needs of the commuters is crucial; transport expects can provide communication to individual commuter via desired communication network (private messaging). These modified messages can contain changes in the service on individual route(s) that a commuter cares for, and any changes that might affect services (Chen et al., 2014). Commuters can appreciate these innovative strategies compared to spam messages received daily. It enhances commuter satisfaction and assist to escalate the commuting of both trains and bus while providing transport expects a new revenue sources such as targeted advertising (Kotchar, 2016).

2.3 Intelligent transport systems and online applications

ITS play a big role as government around the world are employing this tool due to the problem of increasing population leading to congestion in cities, as this tool is used for improving the functioning of transportation system (Lubieniecka 2013). This tool can be applied in many ways with different models as one of its contributions it's Advanced Traveler Information Systems (ATIS), which knows the movement and location of a certain source of transport (car, bus etc.) in real-time and keeps a watch on the condition of the transportation network. ATIS can assist Gautrain/Gaubus and *A re Yeng* for identifying the real movement/whereabouts of bus and train in real-time, allowing commuters to make informed decisions. Functioning of ITS intended to improve the safety, efficiency and capacity of the road. Therefore, ITS to public transport users provides better information before and during a journey (Singh 2011). Ideally one would envisage a transport system that enables people to make informed choices about when and how they travel. Using technology to keep people informed both before and during the journey should be a central feature in the overall transport strategy and provides an essential tool to deliver better network efficiency and improved safety (Gauteng Provincial Government 2012). It seems that the current and future traffic problems in cities and their surroundings are soluble only through technology.

In developed countries there are numerous techniques used to distribute information to commuters. In Lisbon, there is a tool used in urban public transportation to inform commuters in regards to whereabouts of a certain transport mode, this tool is a real-time trip-planner system. According to Alves et al. (2012), this system is capable of informing commuters about which are the better routes to make the journey they want, when they want and what are the estimated travel times, based on the actual locations of the UPT and the travel speeds predicted for several appropriate routes for an hour at most. Increasing population in cities leads to increasing travel demand and therefore a need for supply of effective, efficient, productive, stable, viable and sustainable urban public transportation systems (Olivkova 2017).

Different techniques are used in order to make the movement of urban public transport to flow nicely and reduce the delays on the roads. Time waiting for a certain public transport mode either at a bus station or at a train station is not acceptable by the commuters. Commuters favors public transport mode that does not delay in any form. The introduction of an integrated information application can allow authorities to understand customers to be impacted in regards to where should more capacity of urban public transport be increased and how much, and what alternative can be used to reach commuters e.g. Facebook, Twitter, Text Messages. Advanced technology used in the 21st century provide tools that are crucial in response to unexpected occasions (Kotchar 2016). Big data can be used for capturing the information of commuters that take Gautrain/ Gaubus and *A re Yeng* in order to know which stations are busy, during which times so that the capacity of buses and trains can be added or made more efficient and available for the users. In addition, big data can be used to capture the real time movement of the whereabouts of the urban public transport. Further, ITS system can play a critical role in supporting the online information system to keep track with real-time of the urban public transport. This allow commuters to know the exact time of a certain urban public transport arrival and can plan their journey. Commuters can make informed decisions including the switch in between Gautrain/Gaubus and *A re Yeng*.

3. Research Methodology

The objective of this paper is to assess the information dissemination to commuters by *A re Yeng* and Gautrain/ Gaubus and assess the possibilities of integrating *A re Yeng* and Gautrain/ Gaubus electronically using an online application. A qualitative study research design was adopted. Research instruments used are interviews as they are useful for acquiring the information behind a commuter's experiences and participant observations as they give the authors own perspective of the subject. Interviews and participant observations assist the study to give different views on the daily situations and what is currently happening in regards to the urban public transport systems. Accordingly, Tabulation was developed to present the interviews, and photographs assisted in present participant observation data. Sources of data are Gautrain/ Gaubus, *A re Yeng* commuters, officials and the journal articles. These sources of data (commuters and officials/authorities) are appropriate for the study as they give information from the management and customer/user view producing primary data. Further, journal articles are important in supporting the study based on what other studies revealed. Further, the outcomes of the article are policy brief highlighting current state of rail and road public transport integration and recommending on how best it could be strengthened. Moreover, journal article highlighting the state of electronic integration that has been brought about through innovative urban public transport provision.

A purposive sampling was adopted in order to acquire relevant information. Twenty-five interviews administered with current users of Gautrain, Gaubus, and *A re Yeng* in the City of Tshwane. Both authors collected and analysed the data using content analysis and correlation analysis. Content analysis highlight the current distribution and predicting future improvements, there needs and preferences and correlation analysis highlighting the relations of Gautrain/ Gaubus and *A re Yeng*. Developed questions were based on the information distribution in urban public transport. How easy commuters access information about the times of the transportation, with the current mode of information distribution if they are travelling to areas that need them to switch public transport, do they switch smoothly from one mode of transport to the other immediately. Consequently, their needs and preferences as well as the availability of information about the options available and how one can connect these various modes. Details asked on the possibilities of developing and adopting composite and integrated apps that provide real time information about both public road and rail transport. Such data was analysed to provide guidelines and policy recommendations on rail and road integration purposes. About 10 interviews conducted with officials/authorities from Gautrain/Gaubus, *A re Yeng* and relevant government and municipal departments, representatives of various relevant organizations. Data collected from these officials was mainly the policies that currently guide their developments, their plans, targets and needs. This assist to provide at the end of the study relevant and up-to-date information that help officials to adjust their policies, plans, targets in line with realities, needs, expectations and preferences of current and potential users of public road and rail transport systems in the city of Tshwane. Realties on the ground in as far as integration of rail and road transport systems will be established (Bohte & Maat, 2009).

4. Results and Discussion

Urban public transport in the City of Tshwane both Gautrain and *A re Yeng* bus are innovative formal public transport systems that have been implemented in the past 10 years to improve the reliability and efficiency of public transport. By connecting the two modes of urban public transport through an integrated online application is a good initiative as commuters will be able to switch smoothly from one mode of urban public transport to the other with less delays of long wait, availability of information about the alternative mode of urban public transport give commuters options to plan a journey in time. Further, movement of the people in the City of Tshwane on a daily basis go as far as to the other parts of the city whereby *A re Reng* bus does not reach and Gautrain/ Gaubus reach those areas. Hence, a need for these systems to work together.

Table 1: Interviews feedback

Sources of data	**Number of participants**	**Positive feedback to questions (%)**	**Negative feedback to questions (%)**
Gautrain/ Gaubus officials	4	80%	20%
A re Yeng officials	3	80%	20%
Public transport officials	3	60%	40%
Commuters/Users	25	20%	80%

Interview questions conducted with officials were both negative and positive, 80% of the interviews were positive and 20 % were negative. Gautrain/ Gaubus officials indicate that information is easily accessible by commuters as the system provide an online application to distribute both bus and train information which is mostly accurate. There are alternative used by commuters to access information (see figure 4). 80% of Gautrain/ Gaubus commuters enjoy the information services provided and information is easily accessible. 20 % of negative responds were based on that commuters are challenged to alight on certain locations as the Gautrain/ Gaubus does not get some of the customer's/users destination and the Gautrain/ Gaubus officials/ authorities, they mentioned that it would be difficult for Gautrain/Gaubus and *A re Yeng* since they are two different agencies.

20% of positive feedback by *A re Yeng* bus officials/ authorities were provided which indicate that useful information distribution to commuters is well disseminated to commuters. Timetables are provided at the stations as well as the assistance that are found at the stations assist commuters with the updates and timetables can be viewed online. 80% negative feedback was provided by *A re Yeng* commuters as mostly indicate that the information provided is not useful which delays them on most occasions and expressed they frustrations as the complains laid are not taken to consideration based on the improvement of receiving relevant information of bus times.

Most commuters who use Gautrain/ Gaubus and *A re Yeng* bus daily they agree with the idea of having an integrated online application that can detect the real time information of a certain urban public transport. Most of the public transport users mentioned benefits such as arriving in time at their places of interest such as work, home etc. *A re Yeng* commuters are enticed by the use of real time information as currently the online information provided is not consistent and reliable. Further, the commuters of both modes mentioned the possibility of easy switch in-between if these two systems work together. Consequently, Authorities of Both Gautrain/ Gaubus and *A re Yeng* bus they do not deny the fact that commuters struggle on numerous occasions with arriving to desired destinations and therefore agree with the idea of integrating the two system to benefit commuters which can possibly attract more users too.

4.1 State of formal urban public transport in the City of Tshwane

In South Africa, the City of Tshwane adopted the strategy of BRT system in order to have smart, efficient, reliable public transport for the city commuters and resolve urbanization challenges (see figure 1). This system is adopted as it has proved to be good not only in terms of costs but the desired transportation system that is flexible and integrated to the cities development, reliable, comfortable and attractive. Further, the system assists to tackle congestion challenges.

Figure 1: A Re Yeng (Authors, 2018; www.areyeng.com, 2018)

The above photographs show the BRT system *(A re Yeng*) that is found in the City of Tshwane. The BRT idea and objective in South Africa is to provide a road based public transport designed to move a large number of passengers, effectively from a cost, time and comfort point of view overcoming the traffic congestion and safety matters known to other forms of public transport. A total number of 120 buses were acquired on lease in 2013 in order to make the bus system to be effective and avoid delays (Mostert 2013). However, there are challenges faced in urban public transportation confirmed by the minister of transport Joe Maswangayi on 10 July 2017 at the 36th Southern African transport conference stating that the Bus Rapid Transit is not full-filling the prime objective. He further mentioned that lot of money has been spent but still the desired/imagined role that is supposed to be played by BRT system is failing (Mabena 2017). Browning (2017) supports by stating that when the public transport strategy was launched in 2007, the mini-bus taxi carried out 70% of all public transport users, and still a decade later mini-bus taxi carries 70%. Further, the introduction of the BRT system was to reduce the informal public transport and encounter other challenges.

Advancement of transportation has led to speed trains that are very popular phenomenon around the world. One of the first countries to have such trains is China, and today they are in many countries in Europe. The first rapid transit train in Africa, it was launched in South Africa (Gauteng) known as Gautrain in 2010 (Gautrain Management Agency, 2010). The main Objective of this transport mode was to reduce traffic congestion and quick travel time from origin to destination, and the development of Gautrain was to encourage the use of urban public transport. This concept is tailored to achieve smart mobility and it is very fast in nature (Liu and Teng 2014). The Gautrain project as it was established, a bus system was developed as well which is known as Gaubus and these two are intertwine. Gaubus is developed to penetrate in the areas that the Gautrain cannot.

Figure 2: Gautrain

Figure 2 depicts the Gautrain which also have the Gaubus. This strategy was aiming to bring efficient, and reliable public transport. The strategy of Gautrain and Gaubus shows that interoperability is possible between the two public transport modes (train and bus) that they can work hand in hand. These transport systems are developed to cater for growing population and have the same objective. Gautrain moves from the City of Tshwane to Ekurhuleni and the City of Johannesburg. There are three Gautrain Stations in the City of Tshwane which are Hatfield, Pretoria and Centurion.

4.2 Spatial connectedness of the two systems

The spatial planning of public transport between Gautrain and *A re Yeng* confirms physical integration in some areas in the city. This clearly indicates that transport and spatial planners were trying to integrate the public transport of the city physically in order to have effective and reliable public transport. Therefore, trying to connect these transport modes electronically, challenges faced by commuters/ users, *A re Yeng* authorities and Gautrain authorities might be improve in a positive manner.

Figure 3: Physical integration (Authors, 2018)

Figure 3 shows physical integration that exist in the City of Tshwane between Gautrain/ Gaubus and *A re Yeng*. Gautrain / Gaubus Hatfield station is 70metres away from the *A re Yeng* bus station. The distance separating the two urban public transport station is good as it is a short walking distance for users. Commuters switch easily from one urban public transport mode to the next. The only challenge between the two systems is timetabling.

4.3 Information dissemination and harmonised scheduling

Distribution of information is important and necessary to be up-to-date. Users are attracted to a system guaranteed to them. Less time spent at the train and bus stations attract more commuters to use that specific urban public transport. Integrated urban public transport is a desirable system for all users as it allows necessary alternatives.

Figure 4 shows how the information is distributed to *A re Yeng* and Gautrain/ Gaubus commuters. Both systems have route maps at the stations that assist users to make ridership easy. Information distribution operations of the Gautrain are managed technologically. There is an online application that is used which is more precise to time tabling. Integration of the high-speed train and the BRT electronically with the use of this sort of online application in the city could make the movement of the public transport to be fast, delays can be reduced and commuters/ users can make informed decisions to use the available public transport mode. Positive information dissemination can increase the use of the public transport. The number of vehicles on the roads can be reduced which means less traffic congestions. This makes the system to be more effective, the train travel at a high speed, no traffic congestion faced, and it arrives to its destination as indicated on the timetable. Information dissemination in regards to Gautrain, it is well distributed as individuals can check the times online anywhere.

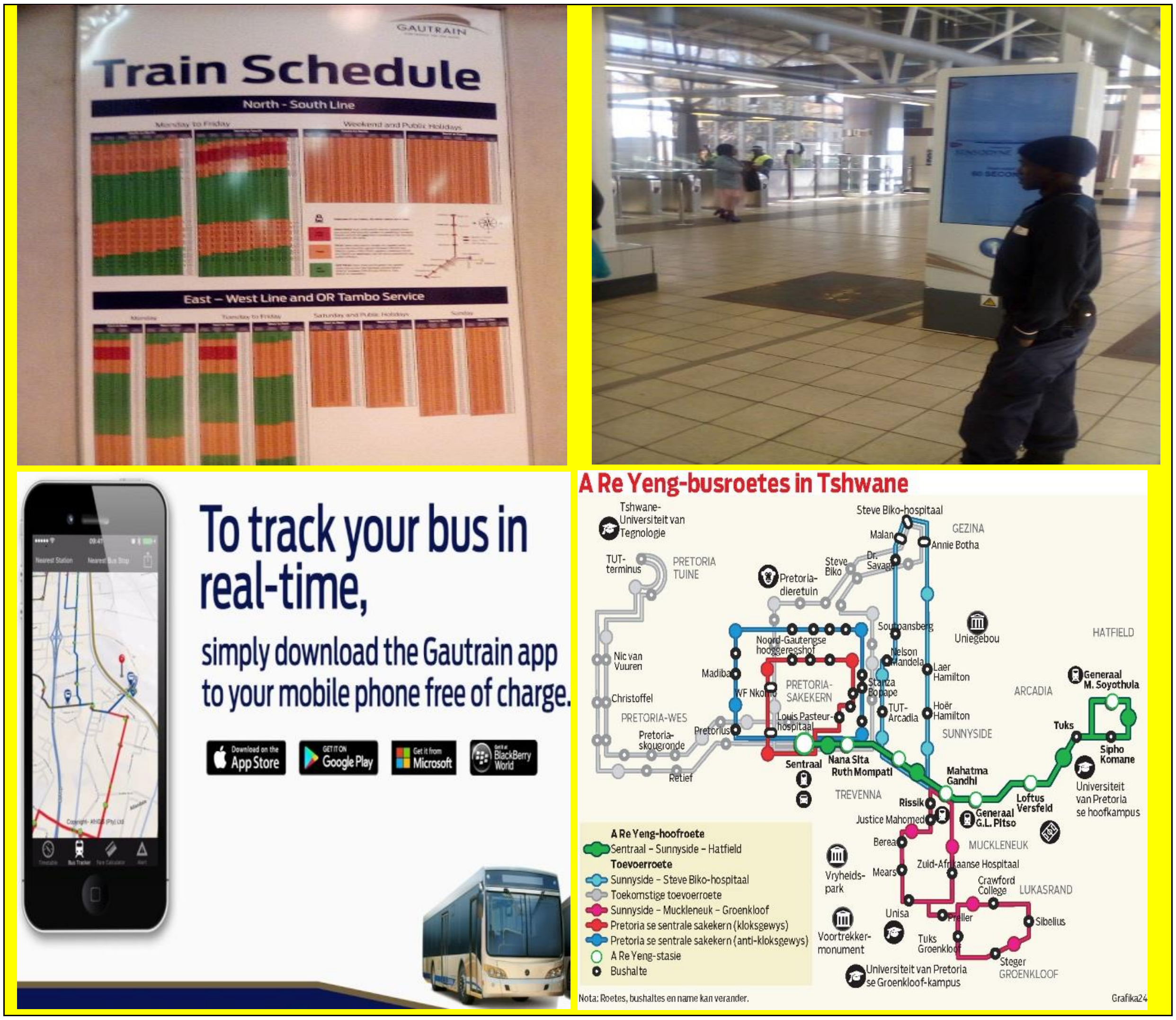

Figure 4: Information Distribution (Author's, 2018; www.gautrain.com, 2018; www.areyeng.com, 2018).

On the other hand, if the users have no access to the online application, there is information at all Gautrain/Gaubus stations as there are timetables provided. Further, Gautrain/ Gaubus users are able to plan the trips as they are aware of the travelling conditions and at all stations there are information machines that provides trips, time and movement information of Gautrain/Gaubus. However, with the *A re Yeng* bus, there is a lack of reliability, as commuters on most instances tend to wait a long time for a bus to arrive at the station. This causes less customer satisfactory leading to reduction of ridership and less attraction for new users. One of the challenges is the lack of information distribution; *A re Yeng* commuters cannot access real-time information, the online information that is provide on the *A re Yeng* website only mentions that the bus arrives at the station every 10 minutes during off-peak time and 7minutes during peak-time which is debatable. The information is provided at the bus stations, and both the information provided online and at the bus station it is not true on most cases. Nevertheless, on some instances the bus is delayed by traffic congestion, dysfunction of the bus (e.g. flat tyres, lack of service etc.), but it is beneficial that commuters are updated by such instances.

Integrated urban public transport in developed countries is very popular. European countries such as Austria, Spain and Germany to mention a few, use this strategy to make travelling convenient for commuters. The movement of commuters become smooth as passengers switch from one mode to the next. Moreover, the integrated system allows the users to have options of which urban public transport mode to use, and are able to plan the trip properly and assist commuters to switch in between in order to reach the desirable destination. The COT has innovative formal urban public transport that can attract more commuters. However, the system need to be user friendly in relation to improved service, travel information and reliability for both systems (Adewumi and Allopi, 2013). Further, cost is an important factor that influences the demand for public transport in relation to the time-spent waiting, boarding and stopping from vehicles combined with the risks and inconveniences involved in those actions. Gautrain/ Gaubus use an online information application that is well managed indicating that it is possible to have a bus and train system that is synchronised. *A re Yeng* information distribution is not strong which makes is unreliable on most occasions. Since there is a physical connection on some locations between the two modes, connecting them through the use of one information application showing real time movement, arrival and departure time could strengthen both systems. This will give customers more alternative to get to the desirable destinations. Further, the integrated online information application could be developed in a way that it informs commuters about which are the better routes to make the journey they want, when they want and what are the estimated travel times, based on the actual locations of the UPT and the travel speeds predicted for several appropriate routes for 60 minutes at most. In addition, the possibility of integrating these two modes would only require a few changes and not starting a development from the beginning as both systems has good infrastructure that exist currently.

5. Conclusion

City of Tshwane formal urban public transport is not integrated and with the use of the integrated online application could reduce the negative impacts and improve the functioning of the two systems. On certain locations in Tshwane, there is spatial connectedness allowing easy switch in-between the two systems made by commuters. There are routes and places that are serviced by the *A re Yeng* that are not included in the Gaubus systems but that the Gautrain commuters would want to reach, hence synchronising the system would benefit commuters at large. It is possible to schedule the Gautrain and BRT systems in such a way that they work together harmoniously, in terms of synchronising arrival and departure times and informing the commuters and connecting systems electronically. Integrating public transport systems is a possibility as has been demonstrated in developed countries such as Spain, Australia, Austria and Germany just to mention a few. Even some emerging economies that are fall within the league of South Africa such as Brazil, Russia have managed to integrate their public transport systems. This goes to confirm that South Africa has what it takes to progressively engage in innovations that leverage its economic performances and this is envisaged to start nowhere else besides the Gauteng province, the cornerstone of the South African economic expansion, advancement and technological uptake and perfection. Advancement of technology has improved the level of how people live and function in the third millennium. It has become more of a dependent source of providing information and doing things that seem to be impossible.

This paper is envisaged to contribute beneficial information in the development of integrated UPT that will assist as guidance in the operations of innovative public transport systems in the City of Tshwane and the Gauteng province. Essentially, the work will provide guidelines and policy recommendations that will promote the development and running of effective, efficient, reliable and well-integrated public transport systems (road and rail) that foster socio-economic benefits and spatial transformations. Electronic technologies for urban public transport operations is useful as it provides accurate information regarding the whereabouts of *A re Yeng*, Gautrain and Gaubus to assist with areas of demand and supply in order to have effective and efficient urban public transport.

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Barriers to Enhancing Environmental Sustainability of Construction Projects in Zimbabwe: Perspective of Construction Consultants

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Abstract

Achieving environmental sustainability necessities of construction projects has remained elusive within the Zimbabwean construction industry. Despite the existence of the Environmental Management Agency, that is mandated to regulate this environmental sustainability drive, the industry is inundated with conflicts and controversies that have hampered project success or even stagnated projects altogether. Since Environmental Impact Assessments, their audit and monitoring are key in this endeavour, the focus of this study has been placed on construction consultants, since they must translate impact assessment requirements within contracts documentation and ensure attainment during project execution. Identifying the barriers encountered towards attaining project success in this regard is paramount to initiating and implementing intervention strategies that enhance environmental sustainability of construction projects. Therefore, the aim of this research was to identify and rank the barriers to the achievement of environmental sustainability on construction projects in Zimbabwe. Interviewer-administered questionnaires were used to collect both quantitative and qualitative data from all the consultants situated in Harare wherein they expressed their opinions on the severity of pre-selected barriers using a five-point likert scale and further suggested intervention strategies. The results indicate that weakness in legislation, lack of incentives, lack of proper training and education, lack of awareness and lack of interest from the client, are the most significant barriers to delivery of environmentally sustainable projects. Various remedies proposed include enhanced stakeholder integration, mandatory environmental compliance on tendering and execution, environmentally conscious organizational structures and cultures to be set, and disciplines that intensively train environmental sustainability in colleges and universities to be established. Adoption of these interventions was deemed highly significant towards the achievement of environmental sustainability on Zimbabwean construction projects.

Keywords: environmental sustainability, sustainable construction, Zimbabwe

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1. Introduction

The global environmental concerns have increasingly intensified the pressure for enhanced environmental protection (Pun *et al.*, 2001) and this has permeated to construction projects where their successful delivery is increasingly dependent on improving environmental management practices (Gluch and Riasanen 2012). Hence, environmental management needs to be incorporated into the policies and processes of a business if it is to follow sustainable development principles (Chari and Chiriseri, 2012), thus consultants within the construction industry need to drive this agenda. Chirisa (2014) emphasizes that environmentally sustainable construction projects improve and modernize human survival, biodiversity, equity and life quality. However, Gluch and Riasanen (2012) argue that the current environmental practices are not in synchrony with already established cultures and thus allude to one of the greatest barriers towards achievement of environmental sustainability on construction projects. Though numerous studies on environmental sustainability have been undertaken: Spence and Mulligan (1995); Ofori (1998);Ebohon (2000); Abdullah and Awang (2006); Lorenz *et al.*, (2008); Matar *et al*.,(2008); Pinkse and Dommisse (2008); Ortiz *et al*. (2009); Pitt *et al.*, (2009); Sev (2009); Son *et al*., (2009); Haseeb *et al.*, (2011); Tam *et al.* (2011); Chirisa (2014); Gumindoga *et al.*,(2014);; Ogunbiyi (2014); Zahedi *et al*, (2014),the dilemma of its achievement remains elusive to construction industries the world over.

Sustainability in the construction industry was initiated in the 1960s but got its momentum in the late 1980s and the quest for sustainability has put the construction industry under immense pressure from the government and general public to improve its unsustainable patterns of project delivery (Brundtland report, 1987). The sustainability concept was then embraced in sustainable development which originated in the 1980s and it has set guidance measures for the correction of market failures, ensuring regenerative capacity of renewable resources, avoidance of cumulative pollution, steering product processes towards eco-efficiency in project delivery (Turner, 2006), amongst other aspects. Ofori (2012) intimated that the environmental impacts of the construction industry are extensive, often irreversible, readily identifiable and sufficiently documented. Raupach *et al*., (2007) also stated that the then present environment condition was a consequence of the increasing consumption of natural resources whose depletion exceeds what is physically possible to sustain in the long-term with effects of degradation of the ecosystems and conditions of human life. In Zimbabwe, Mutangi and Mutari (2014) bemoan that concepts of environmental sustainability have been adopted from the developed countries without modification that suits specific needs of the nation. In addition, environmental issues have been solely assigned through the Environmental Management Act. Majome (2017) further allays that the Environmental Management Agency (EMA) is one of the better-known and active government agencies whose activities are less pronounced in urban areas and in various industrial sectors.

The Environmental Management Act (Chapter 20:27) allows for the Environmental Management Agency (EMA) to participate in the promulgation of reasonable legislative, policy and other measures that: i) prevent pollution and land degradation; and ii) secure ecologically and sustainable management and use of natural resources while promoting justifiable social and economic development.

The key objective of the Environmental Management Agency (EMA), within the context of this study, is to regulate environmental impact assessment plans for construction projects through auditing and monitoring the whole construction process. Emphasis should be on good construction site practice, from project initiation to completion, by first preparing an environmental risk assessment for all construction activities which aim at preventing erosion, runoff and land disturbance by leaving maximum vegetation cover which has become just a formality as corruption has taken over (Ndubiwa and Mbiba 2006). This is confirmed by the Government Gazette 380 of 2013 which, though it declares some 26 wetlands in Harare as protected areas, the city council violates this as they continue to approve house construction on wetlands and approve shoddy works that have negative impacts on the environment (Mpofu, 2015; Masara, 2017). Further to this, evidence shows that the Environmental Management Agency (EMA) “erroneously” approves some of these projects, while the blame has been placed with the city council in other instances (Masara, 2017). Majome (2017) adds that major threats of pollution, deforestation, erosion and siltation of rivers, are a cause for concern across all industries, including the construction industry. This reflects failure, specifically by the regulating authority, though the construction industry has the ability of addressing these shortcomings through equipping the construction consultants with the appropriate knowledge amongst other needs. Hence, as environmental sustainability challenge persists, a proactive approach needs to be undertaken that considers the contribution of construction consultants on the existing barriers that have prevented successful construction project delivery.

Therefore, this study will utilize barriers from literature to unearth the most significant barriers to failure to achieve environmentally sustainable construction projects in Zimbabwe and consequently enhance project success. The study will also tender some intervention strategies of eliminating the barriers and improve on the delivery of environmentally sustainable construction projects.

2. Environmental Sustainability

The construction industry and its associated activities have adverse impacts on the environment. Serious energy consumption, dust and gas emissions, waste generation, noise pollution, land use, existing site dereliction, habitat destruction, the use of natural resources, the use of water resources, and water discharges (Tam *et al*., 2006). Project success environmentally is a pillar to economic progress (; Zahedi *et al*, 2014; Pocork 2016; Taylor *et al*, 1994; Ogunbiyi’ 2014) hence it is a cause for concern.

2.1 Barriers to environmentally sustainable construction projects

Studies over the years have identified barriers to successfully deliver sustainability conscious construction projects in developed and developing countries such as China (Gouging and Shaojun 2000); Kenya (Watuka and Aligula 2002); Zimbabwe (Chari and Chiriseri 2012); (Haseeb *et al*., 2011); Ndubiwa and Mbiba (2006). However, a specific focus on environmental sustainability is pertinent. Extensively environmental sustainability is affected by barriers emanating from all the stakeholders with legislative, educative, regulatory, and consultative and clientele amongst others as the chief sources.

In a study by Mills and Glass (2009) on the barriers that would hinder achievement of environmentally sustainable resources 10 barriers were identified which included: high costs, high risk and value demand, tendering and procurement inadequacies, lack of cooperation and networking, lack of knowledge and common terminology, unavailability of integrated methods and innovation process. The Urban Sustainability Support Alliance (USSA) in Sydney (2009) lists some of the barriers to effective environmental sustainability management and these include lack of organizational support, failure of leadership to inspire others in the organization, level of personal commitment, knowledge and leadership provided by senior management, in particular. In a comparative study of the developing and developed countries, Revell and Blackburn (2007) identify the most severe barriers in advancing environmental sustainability as: lack of awareness to regulations, lack of information dissemination about new or updated regulations by the government and businesses only willing to fulfil minimum requirements. A study of the construction industry found that builders do not believe a clear business case exists for energy or waste efficiency measures (Revell and Blackburn, 2007). To support their view, they cited: a lack of incentives to pursue efficiency measures; the fact that clients pay the energy bills; the time it takes to sort waste; and the extra funding needed to store reusable materials. In another comparative study, the financial concerns and perceived elevated costs in implementing environmental practices was one of the biggest barriers for its success (Taylor *et al*, 2003).

The attitudes of the construction industry stakeholders play a varied role in the implementation of environmental practices. While a stakeholder may perceive that their business has a minimal impact on the environment, others believe that they have a moral imperative to act but this however, becomes a drawback (Jenkins, 2006). The many challenges stem mainly from the need for balancing the main sustainability dimensions namely economic, social and environmental issues and having linear approaches rather than cyclical is considered a blow to environmental success (Miyatake, 1996).

Environmental legislation and regulation must not be viewed as obstacles to competitive advantage. Dependability of the construction industry on other sectors to implement sustainability is a major barrier. The sectors include the manufacturers of construction materials and components (Roberts, 1997). With construction projects being on different locations it become a challenge for sustainability implementation as cited by Stavins (1996). However, the construction industry has negative influences on the environment in Malaysia, such as soil erosion and sedimentation, destruction of vegetation, flash floods, dust pollution, and the use of building materials harmful to human health (CIDB Malaysia, 2007) hence a need to put intervention strategies to overcome the barriers.

3. Research Methodology

3.1 Research design

A mixed method approach was employed where both quantitative and qualitative data was solicited through both open and close ended questions within interviewer-administered questionnaires. The study solicited views from consultants: Architects, Engineers and Quantity Surveyors. All consultants were selected, to participate in the study, from the list of active consultants according to the specific body of professionals' resident in Harare, as the total population was relatively small. Of the 30 registered Quantity Surveying firms with the Zimbabwe Institute of Quantity Surveyors (ZIQS), 29 of them, translating to 97%, are situated in Harare. From the 44 of registered Architectural firms, with the Institute of Architects of Zimbabwe (IAZ), 41, translating to 94%, are situated in Harare. From the 46 consulting firms registered with Zimbabwe Association Consulting Engineers (ZACE), 40 of them, making 87%, are situated in Harare. With an average percentage of 92% of the total population being situated in Harare, the information is also representative of the whole country. All 110 consultants were sought for participation in the study through scheduling appointments within the data collection time frame.

3.2 Data collection methods

Interviewer-administered questionnaires were used to obtain opinions from the consultants. Saunders, Lewis and Thornhill (2009) support the use of interviewer-administered questionnaires by highlighting that they have a combination of defined themes, structured questions and open-ended questions may be asked though uniformly within all organizations. The interviewer-administered questionnaire was built up of the barriers to achieve environmentally successful construction projects from literature and intervention strategies that have or may be implemented. Literature was gathered from statutory instruments, journal articles and reports. Professionals expressed their views by ranking according to severity on a likert scale (from '1' very low extent a barrier to '5' extremely high extent a barrier). The literature driven barriers were defined with respect to their nature which are: lack of awareness, weakness in legislation, lack of government intervention, lack of pro activeness by consultants, insignificant fines to non-compliance, lack of all-stakeholder integration, lack of interest from client, lack of proper training and education and lack of incentives. To complement the quantitative data, open ended questions were included to obtain qualitative responses on the interventions that can be implemented.

3.3 Data analysis

Mean scores and severity index were used to analyze the ratings and rankings given by respondents. The statistical Package for the Social Sciences (SPSS) was used to compute the frequencies, mean scores and valid percentages used to rank the barriers and calculate the severity index (Kaming *et al.* 1997; Oladapo 2006).

The severity index is defined as:

$$S.I. = \left\{\sum_{i=1}^{i=n} w_i f_i\right\} \times \frac{100\%}{n} \quad \ldots\ldots\ldots\ldots\ldots\ldots$$

Source: Ogunbiyi (2014:118)

Where: *S.I.* is the severity index; *fi* is the frequency of response; *wi* is the weight for each rating (i.e. rating in scale/number of points in a scale), and n is the total number of responses. The value *(fi x 100)/n* is the valid percentage (Elhag and Boussabaine, 1999). This was employed mainly to ensure true ratings and rankings agreement are arrived at and eliminate the element of bias. Qualitative data was analyzed through template analysis especially on the intervention strategies that have been implemented and how they have been impacted by the subjective influence of the consultants. Saunders, Lewis and Thornhill (2009) justify its use by relaying that template analysis identifies relationships between phenomena.

4. Results Analysis and Discussion

4.1 Respondents' demographics

A total of 20 interviewer-administered questionnaires were conducted with consultants that responded to the request for interviews and also those that were able to schedule the interviews within the data collection time frame. The respondents were made up of Architects (25%), Engineers (30%) and Quantity Surveyors (45%) respectively. This represented an average response rate of 18% with regards to the total population and as suggested by Dalen (1979) that any sample from 10% to 20% is representative enough to warrant generalization of results. The demographics of the respondents who participated in the study show that they have managerial and technical experience to contribute valid opinions on the barriers as 44% of the respondents had more than 15 years' experience within the Zimbabwean construction industry. Hence, they are best able to reflect on the barriers that they had encountered and still encounter since the sustainable development drive gathered momentum through various instruments like the Environmental Management Act. Further to this, they were able to contribute on the intervention strategies they implemented and how successful these were in enhancing project success.

4.2 Barriers to environmentally sustainable construction projects

The study revealed that there are several barriers hindering the success of environmental sustainability of construction projects in Zimbabwe (Table 1). The highest ranked barrier is believed to be the most hindering factor, following the Pareto rule as suggested by Alinaitwe *et al.*, (2007). Discussion was on those barriers which had a severity of 50% or more.

Table 1: Composite analysis

	Barrier	**1**	**2**	**3**	**4**	**5**	**TR**	**MR**	**SI**	**Rank**
1	Weakness in Legislation				4	16	20	4.8	81%	1
2	Lack of incentives				6	14	20	4.7	79%	2
3	Lack of proper training and education			2	12	6	20	4.2	71%	3
4	Lack of Awareness		1	6	3	10	20	4.1	69%	4
5	Lack of interest from client			13	7		20	3.35	57%	5
6	Lack of all stakeholder integration			20			20	3.0	51%	6
7	Lack of Government Interventions		7	8	5		20	2.9	48%	7
8	Lack of pro activeness by consultants	9	11				20	1.55	26%	8
9	Insignificant fines to non-compliance	7	8	5			20	1.0	18%	9

4.2.1 Weakness in legislation

Respondents ranked weakness in legislation to be the major barrier in the implementation process of environmental sustainability management with severity index of 81%. Acts, policies and legislation that regulate the environment must be rigorous in order for the construction activities to conform to the set standards. One of the respondents indicated that the environmental regulators delay approvals hence on projects that are time sensitive; parties will be left with no option but to ignore the legislations on the environment. The respondents are in agreement with the idea that the concept of sustainable construction needs to be incorporated into the policies and processes of a business if it is to follow sustainable development principles as argued by Chari and Chiriseri (2012). This shows that new management methods, new cultural orientation and extensive refinements to systems, practices and procedures that enhance environmental construction sustainability must be put in place. A combination of the new strategies with the stakeholder theory, where all stakeholders are engaged on a whole life basis as some respondents indicated will yield better results. Voluntary regulation also can be of use to overcome the barriers when implemented out of personal ethics (Taylor, 2003); this will complement the weaknesses of the legislation.

4.2.2 Lack of incentives

Where the project sponsor is the government, political motives are the major drivers on a project hence lack of incentives was ranked second with a severity index of 79%. Respondents who have undertaken public sector construction projects cited that there is no motivation for them to embrace environmental sustainability as they work on directives from political players. This is in agreement with sentiments from the Building Research Establishment (2000) where it is said the construction industry project delivery process substantiates the need for the industry to engage with sustainable development. Those that have undertaken projects in the private sector however proffer that the need for future work is the only motivation for enhancing environmental sustainability and this is still insufficient if global and national requirements are to be met.

4.2.3 Lack of proper training and education

Profit was indicated as the main reason for carrying out construction projects. Hence the respondents indicated that few are circumstances when they would train and educate their employees on environmental sustainability issues if it is not for compliance reasons. This was ranked a third barrier with a severity index of 71%. Though the study introduces environmental sustainability as a parameter which is equally important to time, cost and quality constraints, the apparent reluctance by organizations to train and educate such issues is worrisome. This is exacerbated by the lack of curriculum reform in colleges and universities to align with the sustainability development drive. Respondents argued that on bidding, knowledge on environmental sustainability must be a pre-requisite for both the consultants and the construction companies, for meaningful strides within its context to be achieved. All employees must be partakers of the implementation process regardless of their designation as knowledge imparted through education and training is important. Pocork (2016) alludes to this by reporting that in order to ensure that the organization and its people give their backing to the sustainable development policies, an appropriate corporate culture is essential. In the process of implementing sustainable environmental management policies, many companies have experienced a kind of organizational renewal (Sezer 2016) which should be treated as a project on its own with start date and finish date, objective and outcomes. These advances have however not yet cascaded into the Zimbabwean construction industry.

4.2.4 Lack of awareness

Lack of awareness of environmental sustainability was ranked the fourth barrier with a severity index of 69%, which justifies why some respondents could not even define it. In cases where more experienced respondents gave responses they valued environmental issues in general but not with reference to sustainability. Respondents seem to agree with Watuka and Aligula (2002) when they carried out a study focusing on the design and construction teams’ awareness and participation in applying sustainable construction hence there is need for professionals to improve the levels with which they embrace environmental sustainability. Also, the respondents seem to agree with Revell and Blackburn (2007) when amongst some of the barriers in advancing environmental sustainability include lack of awareness to regulations and lack of information dissemination about new or updated regulations by the government. Lack of proper training and education and lack of awareness are two barriers that are highly related but will require different approaches to remedy. The majority of respondents argued that awareness was an immediate short-term response that must be driven by the various professional bodies through engaging environmental sustainability experts in seminars and workshops. They further went on to suggest that continuous professional development should make such seminars and workshop credits a pre-requisite for re-registration within the key professional bodies.

4.2.5 Lack of interest from client

The client was viewed as a moderator where he can aid the implementation process or hinder the process. Lack of the client's interest was ranked fifth with a severity of 57% showing the stance of the client can enhance or hinder success of projects. This is contrary to the assertion that the demand and the willingness of clients eventually determine the progress of any sustainable business. The resistance by the clients to consider all the built assets as business which must be sustainable hinders achievement of environmental sustainability (Hook and Stehn 2008). The consultants have an important role in advising the client to take a lead and initiate environmental sustainability as they are the owners on the final product. From the above discussion clients are playing a moderate role. For improvement the client must take a lead stance. The apparent difference in approach between private sector and public sector clients was noted by respondents. The major concern highlighted was that the public sector, being the larger of the two and also having a higher expectation to align with legislation, was the sector most severely affected.

4.2.6 Lack of all stakeholder integration

Lack of stakeholder integration is not as threatening as indicated by respondents since the nature and origin of the project will determine the inputs and efforts by each stakeholder hence it was ranked a lesser threatening barrier with a severity of 51%. Where the stakeholder theory being proposed by the researcher can be of great importance in facilitating projects as all the stakeholders are taken to the same level on environmental issues. This is in agreement with Revell and Blackburn (2007) where he alludes that stakeholders do not believe a clear business case exists for energy or waste efficiency measures which are environmental sustainability elements, hence integration will render it a success.

The respondents support the view by the PM journal January (2017) where the project manager has an important role to influence the whole team to embrace the environmental sustainable practices. The respondents rest the responsibility on the government which is contrary to voluntary regulation which can be of use to overcome the challenges when implemented out of personal ethics (Taylor, 2003). The PM journal (2017) is in agreement with Taylor (2003) that initiatives that are voluntary will assist greatly in achieving environmentally sustainable projects. Hence pro activeness is required from all the stakeholders.

5. Conclusions and Recommendations

Attainment of environmental sustainability standards of construction projects has remained elusive within the Zimbabwean construction industry. Conflicts and controversies continue to hamper project success and some projects being stagnant altogether even though organizations such as the Environmental Management Agency, that is mandated to regulate this environmental sustainability. Therefore, the aim of this research was to identify and rank the barriers to the achievement of environmental sustainability on construction projects in Zimbabwe. A mixed method approach was employed where both quantitative and qualitative data was solicited through both open and close ended questions within interviewer-administered questionnaires. The study solicited views from consultants: Architects, Engineers and Quantity Surveyors. All consultants were selected, to participate in the study, from the list of active consultants according to the specific body of professionals' resident in Harare, as the total population was relatively small. With an average percentage of 92% of the total population being situated in Harare, the information is also representative of the whole country.

All 110 consultants were sought for participation in the study through scheduling appointments within the data collection time frame. Respondents gave the barriers hindering successful deliverance of environmentally sustainable construction projects in their descending order of severity as follows: weakness in legislation, lack of incentives, lack of proper training and education, lack of awareness, lack of interest from client, lack of all stakeholder integration, lack of Government interventions, lack of pro activeness by consultants and insignificant fines to non-compliance.

For further research there is need to look on the influence of the political and economic elements of sustainability on success of construction projects, with particular reference to the Zimbabwean construction industry. The study will also augment into the environmental sustainability management hence improving the delivery processes of construction projects to make them a success with all parameters taken into consideration. The roles played by the government in the construction industry with regards to sustainability as it is the major player of the industry need to be researched on, this will add knowledge on legislation and initiatives on Environmental Sustainability Management as this is a major regulatory stakeholder. Also relations of all stakeholders can be established from this research where the stakeholder theory is explored further in sustainability.

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Interplay Between Infrastructure Development and Climate Change Vulnerability in Lusaka: A Desktop Survey

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Abstract

An increase in extreme weather events such as drought and dry spells, seasonal or flash floods as well as extreme temperatures has been evident in Zambia over the past few decades. Resilience of Critical Infrastructure such as Roads, power, water and the building infrastructure to such extreme weather events is one of the most demanding challenges for both government and society. Using literature study approach this research reviewed existing literature on climate change, its impacts and vulnerability in Zambia. The objectives of the study were to establish an interplay between infrastructural development and climate change related vulnerability; to investigate the extent to which the existing policy governing climate change in Zambia is relevant in addressing infrastructure development adaptability to vulnerability. The aim was to highlight the need to develop an integrated infrastructural development planning model to mitigate Vulnerability in Lusaka. The study revealed that climate change and its associated impacts are now unavoidable. Zambia is vulnerable to the adverse impacts of climate change as a result of its geographical location, the multiple socio-economic stresses it is subjected to, and its low adaptive capacity. Furthermore, the study established that climate change affects the function and operation of critical infrastructure (CI) with water frequently being cited as one of most vulnerable. Reduction in available water recharge points due to an increase in impermeable surfaces which are a part of the built environment, threatens the water supply. More so, in case of high precipitation, the impervious surfaces prevent natural infiltration of water into the ground leading to floods together with damage to critical infrastructure. Therefore, as part of the main PHD study this paper highlights the need to develop an integrated infrastructural development planning model to mitigate vulnerability.

Keywords: climate change, extreme weather events, infrastructure, vulnerability

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1. Introduction

Climate is weather averaged over an extended period of time (30-year intervals are typically used in establishing baseline climatology). The United Nations Framework Convention on Climate Change (UNFCCC) (1992, pg.3) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". Climate change is caused by greenhouse gasses (GHGs), which enhance the "greenhouse" properties of the earth's atmosphere. These gasses allow solar radiation from the sun to travel through the atmosphere but prevent the reflected heat from escaping back into space. This causes the earth's temperature to rise (Water Aid, 2007). GHG emissions have been rising since industrialization in the 1900s, due to increased burning of fossil fuels. Further significant increases in GHG levels are expected, particularly as developing countries become more industrialized. Based on present trends, the international Energy Agency (IEA) World Energy Outlook predicts a 53 percent increase in global primary energy demand by 2030, with 70 percent of that coming from developing countries. As emerging economies, such as China and India grow, their contribution to energy demand will account for an increasing proportion of the total. Fossil fuels are expected to dominate this increase, and the subsequent GHG emissions will in turn lead to rising temperatures (Ibid).

The process of climate change, with its projected changes in temperatures, precipitation patterns, wind conditions and the occurrence of extreme weather events, have clear implications on infrastructure. All human settlements are critically dependant on many types of infrastructure, from power and water supplies to transportation to systems of waste disposal (UNFCCC, 2006). In many parts of the world, particularly in developing countries, this infrastructure is already under severe strain, as a result of population growth, rural–urban migration, high levels of poverty and the demand for more roads and vehicles. All these strains are likely to interact with, and be exacerbated by, different aspects of climate change (UNFCCC, 2006).

In Zambia, Mudenda (2010) asserts that "accelerated economic and infrastructural development will probably increase the risks of climate change. Clearing forests for construction and increased industrialization will have negative consequences on the environment and atmosphere". Furthermore, Zambia needs to mainstream climate risk reduction in its developmental process because the more developed it becomes, the more vulnerable (Ibid). Hence the need to develop an integrated infrastructural development planning model to mitigate climate vulnerability. As part of the main PHD study this paper focuses on how well we can put up our infrastructure so that in cases of extreme weather events (EWEs), we are not vulnerable to low water supply or flooding together with infrastructure damage.

2. Defining Climate Change Vulnerability

Zambia National Policy on Climate Change (NPCC) (2016, pg. viii) defines vulnerability as “the degree of susceptibility to the negative effects of climate change. It is a function of the type, magnitude and frequency of climate events to which a system is exposed to (exposure) as well as the sensitivity of the system and its capacity for adaptation (adaptive capacity).” While *Yarnal et. al (2007) refers to* Vulnerability as “the degree to which people or the things they value are susceptible to, or are unable to cope with, the adverse impacts of climate change.” Vulnerability determines how severe the impacts of climate change might be. According to *Yarnal et. al (2007)* there are three dimensions of vulnerability to climate change these are: exposure which is the degree to which people and the things they value could be exposed to climate variation or change; the second dimension is Sensitivity, which is the degree to which they could be harmed by that exposure; and lastly adaptive capacity, which is the degree to which they could mitigate the potential for harm by taking action to reduce exposure or sensitivity.

The expression “things they value” not only refers to economic value and wealth, but also to places and to cultural, spiritual, and personal values (Ibid). In addition, this expression refers to critical physical and social infrastructure, including such physical infrastructure as police, emergency, and health services buildings, communication and transportation networks, public utilities, and schools and day care centers, and such social infrastructure as extended families, neighbourhood watch groups, fraternal organizations, and more (Ibid). The expression even refers to such factors as economic growth rates and economic vitality. People value some places and things for intrinsic reasons and some because they need them to function successfully in our society. Some people and the things they value can be highly vulnerable to low-impact climate changes because of high sensitivity or low adaptive capacity, while others can have little vulnerability to even high-impact climate changes because of insensitivity or high adaptive capacity. Climate change will result in highly variable impact patterns because of these variations in vulnerability in time and space (Yarnal et al, 2007).

3. Climate Change Outlook

3.1 Global perspective

Climate change and its associated impacts are now unavoidable. A growing body of scientific literature provides unequivocal evidence that “climate change will continue for many decades, and even centuries, regardless of the success of global initiatives to reduce greenhouse gas emissions” (Natural Resources Canada, 2007 as cited in Cunningham et al, 2013). The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) states that climate change is unmistakably occurring and is already visible in some recent observations of the climate. The global temperature has increased from 0.56°C to 0.92°C in the last century (1906-2005), and it is shown that 11 of the 12 hottest years between 1850 and 2007 took place in the last 12 years prior to 2007 (Hooff et al, 2014). Temperature increase between 1.1°C and 6.4°C is predicted until the end of this century, when compared to the temperatures in the period 1980-1999 (Hooff et al, 2014). However, it is important to note that the predicted climate change differs per continent, country and even per region (Ibid).

3.2 Vulnerability in Zambia

Climate change/variability have caused challenges related to extreme weather events such as droughts, floods, heat waves, spread of climate-related diseases and rise in sea level, and these are expected to increase further both in frequency and impact under a projected warmer atmosphere (IPCC, 2015). Average temperatures in Southern Africa rose by 0.5°C over the last century (Southern African Research and Documentation Centre, 2008) as cited in SADC Integrated Water Resources Management Initiative (SADC – WIN) (2017). Evidence shows climate change and climate variability will have a negative impact on water security as communities, households and individuals will become increasingly water insecure due to water scarcity and flooding (Ndaruzaniye, 2011; Lesolle, 2012).

In Zambia, according to a 2010 climate analysis of the last four decades, the Zambian Metrological Department (ZMD) established that frequency of extreme events has increased. They also recognised that there will be a change in the annual pattern of precipitation (Future Climate for Africa [FCFA], 2016). It is expected that while rainfall events will tend to become less frequent, there will be more intense rainfall events, separated by a large number of dry days. This variable precipitation is likely to have significant impacts in Zambia and on Lusaka in particular (FCFA, 2016).

Drought is likely to become more intense, with significant implications for Lusaka. The 1991–2 drought is estimated to have cost Zambia in the region of US$300 million. In Lusaka, 70% of the workforce are engaged in agricultural activity and urban agriculture is a major source of livelihoods; thus the country is particularly vulnerable to drought conditions (Ibid). Zambia also has a history of experiencing extreme flooding events. The 2006–7 rainy season saw nearly 1.5 million people affected and over the last 30 years Zambia has lost an estimated US$ 13.8 billion or 0.4% of annual Gross Domestic Product (GDP) growth to flooding and drought events (GRZ-Government of Republic of Zambia, 2007 as cited in FCFA, 2016).

4. Methodology

The method adopted in this study was a literature review approach. Information was searched out from the books, journals, scripts, dissertations, conference papers and other published reports. According to Kirsten (2017) “literature research is focused on acquiring theoretical knowledge about a concept or topic”. Literature review accomplishes several purposes. It shares with the reader the results of other studies that are closely related to the one being undertaken. Further, it relates a study to the larger, ongoing dialogue in the literature, filling in gaps and extending prior studies. It provides a framework for establishing the importance of the study as well as highlighting the gaps Creswell (2014).

5. Impacts of Climate Change on Infrastructure

According to the NPCC (2016), Zambia is vulnerable to the adverse impacts of climate change as a result of its geographical location, the multiple socio-economic stresses it is subjected to, and its low adaptive capacity. According to the study, on the economic impacts of climate change conducted in 2011 by Government, a Gross Domestic Product (GDP) loss of about USD 5 Billion over a 10 to 20-year period was estimated. The study estimated that loss of agricultural productivity and its associated effects on poverty levels, the potential impact of an energy crisis related to power generation, the higher costs of treating climate related diseases such as malaria, and the loss of natural environments which provide critical services to urban, peri-urban, and rural communities are major contributors to GDP loss.

5.1 Water and sanitation

The water resources in Zambia represent about 40% of the water resources in the Southern African region. The country has major rivers such as the Zambezi, the fourth largest in Africa and its tributaries (Luangwa and Kafue), and lakes such as Tanganyika, Mweru, Bangweulu and Kariba. In as much as Zambia has abundant water resources, the country has isolated semi-arid areas in the southern and western parts (NPCC, 2016, pg. 5). With changes in rainfall variability, these regions have experienced devastating floods and/or droughts. Furthermore, both flood and drought conditions have worsened access to safe and clean drinking water among households. This situation has increased the prevalence of water borne diseases and labour burden on women and girls who are the main drawers of water for their households in the peri-urban and rural areas. Other impacts of climate change on ecosystems include reduced flows and drying up of water bodies leading to possible degradation of aquatic habitats and disruption of aquatic ecosystem functions and services (Ibid).

With respect to sanitation, FCFA (2016, pg. 15) states that “inadequate and poorly maintained infrastructure leads to contamination of groundwater sources and significant health risks.” Only 35% of the population in Lusaka had access to a flushing toilet in 2010 and the sewer system serviced only 65% of the population in 2012. The city, via the Lusaka Water and Sewerage Company (LWSC), operates two conventional treatment plants at Manchinchi and Chunga, both are near to capacity (Ibid). The lack of sanitation infrastructure is particularly important in the informal settlement areas where contamination of ground and surface water results in serious disease outbreaks including cholera. Increased flooding events from climate change would exacerbate contamination and health concerns stemming from inadequate sanitation infrastructure, and strong storm or flooding events could further damage existing infrastructure. Drainage is a significant problem during the wet season in Lusaka as many parts of the city are flat and prone to pooling water. The health consequences of poor drainage are exacerbated by inadequate solid waste pickup and management systems (Ibid).

5.2 Urban economic infrastructure

At present Lusaka's urban infrastructure is unable to support its growing population and is typically poorly maintained. The fragility of the current infrastructure endowment is already a challenge but is one that will arguably be accentuated by climate change (FCFA, 2016, pg., 20). Extreme weather events have the potential to both create catastrophic failure in systems built within historically determined design thresholds, as well as accelerating depreciation of already under-maintained infrastructure (Watkiss, 2014).
Furthermore, FCFA (2016, pg. 21) states that "within the transportation sector roads are a key issue as damage prevents effective access to markets and hinders the penetration of services". Increased instances of flooding and storm events, or a prolonged rainy reason resulting from climate change would lead to increased water on the roads, exacerbating existing damage. More so, the built environment, including industry, commercial, and government buildings and offices, is also often poorly maintained and may be further damaged by storm or flood events. Additionally, heat damage may lead to material stress or decrease staff productivity (ibid).

6. Interplay between Infrastructure Development and Climate Change Vulnerability

The increased frequency and intensity of EWEs can cause hazard events such as flooding, drought, ice formation and wild fires which present a range of complex challenges to the operational resilience of CI. The economic and societal relevance of the dependability and resilience of CI is obvious: infrastructure malfunctioning and outages can have far reaching consequences and impacts on economy and society (Ibid). The cost of developing and maintaining Critical infrastructure is high if they are expected to have a realistic functional and economic life (50+ years). Hence, future EWE has to be taken into account when considering protection measures, mitigation measures and adaption measures to reflect actual and predicted instances of infrastructure failures *(Kiel et al., 2016)*. Climate change affects the function and operation of critical infrastructure with water frequently being cited as one of most vulnerable types of infrastructure to climate impacts (Natural Resources Canada, 2004) as cited in Cunningham et al, (2013).

To understand how infrastructural development can affect groundwater, it's important to recognize that all land has groundwater beneath it (Wisconsin Groundwater Coordinating Council, 2002). Groundwater flows through underground soil and rock materials, generally from higher to lower areas on the land surface. Sometimes we plan to directly use that groundwater, as when we drill individual drinking water wells. But even when we do not plan to use it, infrastructure development may affect both the quality and quantity of local groundwater (Ibid). Land covered with impervious surfaces such as homes, driveways, roads and parking lots may have more runoff and less groundwater recharge than undeveloped land (Ibid). Reduction in available recharge due to an increase in impermeable surfaces as part of the built environment threatens the water table. Furthermore, in case of too much rains the impervious surfaces will prevent natural infiltration of water into the underground thereby leading to floods and damage the critical infrastructure such as roads and buildings. However, increased groundwater recharge may still occur if the runoff water naturally infiltrates onsite or is infiltrated by raingardens or other storm water management systems (Wisconsin Groundwater Coordinating Council, 2002).

In Lusaka, Zambia which is the area of proposed research, according to African Development Bank (AfDB) (2015) as cited in FCFA (2016) "the aquifer appears to be under stress due to sustained over-extraction (groundwater accounts for 57% of water used in the city)" as well as pollution from industry, leakages from latrines, septic tanks and unplanned quarrying of construction materials. There is also increased consumption of ground water recharge areas due to increased urbanization (Ibid). However, it is important to note that water supply challenges in Lusaka exist primarily because of development pressures and aging infrastructure. Climate change may place additional strain on water supply if droughts decrease the availability of groundwater from already developed sources, and/ or decrease flows from the Kafue River and thus increase competition for its allocable withdrawals. Additionally, private boreholes are also drying up as a result of damage caused to aquifers as well as over extraction of the resource (FCFA, 2016). According to Mudenda (2010) Climate risks are definitely a challenge to development in Zambia. The process of climate change, with its projected changes in temperatures, precipitation patterns, wind conditions and the occurrence of extreme weather events, have clear implications on infrastructure.

7. Existing Policy Governing Climate Change in Zambia

7.1 The national policy on climate change

The National policy on climate change was passed in April 2016 whose prime objectives is to: "provide a framework for coordinating climate change programmes in order to ensure climate resilient and low carbon development pathways for sustainable development towards the attainment of Zambia's Vision 2030". The policy is guided by the following principles (NPCC, 2016):

- **Sustainable Climate Change response: -** All climate change actions shall be environmentally sustainable and positively contribute to national economic growth and social development objectives, including poverty alleviation, access to natural resources and basic amenities, gender equality and equity and infrastructure development.

- **Compliant with international obligations: -** All climate change interventions shall promote and fulfil relevant international obligations as enshrined in various Multilateral Environmental Agreements (MEAs) on Climate Change.

- **Resilience building as an integral part of the development process: -** All developmental efforts shall contribute to building resilience to climate change
- **Collectiveness and inclusiveness: -** Climate change response measures shall be done collectively and inclusively.
- **Consultative approach: -** Climate change actions shall be undertaken in an integrated, consultative and multi-stakeholder approach with special consideration for vulnerable groups.

- **Ecosystem integrity: -** Climate change actions shall take into account the important role ecosystems play in addressing the impacts of climate change.

- **Complementarity of Adaptation, Disaster Risk Reduction (DRR) and mitigation: -** Climate change actions shall recognize the complementarity of adaptation, disaster risk reduction and mitigation.

7.1.1 Adaptation and Disaster Risk Reduction Measures

The following measures have been formulated to promote and strengthen the implementation and adaptation of disaster risk reduction to lessen vulnerability to climate variability as well as change (NPCC, 2016).

- Strengthen the mechanism for identifying risks and hazards in order to facilitate planning and early warning;
- Strengthen surveillance and control of climate change related pests and diseases;
- Strengthen the resilience of infrastructure, ecosystems and promote innovation, knowledge and education;
- Promote Community-based risk management activities and use of social safety nets for the most vulnerable;
- Promote use of financial instruments such as weather-indexed insurance, carbon instruments and catastrophic bonds to enhance resilience and cover climate related risks;
- Promote the adoption of appropriate Climate Smart Agricultural (CSA) technologies for different agro-ecological zones;
- Promote landscape based livelihood diversification;
- Promote monitoring and management of wildlife habitats;
- Establish and/or strengthen mechanisms for monitoring networks and information systems for improved utilization of climatic data and information;

- Promote the communities' ability to develop physical and social infrastructure that are resilient to the adverse effects of climate change; and
- Promote the protection of water catchment areas, including the development of environmentally friendly infrastructure for bulk water transfer (water ways), storage, management and utilization of water resources.

7.2 Other Sectoral Legal Frameworks

The implementation of the National Policy on Climate Change is complemented by other sectoral legal frameworks which includes the following as shown in Table 1.

Table 1: Existing legal frameworks complementing the national policy on climate change in Zambia

Enabling Act	**Purpose**
Environmental Management Act No. 12 of 2011	The Act provides for the management of environment and natural resources
Forest Act No. 4 of 2015	The Act provides for the conservation and protection of forests and trees
Zambia Wildlife Act No. 15 of 2015	The Act is responsible for wildlife management and conservation
Lands Act Cap 184	The Act is responsible for the management and administration of land in Zambia
Agriculture Lands Act Cap 187	The Act provides for sustainable agricultural practices, development, investment and management
Agriculture (Fertilizer and Feed) Act No. 13 of 1994 , Cap 226	The Act provides for the regulation and control of manufacture, processing, importation and sale of agriculture fertilizers.
Energy Regulations Act No. 23 of 2003	The Act among other issues regulates energy use and efficiency
Mines and Minerals Act 11 of 2015	The Act provides for mineral and mines development
Urban and Regional Planning Act No. 3 of 2015	The Act provides for planning for all land in Zambia
Road Traffic Act No. 11 of 2002	The Act provides for road safety and transport management
Water Resources Management Act No. 21 of 2011	The Act provides for the regulation and management of water resources
Zambia Development Agency Act No. 11 of 2006	The Act provides for the trade, investment and industrial development in Zambia
National Heritage Conservation Commission Act, Cap 173	The Act provides f or heritage conservation and management
Fisheries Act No. 22 of 2011	The Act provides for sustainable fisheries and aquacultural development and management.
Disaster Management Act No. 13 of 2010	The Act provides for Disaster preparedness and response.
Public Finance Act No. 15 of 2004	The Act provides for the control and management of Public Finances

Source: NPCC (2016)

8. Conclusion

Resilience of Critical Infrastructure to Extreme Weather Events, such as heavy rainfall or drought is one of the most demanding challenges for both government and society. Zambia is vulnerable to the adverse impacts of climate change as a result of its geographical location, the multiple socio-economic stresses it is subjected to, and its low adaptive capacity. Further, Climate change affects the function and operation of critical infrastructure with water frequently being cited as one of most vulnerable. Reduction in available recharge due to an increase in impermeable surfaces as part of the built environment threatens the water supply. More so, in case of high precipitation, the impervious surfaces prevent natural infiltration of water into the ground leading to floods together with damage to critical infrastructure. Hence there is need to develop an integrated infrastructural development planning model to mitigate such vulnerability.

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Critical Analysis of Design Standards for Zambia Transportation Infrastructure: The Implication of Climate Change

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Abstract

Infrastructure is the backbone for our society which the government, companies and citizens rely on. The availability of a good road network infrastructure is vital, and factors that affect the roads negatively should be avoided or prevented at all costs. However, extreme weather events due to climate change pose a great risk on critical infrastructure such as roads demanding for a timely revision and updating of the road design standards. This paper analysed the road design standards performance relative to sub-base and base layers of paved roads in Lusaka and how climate change has an implication on them. The methodology adopted for the study included both the qualitative and quantitative approaches. Detailed literature review, laboratory testing as well as interviews with respondents from Road Development Agency, Ministry of Works and Supply as well as the Meteorological Department of Zambia were conducted. The research established that there is a change in rainfall and temperature patterns by 1.4417mm and 0.0044°C respectively. Further, that the road design standards widely used in Zambia are the Government of the Republic of Zambia (GRZ) Guidelines as well as the Southern Africa Transport and Communication Commission (SATCC) which are outdated and consider climate change based on historical events. The paper therefore recommends revision of the current SATTC design standards in order to cater for projected future changes in climate. More so, that Zambia should have a periodic revision of design standards, this is because climate and other environmental factors that affect pavements keeps changing periodically.

Keywords: climate change, design, infrastructure, standards, transportation

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1. Introduction

The United Nations Framework Convention on Climate Change (UNFCCC, 2007) defined climate change as a change in climate attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which in addition to natural variability is observed over comparable time period. This change implies increased or decreased rainfall, high temperatures, rising sea levels and other weather-related disasters such as storms.

Climate change is slowly affecting the various sectors of the economy which include transport, construction, water supply and sanitation, agriculture, forestry, fisheries, tourism, health, mining, and the manufacturing industry. This is justifiable by the following; high temperatures combined with increased solar radiation may reduce the life span of asphalt road surfaces by causing cracks due to the softening of the surface, hence making the roads impassable. High rainfall cause pothole development on constructed roads and floods, thereby causing delay of transportation of goods and services and traffic accidents (Tayor M., and Philp M., 2011) . High rainfall causes flooding of the drainage system as well as an in increase in the soil moisture which affect the substructure of the structure. This research is narrowed to studying the implication of climate change on the design standards of the transportation infrastructure, specifically road infrastructure.

The fourth assessment of the Intergovernmental Panel on Climate Change (2007) documented that the emission of greenhouse gases has increased by 70% from 1970 to 2004 due to human activities. Increased greenhouse concentration in the earth's atmosphere traps some of the sun's heat; affecting global average surface temperature, sea levels and the Northern Hemisphere's snow cover (Kalantary, December 2010). Clearly, this indicates an increase of climate change due to human activities by 70% in the same time period, and more due to other activities. Completely curbing the causes of climate change is futile, therefore the need to make adjustments in other sectors such as design standards.

Design standards provide uniform application of the best engineering knowledge that has been developed over time through experimental studies and actual experience (Meyer, 2008). The knowledge is based on the physical forces acting upon the structure such as fixed load, wind loads, seismic forces, dynamic loads, buoyancy and wave loads, as well as material properties due to pressures and temperatures. An understanding of how environmental factors affect the designed structure or the material components in the structure is important when applying engineering design standards. Therefore, the design of structures such as roads cannot be divorced from the environment in which they are built in, otherwise failure will occur (Li Q., 2011). Climate changes such as temperature change may cause gradual changes to the designed structure, thus an acknowledgement of climate change in making design standards is very important. Considering how changing environmental conditions over a longer timeframe could affect how engineering design should occur, and in particular, whether current design standards and principles are adequate for infrastructure that could potentially last a 100 year.

2. Climate Change on Transportation Infrastructure

Transport or transportation is the movement of passengers, goods and services from one point to another. The modes of transport include rail, road, air, water, pipeline, cable and space (Fred, 2016). An efficient mobility system for goods and services is an essential facilitator of economic development. A poor transportation system may lead to delays in the movements of goods and services. Climate change threatens the sustainability of critical transport infrastructure such as road networks. According to Meyer (2008) “the design standards set 50 years ago, are not sufficient to accommodate the impacts of Climate change now. He stressed the need to review and revise the United States of America highway design standards by developing new design standards to address future climate conditions”.

Madan (2009) examined the impacts of Climate change on Transport in Asia by identifying the vulnerable components of transport infrastructure which are at high risk. The study established that design consideration is an important aspect for adaption. And that there is need to strengthen institutional capacity to initiate policy guidelines and implementation of adaption programs.

Daniel (2014) assessed the economic impact of climate change on road infrastructure using the stressor-response methodology. The analysis indicated that it will cumulatively (2020-2100) cost Ghana US$473 million to maintain and repair damages caused to existing roads as a result of climate change, compared to US$678.47 million if the country adapts to the designing and construction of new road infrastructure expected to occur over the asset’s lifespan. The research provides decadal and average annual costs up to the year 2100 for the ten regions through the potential impacts of 54 distinct potential climate scenarios.

LiQ (2011) observed that “pavements are designed, constructed and maintained based on typical historic climatic patterns, reflecting local climate and incorporating assumptions about a reasonable range of temperatures and precipitation levels.” Changing climate can impact the properties of pavement layers, making them susceptible to accelerated damage under traffic loading, reducing their serviceable life span, and increasing maintenance costs (Daniel., 2014).

3. Climate Change in Zambia

Climate change/variability have caused challenges related to extreme weather events such as droughts, floods, heat waves, spread of climate-related diseases and rise in sea level, and these are expected to increase further both in frequency and impact under a projected warmer atmosphere (IPCC, 2015). Average temperatures in Southern Africa rose by 0.5°C over the last century

(SADC/SARDC, 2008)as cited in SADC Integrated Water Resources Management Initiative (SADC –WIN) (2017).

In Zambia according to a 2010 analysis of the last four decades of climate, the Zambian Metrological Department (ZMD) established that frequency of extreme events has increased. They also recognised that there will be a change in the annual pattern of precipitation (Future Climate for Africa [FCFA], 2016). It is expected that while rainfall events will tend to become less frequent, there will be more intense rainfall events, separated by a large number of dry days. This variable precipitation is likely to have significant impacts in Zambia and on Lusaka in particular (FCFA, 2016).

3.1 Temperature

Analysis of the decade circles from 32 meteorological stations in Zambia shows that summer temperatures have been increasing at the rate of 0.6°C per decade. Temperature variations can cause pavement damage due to expansion, contraction and slab curing. Excessive contractions result in large transverse cracks. The impacts of temperature on asphalt pavement is different from that of concrete pavements. High temperatures decrease the stiffness of the Asphalt pavement, thereby increasing the rate of rutting. This results in a loss of pavement texture which can be a cause of traffic accidents. Rutting, which is observed to occur during the day when the temperature of the road surface exceeds 45°C, also reduces skid resistance of the road surface. Rigid pavements are prone to slab buckling as a result of expansion induced by high temperatures (ZMD).

3.2 Rainfall

The quantity and intensity of precipitation affects the quantity of water infiltrating into the subgrade and the depth of ground water table. Data from all of Zambia’s meteorological stations reflect that of the 14 years between 1990/1991 and 2003/2004, at least ten years experienced below normal rainfall in each AER. “Currently, Zambia experiences an average annual potential evapotranspiration (ranging from 1394 to 1892 mm) that exceeds average rainfall (estimated at 684 mm between 1970 and 2000) resulting in a precipitation deficit of up to 1100 mm each year.” (Mwanaumo, 2017). Rainfall variations have an adverse impact on pavements. Increased precipitation will increase the moisture content of granular sub-layers under the surface of the pavements. The effects are stripping (loss of adhesion), bearing capacity problems and rutting. Excess water in the foundation reduces the foundation’s bearing capacity and stability, thus the road is prone to fail under minimum loadings. Stripping reduces the road’s Shear strength as the aggregate contact and interlock is reduced.

Figure 1:Sinazeze- Maamba Road (Source: Mwebantu Media)

Figure 2: Luangwa- Feira Road D145 (Source: www.rda.org.zm)

Effects of climate change on road infrastructure have been evident as shown in figures 1 and 2. Figure 1 show the Sinazeze-Maamba road which failed due to the flooding of the foundation of the road. The design of the road did not carter for future climate changes that will yield higher rainfall that the drainages and culverts can contain. Similarly, figure 2 is D145 Luangwa-Feira Road that failed due to heavy rainfall and suspected seismic movements in the area. The underground water (due to high rainfall) from the nearby mountains had seeped into the foot of the mountain and the pavement layers of the road caused shearing on a section approximately 300m.

4. Road Standards and Design in Zambia

Engineering Design Standards are accepted practices adopted by engineering professions to provide uniformity in the application of engineering knowledge (developed overtime through experience and experimental studies) in the design, construction and maintenance of infrastructure. (Michael, 2009). Design knowledge is based on an understanding of forces acting on an engineered structure and how the structure will withstand these forces without failing. Construction and maintenance are dependent on the designs.

Design standards vary depending on the region. The forces such as Seismic forces experienced in one region cannot be considered in another different region, or the weather conditions such as snow and rainfall. Therefore, the standards used are different and require to be revised as the factors that influence them keep changing with time. Zambian transportation infrastructure is designed based on the Southern African Transport and Communication Commission (SATCC) Standard Specifications for Roads and Bridge works and Government Republic of Zambia

Pavement Design Guidelines. Other technical standards such as the Technical Recommendations for Highways (TRH), Technical Methods for Highway (TMH), Road Note (RN) and Overseas Road Notes (ORN) are used to supplement the SATCC and GRZ standards

4.1 Southern Africa Transport and Communication Commission (SATCC)

The Southern African Transport and Communication Commission was declared on 1st April 1980 by the governments of Southern African Development Community (SADC) and was approved in July 1981. It is aimed at coordinating the use of existing transport and communications systems and the planning and financing of additional regional facilities to establish efficient, and sustainable transport, communication and meteorology services in the region. The code covers things such as; drainages, earthworks and Pavement Layers of gravel or crushed stone, asphalt pavements and seals; ancillary roadworks; structures as well as testing and Quality control (SATCC, 1998).

4.2 Government of the Republic of Zambia (GRZ) Pavement Design Guidelines

It gives a brief description on the relevant design parameters, design traffic, climatic conditions, and subgrade bearing capacity, material properties for the pavement layers and how they can be combined. The standards units of measurements are based on International System of Units, SI. The design methods in the guideline are adopted from the American Association of State Highway Transportation Officials (AASHTO) design concept as set forth in the "ASSHTO Interim Guides for Design of Pavement Structure", 1972-1986. The other adopted design methods are from the Transport and Road Research Laboratory (TRRL) design stated in road note 31. These designs are applicable to the different climatic conditions encountered in the SATTC region.

5. Methodology

The research method adopted in this study involved the use of both qualitative and quantitative approaches. According to Rajasekar (2006), quantitative research is based on the measurement of quantity or amount. It is applicable to phenomena that can be expressed in terms of quantity. Qualitative research on the other hand is concerned with qualitative phenomenon, i.e., phenomena relating to or involving quality or kind. Qualitative and quantitative methodologies were employed to investigate, analyze and compile the required information because the study is centred on both the deductive approach and inductive approach.

Interviews were conducted targeting the Road Development Agency (Construction Unit and Planning and Design), Ministry of Works and Supply (Buildings Department) as well as the Meteorological Department of Zambia. These were used to study and analyze the Zambian road design standards and climate respectively. The respondents had experience in pavement design, evaluation and analysis.

6. Findings

6.1 An assessment was carried out to determine the effects of climate change on precipitation and temperature in Lusaka

The findings of the results collected from the three different site stations in Lusaka namely; Lusaka City, Kenneth Kaunda Airport and Mt Makulu Station for the period in years from 1990 to 2016 revealed an average increase in rainfall pattern of 1.4417 as well as an average change in temperature of 0.0044 as shown in figure 3.

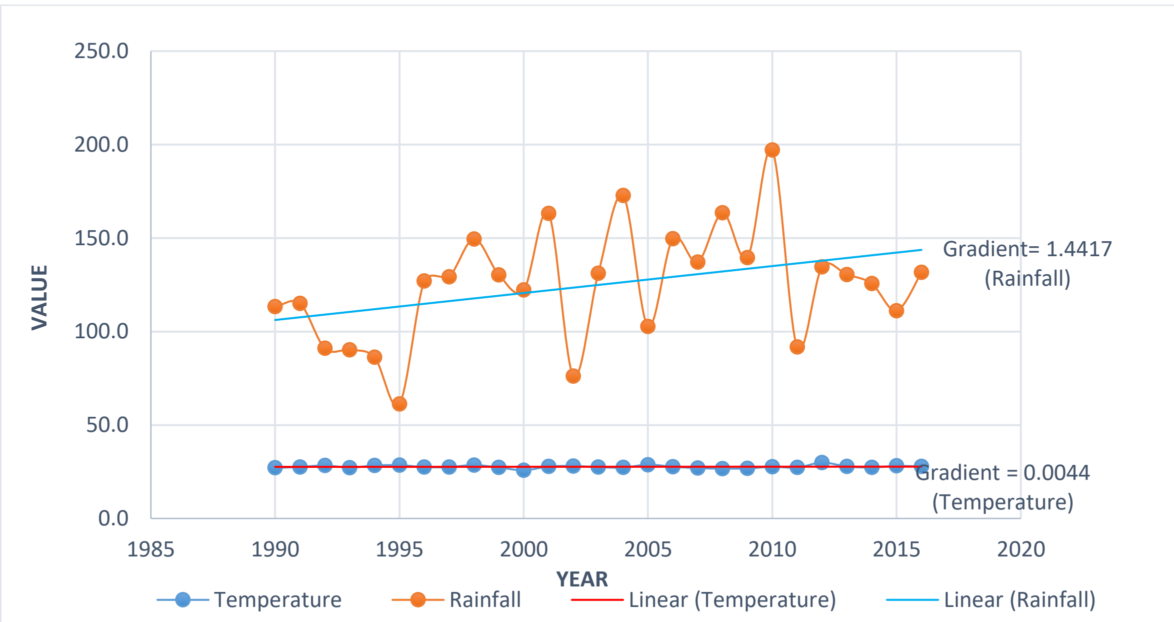

Figure 3: Average Temperature and Rainfall

6.2 Climatic and environmental factors affecting the design of pavement structures

The findings of the study revealed that climatic and environmental factors are always accounted for in the designs, but that, they are based on average historical data collected over the years. Furthermore, that factors considered are; rainfall, temperature, Humidity, Soil types and its drainage capabilities, Stage measurements of streams and rivers; Winds, and Flooding. The research revealed that the factors with the highest impact on the design are rainfall and temperature. These are used in SATCC code to establish whether a region is nominally dry or wet, which forms the basis of which catalogues to be selected.

The respondents outlined the following as the advantages of using the SATCC; the code of practice is regionally accepted and applicable in the Southern region of Africa; it is familiar to most players in the road sector; it is quick and cheap to apply; it is easy to follow and handy for the field design works as it is not too academic.

However, the respondents highlighted the following to be the shortfall attributed to the use of the SATCC code; it was indicated that regardless of the code being customized to the Southern African conditions, some conditions are not reflected in the Zambian regions. These regions mainly include climate patterns and types of construction materials; The code does not take into account the weathering of materials proposed into pavements as well as the fact that it does cover sandy subgrade materials adequately. Further, comments on the GRZ guidelines were that the guide need to be revised as it is out of date.

7. Discussion

7.1 Effects of climate change on road base and sub-base

Weather has an influence on the construction and performance of roads. Changes in the weather patterns affect the road infrastructure negatively. Extreme changes in precipitation levels yield either droughts or floods. Intense precipitation events lead to increased flooding of the road foundations. This in turn affects the base layers of the roads by breaking the intermolecular forces and adhesion forces between the soil particles. Furthermore, flooding weakens the foundation layers of the road thereby, affecting its capacity to support the loads of various carriages as well as leading to corrugation. During intense precipitation events, the temperature is very low; therefore, the soil moisture content becomes high as the rate of evaporation is lower than the rate of infiltration. The resultant is a foundation with very low stability to endure the pavement loadings

More so, during periods of drought events, the temperatures are very high while precipitation is low. High temperatures cause the softening of the road surface (for bituminous surface finishing) and expansion of the base and sub-base layers of the road. The expansion of the road layers can damage the road, thus causing the cracking effect.

7.2 Road design standards used in Zambia

Road Design standards are guidelines that provide uniform application of the best engineering knowledge that has been derived over time through experimental studies and actual experience (Meyer, 2009). From Meyer’s definition, design standards require to be updated over time as knowledge keeps evolving and new, advanced experiments are developed. The “engineering knowledge” is based on understanding the underlying physical forces, such as fixed forces and dynamic loads, acting upon an engineered structure. Other factors considered are changes in material properties due changes in the weather or loadings. The selection of respondents was based on their work experience in the design, evaluation and analysis of pavement design. All the respondents had at least 5 years of work experience. This gave an assurance of how much knowledge and how firm their standing is in the topic.

In analysing the design standards used in Zambia, the study revealed that two design standards are used namely the SATCC and GRZ guidelines. The SATCC Standard Specifications for Road and Bridge Works is a draft which was published in 1998. On the other hand, the GRZ guidelines were published in 1994. Both guidelines consider climate change based on historical events whilst on the contrary, current studies recommend future prediction of climate change rather than basing it on historical events as climate keeps changing all the time at different rates. Therefore, the answer to “whether or not the currently used design standards cater for changes in climate change” is no. This is because the guidelines are still out of date and there is a need to update them based on current climatic changes and predicted climatic conditions.

8. Conclusion and Recommendations

The study established that the Zambian Roads are designed based on the SATCC and GRZ guidelines. These are the main design standards used. However, both standards have a lot of shortfalls. The SATCC is generalized to the Southern African conditions, but due to varied climatic conditions in the region, it does not suffice fully for the Zambian conditions. The GRZ guidelines are obsolete and their application restricted mainly for reference purposes. The design standards are supplemented by other technical standards such as the Technical Recommendations for Highways (TRH), Technical Methods for Highway (TMH), Road Note (RN) and Overseas Road Notes (ORN). The study further established Changes in rainfall patterns as well as temperature variations and that this has an effect on the base and sub-base layers of the roads infrastructure. The change in weather conditions yields failure of the foundation layers either during flood or drought conditions.

The research therefore recommends that, there is need to revise the Zambian Transportation design standards with regards to climate change. Seeing that the climate varies in the three regions, safety factors for each region should be considered to carter for future climatic changes. A policy should be implemented to have a periodic revision of design standards in Zambia.

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Professional Ego Versus Maslow's Hierarchy of Needs during Execution of Infrastructure Projects

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Abstract

The delivery of infrastructure projects not only benefits the initiators or clients of the projects, but also constitutes the agent for fulfilling self-developing needs of professionals. The purpose of this study is to identify the extent to which professional needs are hierarchised as compared with five Maslow's motivation needs and to test if there is any subsequent statistical significant difference between those professionals. A nationwide web survey was adopted for data gathering using a questionnaire to purposively selected professionals including quantity surveyors, project managers, architects, and consulting engineers. In total, 99 professionals participated in the survey. Data were analysed using descriptive and inferential statistics, namely Kruskal-Wallis and Mann-Whitney. Findings revealed the development of area of expertise of professionals ranked as a first need, and this corresponds with Maslow's top level need. The desire to gain experience towards professional registration was least-ranked. This implies that respondents are concerned with developing their areas of expertise. A statistical significant difference was found between architects against quantity surveyors and project managers. The difference demonstrated diversified professional needs towards the fulfilment of the professional ego, and this explained the reason why professionals involved with the projects have their specific professional identity. Further studies should establish the cause of this statistical difference. Respondents were dominated with higher level management profile; lower level employees would have revealed different patterns.

Keywords: infrastructure, Maslow's hierarchy of needs, professionals, self-development

1. Introduction

The process for delivering infrastructure projects does not only achieve the economic growth of a country; but also, constitutes the opportunity for empowering professionals involved into the execution of these projects. During the execution of infrastructure projects, involved professionals are motivated towards higher performance to meet project objectives; subsequently, their personal and professional needs are met. In the context of the study, construction professionals include architects, quantity surveyors, consulting engineers, and project managers. Henceforth, it is

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imperative to identify needs of professionals employed into the project to motivate them towards higher performance. Luthans (2005) indicates that the focus on identification and understanding of employees' needs is classified under content theories. Milkovich and Newman (1993) establish content theories pertain to fostering what motivate people rather than how they motivated. Early content studies by Abraham Maslow established that employees are motivated by five levels of needs arranged in hierarchical order of priority. Odendaal and Roodt (2003) indicate Maslow's hierarchy of needs include physiological, safety, social, esteem, and self-actualization. Cole (2004) describes that basic needs are placed at the bottom and higher needs at the top. Construction professionals involved into infrastructure projects should be motivated to instil them taking the advantage of this opportunity to strengthen their professional self-development needs. Hence their involvement constitutes and agent for moving from bottom to top level professional self-development needs.

Contextually, self-development needs should be understood as those needs satisfied throughout the professional development process whereby the execution of infrastructure project constitutes an empowering agent towards attaining professional ego. Professional ego should be understood as the identity acquired during empowering process. Given that each professional body has its specific requirements in terms of professional development, professional ego may differ from one profession to the other. For example, attaining professional registration may require one having worked on a number of projects, and or having covered specific aspects of the project. Covering specific aspects of the project demonstrates at what extend a professional has been empowered towards attaining the professional identity within acceptable practice protocols. While Maslow's hierarchy of needs template constitutes a basis for understating needs of employees, it is not evident whether construction professionals involved into the execution of infrastructure projects subscribe to this hierarchical order. The study by Bowen and Cattell (2008) on quantity surveyors' satisfaction and career issues identified the recognition for extraordinary work, opportunity to do challenging and creative work, non-repetitive work, degree of supervision and initiative, participation in decision-making, and opportunities for social interaction to be statistically significant in quantity surveying professionals. McKay (2014) matching Maslow's hierarchy of need and architecture, believed the access to higher level requires the satisfaction of lover level needs. McKay (2014) contends that if higher level needs remain unfulfilled, the person regresses to lower level needs that appear easier to satisfy. Orfano (2016) believes for any project to be successful, all its needs have to be met. Hence, Orfano (2016) states project managers can use Maslow's hierarchy of needs in the context of projects and their management. The objective of this study is to identify at what extend professional needs are hierarchised as compared with Maslow's hierarchy of needs. The hypothesis will test whether there is any statistical significant difference in terms of professional ego needs between professionals involved into the execution of the project.

2. Professional Needs Versus Maslow's Hierarchy of Needs during the Execution of Construction Projects

2.1 Duties of professionals enhancing the development of their identity

The delivery of infrastructure project involves the participation of various professionals, who along the process, develop and strengthen their professional identity. Participants to the infrastructure projects have to be motivated towards higher performance. It has believed that money motivates people towards higher performance since is helps employee to satisfy their needs. However, professionals may be motivated by other professional development needs factors other than money.

Professional development is linked to the performance of duties and core functions for each profession. RICS (2012) proposes the duties that can be carried out by a quantity surveyor and these include the following: preparing feasibility studies or development appraisals; assessing capital and revenue expenditure over the whole life of a facility; advising clients on ways of procuring the project; advising on the setting of budgets; monitoring design development against planned expenditure; conducting value management and engineering exercises; managing and analysing risk; managing the tendering process; preparing contractual documentation; controlling cost during the construction process; managing the commercial success of a project for a contractor; valuing construction work for interim payments, valuing change, assessing or compiling claims for loss and expense and agreeing final account; negotiating with interested parties; and giving advice on the avoidance and settlement of disputes.

Project management is the management of projects within the built environment from inception to completion, including management related professional services, hence, the construction project manager is the one point of responsibility in this regard (Government Gazette, 2010). The role of the project manager is to lead the project team to ensure a quality project within time, budget and scope constraints (Oberlender, 1993).

In the context of the study, consulting engineering will comprise the compilation of Jackson (2004) who proposed a following list the most common consulting engineering services associated with construction activities: structural engineers, mechanical engineers, electrical engineers, and civil engineers. Structural engineers design the timber, concrete, or steel structural systems that support a building and basically hold it up to withstand the forces of wind, gravity, and seismic activity. Structural engineers calculate strengths and deflections, foundation sizes, beam thicknesses, and strength of floor slabs (Gould & Joyce, 2009). Mechanical engineers design the heating, cooling, ventilating, and plumbing systems within a building (Jackson, 2004; Gould & Joyce, 2009). They coordinate their efforts with the architectural design, the structural design, and the electrical design (Jackson, 2004). Electrical engineers design and calculate electrical loads and determine the circuitry, lighting, motors, transformers, and telecommunications needed for a building (Jackson, 2004; Gould & Joyce, 2009). They typically work closely with the architect to ensure that the client's expectations are met and often coordinate their efforts with the mechanical engineer (Jackson, 2004). Civil engineers design roads, bridges, tunnels, dams, site drainage, parking lots, runways, and water supply and sewage systems (Jackson, 2004; Gould & Joyce, 2009). They are the ones that take bare land and excavate it, move it, drill it, and shape it to meet the needs of the architectural design and construction (Jackson, 2004). Jackson (2004) refers to architects as licensed professionals trained in the art and science of building design, whose responsibility is to transform the client's programme into concepts and then develop concepts into building images and plans that can be constructed by others. An architect's responsibilities are to translate and develop the client's requirements and graphically represent them so that the contractor can accurately price, schedule, and implement the design (Gould & Joyce, 2009).

2.2 Hierarchy of needs for professional development

Given the discussed duties and functions of professionals above, it is obvious each professional body has its own expectations and hierarchy in terms of professional development. However, it is not evident whether the hierarchical order of their needs follows Maslow's hierarchy of needs pattern. Figure 1 depicts Maslow's hierarchy of needs versus self-development needs required by professionals to develop their identity. Starting from the bottom, physiological needs include food, water, air, and shelter and people concentrate on satisfying these needs before turning to higher-order needs (Lewis, Goodman and Fandt, 2004; Luthans, 2005). On the opposite side, analogically, self-development needs are seen as securing relevant employment from which one has gain professional experience. General security needs reflect the desire to have a safe physical and emotional environment and these include job security, grievance procedures, health insurance, and retirement plans (Lewis *et al.*, 2004). Impliedly, professional self-development needs would be working towards professional registration. Social needs are understood as the sense of belonging and acceptance: qualities that are found normally in friends (Odendaal & Roodt, 2003). Professional self-development needs could be analogically seen as the recognition and approval by peers for performance. Recognition includes participation in events where professionals are rewarded for good practice. People with esteem needs want others to accept them and to perceive them as competent and able (Lewis *et al.*, 2004:463). With regard to professional self-development, esteem is the stage whereby professional attains confidence to work with minimum or without supervision. As a result, professionals attain the maturity, leave their employment and become entrepreneurs who open their own companies. Odendaal and Roodt (2003) stipulate that self-actualization consists of the stage where one possesses potential and achieves self-fulfilment. Self-actualization may involve delegating employees to special assignments that capitalise on their unique skills (Lewis *et al.*, 2004). In infrastructure development context, this is the stage whereby the professional has reached a higher level of performance and develop unique area of expertise.

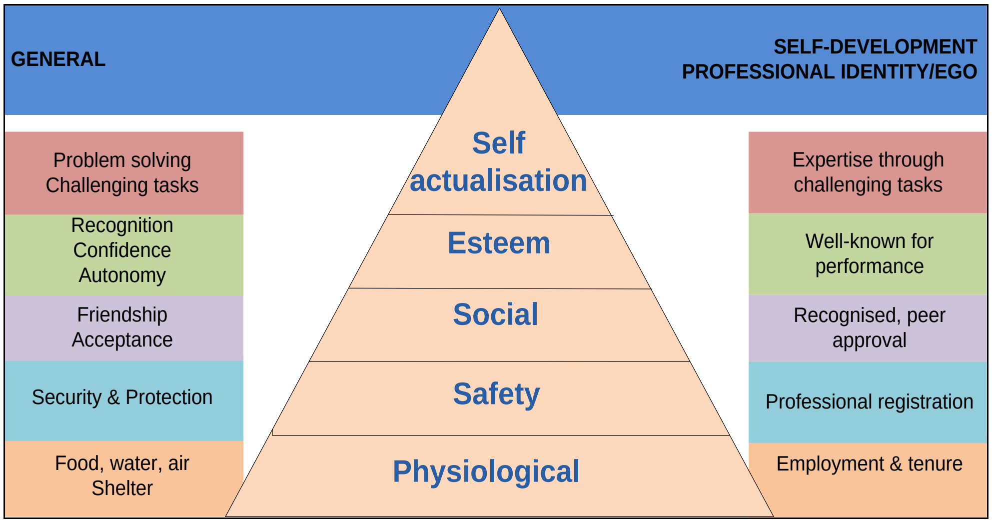

***Figure 1: Maslow's triangle of the hierarchy of needs versus professional development needs*)**

3. Methodology

A quantitative method was used through a survey questionnaire designed with closed-ended questions. One section was dedicated to biographic profile of respondents and the other section consisted of questions evaluating the importance of self-development needs motivating professionals towards higher performance in a construction project. Likert scale questions were in the following format: 1 = unimportant, 2 = little important, 3 = somewhat important, 4 = important, 5 = very important, 6 = extremely important, 7 = utmost important, and U = Unsure. Using a 7 point Likert response format allows the respondents more granularity and hence better decision-making to express how much they agree or disagree with a particular statement.

A web survey strategy was used to gather the empirical data whereby a questionnaire was distributed nationwide by email. Both descriptive and inferential statistics were used to analyse the data by means of IBM SPSS version 24. Descriptive statistics consisted of mean scores and standard deviations. Inferential statistics consisted of testing the statistical significance difference between groups of professionals. Fellows and Liu (2008) propose using the Mann-Whitney U-test when there are two samples, and the Kruskal-Wallis K-Test when there are three samples or more. For this particular study, the internal reliability of variables was tested using Cronbach's alpha coefficient of reliability. Maree and Pietersen (2007) suggest the guidelines for the interpretation of Cronbach's alpha coefficient as follows: 0.90 – high reliability, 0.80 – moderate reliability, and 0.70 – low reliability. Particularly, the reliability for this study was 0.8, hence, the findings of the study are moderately reliable.

4. Findings

4.1 Research participation

Table 1 shows the target population and participation rate. The target population was registered professionals falling under councils regulating architects, quantity surveyors, consulting engineers, and project managers in South Africa. While 77% of emails were delivered, only 2.25% professionals completed the questionnaire. Valid respondents included project managers (32%), architects (27%), quantity surveyors (27%), and consulting engineers (13%).

Table 1: Target population and participation rate

	Target population				**Participation**		**Valid respondents**	
Participant professionals	**Sent out (No.)**	**Not Delivered (No.)**	**Delivered (No.)**	**Delivered %**	**No.**	**%**	**No.**	**%**
Project Managers	2825	558	2267	80	32	1.41	32	32
Architects	1730	442	1288	74	27	2.10	27	27
Quantity Surveyors	719	215	504	70	27	5.36	27	27
Consulting Engineers	466	122	344	74	13	3.78	13	13
Total	**5740**	**1337**	**4403**	**77**	**99**	**2.25**	**99**	**100**

Table 2 shows that 73% of the respondents had more than 10 years in the construction industry, and almost 50% of respondents had more than 10 years in their positions. Most respondents (93%) occupied higher management positions, among others positions included directors, managers, owners, and principals. There was a little proportion of lower level employees which included junior quantity surveyors and candidate architects (7%). Most obviously, this has an implication on findings since self-development needs vary in accordance with the amount of experience one possesses.

Table 2: Experience of respondents in both the construction industry and their positions

Experience	**Construction industry**		**Current position**	
	N	%	N	%
Less than 5 years	5	5	23	23
5-10 years	22	22	28	28
Over 10 years	72	72	48	48
Total	99	100	99	100

4.2 Presentation of findings and discussions

4.2.1 Hierarchy of professional needs in an infrastructure project

Table 3 displays responses of respondents who were asked to indicate the importance of self-development needs motivating professional towards higher performance in a construction project where 1 = unimportant, 2 = little important, 3 = somewhat important, 4 = important, 5 = very important, 6 = extremely important, 7 = utmost important, and U = Unsure. It is evident that the development of area of expertise has ranked first with mean score of 6.00 while the corresponding level in Maslow is at top level. This position is justified by the fact that most respondents had wealth experience in both the construction industry and their positions as well. They were at top level of their professional career. Furthermore, the desire to gain experience towards professional registration which had least mean score of 5.02 is an evidence that participants' main concern was the attainment of expertise and specialization in their professional field. Worthy to note, is the maintenance of performance to secure employment which came at the second position with a mean score of 5.51; this corresponds with Maslow's lowest motivation need. Impliedly, this implies the pressure experienced by construction professionals to secure new jobs for their companies and compulsory participation into continued professional development events. From the ranking of professionals, it is evident that architects score highest mean of 6.2, followed by consultant engineers (5.55), then quantity surveyors (5.08), and lastly project managers (5.36). Impliedly, this shows architects put emphasis on professional needs more than other professions; this is their ego or identity which differentiates them from other professions.

Table 3: Type of project participants have been involved in

Professional needs	**N**	**Arch**	**CE**	**QS**	**PM**	**Tot**	**Rank**	**Maslow**
The development of my area of expertise through challenging tasks	97	6.65	5.85	5.84	5.66	6.00	1	5
The maintenance of performance to secure my employment	97	6.16	5.77	5.63	4.81	5.51	2	1
The approval of professional performance by peers	98	5.81	5.58	4.81	4.68	5.14	3	3
The aspiration to be a well-known professional figure	98	5.51	5.08	4.46	5.38	5.13	4	4
The desire to gain experience towards my professional registration	95	5.96	5.54	4.68	4.34	5.02	5	2
Average Self-development needs		6.2	5.55	5.08	4.98	5.36		
N		27	13	27	32	99		
Ranking of professionals		1	2	3	4			

4.2.2 Test of the hypothesis on hierarchy of professional needs

Table 4 displays results of the test for the normality of self-development needs. A non-significant result (sig value of more than 0.05) indicates normality (Pallant, 2010:63). Given that the sample size is greater than 50, the significance level is based on the Shapiro-Wilk test (Field, 2013:188).

Given the obtained significance value of 0.00, Pallant (2010:63) and Field (2013:185) conclude the normality has been violated; thus the hypothesis was computed using non-parametric tests namely the Mann-Whitney and Kruskal-Wallis tests.

Table 4: Tests of normality for self-development needs

Self-development	**Kolmogorov-Smirnov**			**Shapiro-Wilk**		
	Statistic	Df	Sig.	Statistic	Df	Sig.
	0.142	94	0.00	0.924	94	0.00

The Kruskal-Wallis test was conducted to test the null hypothesis on statistical difference between professional in terms of self-development needs. From Table 5, given that the significance level is 0.014, the null hypothesis is rejected.

Table 5: Tests of significance difference between groups

Self-development needs	**Kruskal-Wallis**	**Df**	**Sig.**
The maintenance of performance to secure my employment	9.285	3	0.026
The desire to gain experience towards my professional registration	10.386	3	0.016
The approval of professional performance by peers	8.573	3	0.036
The aspiration to be a well-known professional figure	6.241	3	0.100
The development of my area of expertise through challenging tasks	10.584	3	0.006
Overall average			0.014

Subsequently, it is established that there is a statistical significant difference in terms of professional ego needs between professionals involved into the execution of the project. This difference has to be identified within professional groups (Table 6). Table 6 shows a further test between groups where the significant difference was found between architects and quantity surveyors (0.011), and between architects and projects managers. While this study could not establish the real cause of this difference, findings reveal the importance which is attached with self-development needs by architects compared with other professions.

Table 6: Mann-Whitney post-hoc professional groups

Professional groups	**Mann-Whitney U**	**Wilcoxon W**	**Z**	**Sig. (2-tailed)**
Architects – Quantity Surveyors	181.500	506.500	-2.550	**0.011**
Architects – Project Managers	216.000	744.000	-2.969	**0.003**
Architects – Consulting Engineers	101.000	179.000	-1.599	0.110
Quantity Surveyors – Consulting Engineers	131.000	456.000	-.619	0.536
Quantity Surveyors – Project Managers	382.500	910.500	-.282	0.778
Consulting Engineers – Project Managers	152.000	680.000	-1.057	0.290

5. Conclusion and Recommendations

The study attempted to establish the comparison between the generic Maslow's hierarchy of needs with the professional development needs fulfilled when executing infrastructure projects. The study revealed professionals have a higher drive towards developing their areas of expertise especially those at higher managerial levels. McKay (2014) believes higher hierarchy level such as self-actualization for architects corresponds with a frustration regression when a professional does not achieved the hoped need. McKay (2014) further indicates when a higher level need is not satisfied the person regresses to the lower level need which is easier to satisfy. Findings reveal the statistical significant difference in a higher level need; typically, the development of the area of expertise. The development of area of expertise need had a highest score (6.65) from architects while the least score was 5.66 among project managers. The regression to lower level was observed as statistical significant difference was found in three lower level needs including maintenance of performance, professional registration, and approval by peer. This demonstrates the importance of the continuous professional development provisions which requires professionals to keep themselves abreast with changes affecting their professions. The Australian Institute of Architects (2009) advises architects to keep up to date with all the latest changes in technology, legislation and sustainable practices as well as new products, materials and approaches to managing your practice or procuring work. The Cape Institute of Architecture (2018) emphases that registered architectural professionals are required as part of their registration and renewal with the South African Council for the Architectural Profession (SACAP) to have accumulated a minimum number of CPD credits during the five year renewal cycle. This shows an endless need for keeping the professional registration status, by satisfying needs from bottom to higher level needs regardless one is a registered professional or not. For them to maintain their professional identity, professionals should comply with the CPD requirements. CPD requirements is an indication professionals are not only empowered through executing the projects, but also, CPD events contribute towards maintaining their professional ego.

There was no statistical difference between architects and consulting engineers, and these professional groups ranked first and second respectively. However, there was a statistical significant difference between architects and other professionals such as quantity surveyors and project managers. Further studies should examine whether the statistical difference and the no difference is a result from the role played by these professionals at various stages of the project or self-development needs attached to each profession. It is suggested that further studies should look at the patterns which will appear if lower level employees had participated into the study.

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HUMAN FACTORS IN INFRASTRUCTURE DEVELOPMENT

DII-2018-006

An Assessment of the Workplace Environment on Productivity and Delivery of Infrastructures

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Abstract

Workplace environment has great effect on workers' productivity. The level of workers' productivity is determined by the workplace items provision. Based on the foregoing, the study aimed to assess the importance of items that should be provided on site and their effects, relative to a workplace environment. The study was conducted within two states in Nigeria, namely: Ado-Ekiti and Ondo. Respondents for the study consisted of tradesmen and professional contractors. A questionnaire survey method was adopted. A total of eighty questionnaires were analysed for the study. Descriptive statistics was employed for the analysis of data. Findings include that the non-provision of these workplace items: workplace free of hazard and undue risks, workplace with opportunity to use talent and good leadership style; negatively affects workers' productivity. The following are the factors with the most effect of non-ideal workplace features: low productivity, demoralization of workers and poor standard of work. Recommendations include that an ideal workplace environment and items should be provided by employers to enhance workers' productivity, relative to motivation, tools and equipment, and materials, adequate work spaces and opportunity to workers to take responsibility

Keywords: construction, environment, project delivery, productivity, workplace

1. Introduction

Infrastructure cannot be delivered on time and with the right specification without some workplace environmental factors in place. Edem, Akpan and Pepple, (2017) declare that it is the quality of the employee's workplace environment that most influence on their level of motivation and subsequent performance. There are a lot of factors that will negatively impact on the delivery of infrastructure, among which are: the availability of tools and equipment, the motivation given, the type of environment workers work in and the management style adopted. Workers require tools and equipment's to execute their tasks, such as power tools and equipment that will assist in the execution of their work. There is a tendency of lack of interest to work when tools and equipment's

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are lacking or in short supply. This ultimately results in low productivity and delay in the delivery of infrastructures, Intergraph (2012) declares that time delays on construction sites may be as a result lack of tools and equipment. The associated problem of delay or non-delivery of project are: dissatisfaction of the client and consultants, cost increases on the project as a result of inflation. On the part of the contractor, there is a gain of bad image, which negatively impacts on repeat or securing of job. There is a negative impact on the development of a country; the problem of sustained skilled workers may loom large as a result of non-entrants of new workers into the industry. The motivation given will induce either happy workers or non-happy workers. The administration of incentives for creative results leads to happy workers and increased production (Dul et al. 2011). Happy workers will always meet production targets, while the unhappy workers will not. In the case of the later, it may imply a likely delay of the project. According to Kahya (2007), unpleasant environmental conditions have both direct and indirect effect on employee's job performance, poor site conditions lowers workers morale (Abrey and Smallwood, 2014). Employees tend to be more productive in a well facilitated work environment. Especially when the quality of comfort derivable from work environment determines the level of satisfaction and productivity of workers. Workers productivity cannot be optimal, if the conditions of work environment are not favourable. Improved work environment must be put in place to enhance employee productivity. The type of work environment in which employee operate determines the way in which such enterprises prosper. Productivity is an important factor in every organization. Profit and loss depend to a larger extent on labour productivity, i.e. How productively employees work. The physical environment is one tool which can be used to exert positive influence regarding workers productivity. Various studies have found that factors such as lighting, noise, and temperature can affect productivity (Kahya, 2007).

The kind of management style adopted may make workers to easily work or not. The bossy kind of management style, may also not make workers to work optimally, and the problem of non-achieving target production resulting in delay may occur. The performance of a corporate organization, which determines its survival and growth, depends to large extent of productivity of its workplace. A good labour management can improve job satisfaction and productivity, and improve labour relations leading to increased job performance. Productivity implies in reaching the highest level of performance with the least expenditure of resources. These put together are reasons for the assurance of an appropriate workplace environment in order to negate the aforementioned problems that may result, should the case be otherwise. This study is initiated to identify the critical work place environmental factors that may negatively affect the delivery of infrastructure in a nation.

2. Literature Review

2.1 Important features of workplace environment

There are provisions that should be made available by employers at workplace to enhance productivity and prompt delivery of project. Among these are: workplace must be free of hazards and risks that could endanger the life's of workers and the work, either of these negatively affects the project in the case of occurrence such as, material loss, fatality and loss of life's. The use by workers their talents should freely permeate work environment. This will promote innovation rather than sticking to old methods that engenders low productivity. Abrey and Smallwood (2014) say that among the factors that can decrease workers morale are: over inspection, multiple contract changes and disruption of work rhythm.

A good leadership style must be applied at workplace environment in order to motivate workers to work optimally. Workers prefer to be gently entreated to work in the place of being coerce to work. For projects to be delivered early, employers should apply time management techniques in the delivery of task, relative to accomplishment of task and as a measure for payment of wages. Lack of planning attracts chaos, non-orderliness, and delays. Security, which in mere term refers to adequate protection, both for life and property on sites must be provided. Workers should not be working in fear, it adversely affects productivity and the delivery of the infrastructure. Employer must promote good interpersonal relationship at workplace environment. The provision of a forum for workers interact, make friends and share ideas on work, that ultimately results in cooperation on work and high productivity and early delivery of the project. A job aid is the external aid to an individual, for the purpose of supporting the individual in doing the work (Naharuddin and Sadegi, 2013). A workplace with adequate provision of work aids such as, scaffolding, tools and equipment, protective personal property and ensuring the suitability of tasks, working environment / space will help to reduce the possibility of accidents and injury or ill-health (Borkar, 2010), which on the negatively impacts on infrastructure delivery. Workplace must be well layout. The tools and equipment and other materials must be placed at the right places and all well labelled. Adequate working spaces must be provided to vacillate task execution. Omar et al., (2011) say that arrangement of working environment to fit the people in it, which is defined as ergonomics positively or negatively affect productivity. The climate of a workplace must be free of discrimination. These include discrimination relative to gender, promotion, allocation of task and favours. Adequacy relative to the supply of materials at workplace eliminates stoppages leading to delay. One of the roles of employers' is the provision of adequate materials on site at all times, both of quantity and good quality.

One of the factors that keeps workers happy and willing to work hard is the prompt payment of wages, Sugiharto (2003) declares that personal factors can influence productivity. Their wages enable them to take care of their families and themselves. Davis, (2009) posit that positive mood is associated with creativity. A worker is entitled to his wages, any form of denial constitute a breach, leads to unhappiness and may negatively affect infrastructure delivery.

Employers must be able to recognize hard work and high productivity. Recognition of creative ideas increases performance (Dul, 2013). The motivation of workers relatively allows for a constant high level of productivity, which positively impacts on project delivery. The non-recognition of hard work demoralizes workers and tends towards low productivity.

Apart from workplace being well layout, it should be well ventilated to reduce the effect of heat on workers, while working and to prevent accidents and air-borne diseases. OSH is the regulation concern with preventing and protecting the health, safety and welfare of people at workplace. OSH foster a healthy and productive workforce environment (Sochod and Lekha, 2007 and Edem et al., 2017). Bambra et al., (2009) state that hazardous physical working conditions were a foremost issue of sickness in the working age population. A good workplace environment should have provision for easy link between workers and management. This assist in reducing discrimination and unfair judgement by workers being able to reach management regarding their grievances and impact positively on productivity and infrastructure delivery. Brener (2004) asserts that the ability of employees within an organization to share knowledge throughout the system depends on the conditions of their work environment.

2.2. Impacts of non-ideal workplace features provision for skilled workers

Low productivity may result from the non-provision of ideal features for work at the workplace environment. This leads in late delivery of the project. Workers may be demoralize to work, prompting lack of enthusiasm for work. This situation tends productivity downwards and workmanship may be poor. Importantly is housekeeping relative to features of workplace environment. An untidy site lowers the morale of workers and productivity (Intergraph, 2012). Housekeeping is a good measure for securing jobs and contractual patronage, as it reveals the competency level of organizations. Accidents on site causing injuries, fatalities and losses could be traced to lack of housekeeping on site, leading to bad image of the industry and disengagement of workers.

3. Research Methodology

This study was conducted in Ado-Ekiti and Ondo states of Nigeria. The study aims to assess the workplace environment on productivity of workers with reference to building construction projects delivery. Questionnaire survey was conducted. Questionnaires were administered via post. Fifty-five point two percent (55.2%) response rate was achieved. Descriptive statistics was employed for the analysis of data. The sample size is broken down as: bricklayers (20=25%), carpenters (18=22.5%), electricians (15=18.8%), plumbers (14.5%) and foremen and supervisors (13=16.3%). This equal to a total of 80 respondents. The random sampling technique was used for the selection of samples in each trade, because they are homogeneous.

Respondents with years of experience above six years (84.2%) predominate the survey sample. Most (75%) of the organizations have 100 employees and above (100-499=56.25% and above 500=18.75%). Organizations of respondents have being in existence for over 11years (75%). Based on the foregoing, the data obtained can be deemed reliable.

Table 1 presents the important features of workplace environment. The most (RI=0.811) rated features of workplace environment is: workplace free of hazard and undue risk. Risk may eventually lead to accident, and accidents may cause fatality and losses. Hazard connotes danger. A workplace that is hazardous may induce on workers reluctance to working there in. These put together causes low productivity of workers and lead to late delivery of infrastructure. Next to workplace being free of hazards and risk is workplace with opportunity to use talent (RI=0.760). An organization that does not allow workers to use their talent maybe recording low productivity. Workers should be allowed to use their initiatives and intuition to solve problems and not to keep waiting for solution to come from above, which may engender delays and late delivery of infrastructure as a result of low productivity. Next to workplace with opportunity to use talent is good leadership style (RI=0.750).The application of a good leadership style encourages the workers to work hard, regarding achieving targets. This is with respect to incentives, bonus recognition of achievement and hard work.

The two least important features on site that negatively affect workers productivity and infrastructure delivery are workplace with good ventilation (RI=0.570) and where the lines of communication is open to management (RI=0.556). The reasons for these factors to be rated least are, construction activity is carried out in the open, therefore, there is cross ventilation, which have no effect on workers that may affect their productivity. On construction sites there are avenues provided regarding letting out of complains. In addition, the foremen, supervisors and site agents are permanently on site to ensure smooth flow of operation and harmony on site.

Table 1: Important features of workplace environment

Features of working place environment	**R I**	**Rank**
Workplace free of hazard and undue risks	0.811	1
Workplace with opportunity to use talent	0.760	2
Good leadership style	0.750	3
Good time management	0.722	4
Workplace with adequate security	0.706	5
Good interpersonal relationship	0.700	6
Workplace with abilities to develop capacities	0.683	7
Provision of transportation facilities	0.681	8
Workplace with adequate provision of jobs aids	0.672	9
Workplace with good layout	0.650	10
Workplace where social climate free from prejudice and rigid classification	0.589	11
Workplace with adequate supply of materials	0.578	12
Prompt payment of employees' wages	0.575	13
Workplace where employees are motivated	0.570	14
Workplace with good ventilation	0.556	15
Workplace that open the line of communication between the workers and the management	0.550	16

Table 2 reveals the effects of non-ideal workplace items provision on the productivity of workers. Notably that all the factors in the construct have somewhat to important influence on workers productivity, that is RI > 0.500. The factor with the most effect is low productivity (RI=0.756). The result f non-provision of an ideal workplace is low productivity. This may be relative to non-availability of the following: working aids, motivation, working space, conducive environment – noise and disturbances and so on. Next to low productivity is demoralization of workers (RI-0.750). A hazardous and risk working environment couple with non-provision of safety equipment may demoralize thee workers. Poor standard of work (RI=0.667) may result due to lack of provision of ideal workplace items to work. These are items to enhance workers productivity, such as, tools and equipment, aids for working, a well laid out site and adequate lighting and so on, when not available negatively affects workers and their productivity.

The factor with the least effect is fatality (RI=0.572). This rating is traceable to its non-frequent occurrence on site.

Table 2: Effects of non-ideal workplace features provision for skilled workers

Effects of non-ideal workplace items provision	**R.I Score**	**Rank**
Low productivity	0.756	1
Demoralization of workers	0.750	2
Poor standard of work	0.667	3
Poor competition advantage as a result of lack of knowledge relative to housekeeping	0.644	4
Minor injuries	0.633	5
Poor contractor patronage	0.628	6
Disengagement of workers	0.594	7
Fatal injuries	0.572	8
Death	0.560	9

4. Discussion

The major finding of this study, which is low productivity of workers due to non-provision of workplace features corroborates the finding of Abrey and Smallwood (2014) declaring that productivity on construction sites is adversely affected by unsatisfactory site conditions that could engender accidents, injuries occurring and result in delay in the delivery of the infrastructure. Rahim et al. (2014) conclude that providing safe and healthy working environments for the employees by the employers is essential in today's working environment. They stress that it will avoid the injuries and health problems, increase working comfort and provide many benefits to the organization. Such as good image, competitive advantage, early delivery of infrastructure and so on.

5. Conclusions

Workplace free of hazard and undue risks, workplace with opportunity to use talents and good leadership application at workplace are the most important features of workplace that must be in place relative to workers optimum productivity. Hazards and risks are dangers that may lead to losses, fatality and deformations of body and permanent disability when they resulting in accident. This phenomenon most workers tries to avoid. The ultimate result is low productivity. The lack of encourage to use talent to solve problem and d. improve methods of doing work stagnates speed. The absence of a good leadership style is a de-motivator to workers and results in low productivity. Regarding the effects of non-provision of ideal workplace items is low productivity, demoralization of workers and poor standard of work. It is recommended that a conducive workplace environment and items should be provided by employers' to enhance workers productivity. Relative to motivation, tools and equipment and materials, adequate work spaces and opportunity to workers to take responsibility.

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Perception of Students about the Technician Profession in Science and Laboratory Technology

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Abstract

In Tanzania, since the transformation of technical schools into A-level schools and colleges into universities or university colleges, there has been little emphasis on technician profession in Science and Laboratory Technology (SLT). This has led to science teachers or graduates being recruited as substitutes to professional technicians. The aim of this research was to study the perception about technician cadres in SLT. An investigation of students' perceptions of technicians in SLT was conducted via questionnaires using a cohort study for 33 students who were admitted at St John's University of Tanzania through NACTE in 2015/2016. The findings from the 33 respondents show that technician professions are perceived to be suitable for males compared to females, as observed from the enrolment, which included only 18.2% females. For career demands, 57.6% of the respondents indicated that technician professions in SLT are highly skilled careers, whereas 33.3% indicated that the career is challenging. Using multiple selections, we investigated the participants' career priority in SLT and observed that: food and beverage industries (63.6%), pharmaceutical industries and health-related research (54.5%), colleges and universities (45.5%), and secondary schools (36.4%). Other areas that were chosen included: material development industries (18.2%), agricultural sciences (12.1%), and environmental sciences (9.1%). This survey indicates that there is a gap among existing technical professionals, the education system, and students when choosing a career in science and laboratory technology. The students need a basic education and sensitisation to the role of technicians in science as part of the national development strategies and priorities.

Keywords: laboratory, science, Tanzania, technology

1. Introduction

The technical profession of science and laboratory technology is a skill-based competence (SBC) that is vital to the national economy and technology growth. Technicians in science have an essential role to play in current and future scientific disciplines. Technicians' practical skills, experiences and knowledge are basic needs in science, as these are more detailed than for common

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researchers and science teachers. Like any other country, in Tanzania there is a general requirement throughout the country for skill-based competence in scientific areas such as academics & research institutions, manufacturing & processing industries, and government agency laboratories. The availability of skilled and competent personnel is crucial in meeting URT's 2025 vision, Five Year Development Plan (FYDP) and the Big Results Now (BRN) strategies. However, without strengthening Public Private Partnership Policy (PPPP), it will be very difficult to bring awareness to the community to realize successful development strategies and implementation.

The Technical Education and Training Policy (1996) established three main purposes for technical secondary schools to ensure that (a) an appropriate and cost effective vocational education is introduced to replace the diversified course package, (b) teaching of science and technology is strengthened in technical secondary schools and (c) training standards are prepared for different fields of vocational education to be taught in current technical secondary schools. However, recently, most technical secondary schools and colleges have been transformed into non-technical schools, universities or university colleges.

Complying with the government, St John's University of Tanzania (SJUT) located in Dodoma region, as an education stakeholder, established the process to start a non-degree programme in Science and Laboratory Technology (SLT), which started in 2015. The registered programmes for the SLT curricula were NTA levels 4, 5 & 6. The enrolment considered NTA Levels 5 & 6 for a Technician Certificate in Science and Laboratory Technology and an Ordinary Diploma in Science and Laboratory Technology, respectively. Thus, a student enrolled in an NTA Level 6 programme must start with the NTA level 4 (Basic Technician Certificate in Science and Laboratory Technology). In the 2015/2016 academic year, students were admitted for a Diploma in SLT via the NACTE Central Admissions System.

Therefore, SJUT is in line with the Tanzania Development Vision 2025 that accords high priority to the education sector, which is considered pivotal in bringing social and economic transformation, as described in the following statement:

> *Education should be treated as a strategic agent for mind-set transformation and for the creation of a well-educated nation, sufficiently equipped with the knowledge needed to competently and competitively solve the development challenges which face the Nation. In this light, the education system should be restructured and transformed qualitatively with a focus on promoting creativity and problems solving* (URT 2000:19).

Thus, the education system in Tanzania, including secondary education, plays a crucial role in the development of the nation through the continuous training and recruitment of knowledgeable, creative, and problem-solving graduates.

According to a report from the Second Secondary Education Development Program, SEDP II, (2010), one of the challenges in SEDP I implementation was "Lack of, or non-use of, laboratories in most schools resulting in students doing science theoretically, and most of them doing poorly.

This poor performance in science subjects has, in turn, resulted in an avoidance syndrome, with most students choosing to enrol in social science/arts subjects, rather than natural sciences". The SEDP work plan was to recruit and post 150 laboratory technicians to schools and colleges from 2010/2011 to 2014/2015. Additionally, by 2012, it was planned that at least three institutions were to have facilities to train laboratory technicians (The World Bank Group, 2010).

In 2013/2014, President Jakaya Mrisho Kikwete of the United Republic of Tanzania initiated the establishment of science laboratories in all public secondary schools in Tanzania. On May 15, 2015, at the summit week of the 2nd Education Tanzania at Jamuhuri Stadium, Dodoma, President J. M. Kikwete congratulated all municipalities, regions, parents, guardians and other stakeholders for their contributions and manpower in establishing science laboratories in each secondary school ward. He ordered regional and district commissioners to ensure that the work is completed by June 30, 2015. Upon dissolution of the tenth term of the Parliament of the United Republic of Tanzania, President Kikwete announced that 5,979 laboratory buildings/rooms had been completed and that 4,410 were at different phases of completion (*Kikwete, Bunge la 10, 2015*).

This implies that public secondary schools will need to recruit laboratory technicians in science. In addition, private schools will need more scientific technical staff. During the recent 5th term government, the president of the United Republic of Tanzania, Dr. John Pombe Joseph Magufuli, announced that more emphasis would be placed in science subjects in secondary schools. As part of a compromise, during the 11th Session Parliament of the United Republic of Tanzania, the Minister of Education, Science and Technology (MoEST) announced the budget for 2016/2017 and that the Ministry is committed to continuing to provide training in vocational schools for science laboratory technicians (*Hotuba ya Bajeti MoEST*, 2016)], giving hope that this technical group will be gradually afforded importance.

Since St John's University of Tanzania (SJUT) is a Christian university, it accommodates her mission and vision in establishing an SLT programme to serve the community in this way as well. Therefore, as one of the private higher learning institutions grooming future technicians in science and laboratory technology, SJUT is joining hands with public institutions, such as the Dar es Salaam Institute of Technology (DIT), the Mbeya University of Science and Technology (MUST) and Arusha Technical College (ATC) that provide similar programmes. As part of a wider scope, the SJUT curriculum covers core modules in chemistry, physics and biology and offers fundamental modules in communication skills, information technology, mathematics, developmental studies, and business & entrepreneurship to meet current market demands.

1.1 The purpose of this survey

The purpose of this survey was to explore and unravel the hidden perceptions about technicians in SLT to provide more insight for setting priorities to meet community needs for employment, market demand, graduation choices and job satisfaction. The survey targeted admitted students in the SLT programme and the way the programmes match their future career aspirations and their knowledge on the institutions that offer the programme to which they were admitted. Specifically, the survey addressed the following research questions:

1. What are the students' perceptions about the SLT program?

2. What knowledge do students have regarding a future career with a diploma in SLT?

3. What knowledge do student have on the institution offering a diploma in SLT programs?

2. Research Methodology

The survey was a cohort study that used a questionnaire and involved 33 students at St. John's University of Tanzania who were enrolled for a Diploma in Science and Laboratory Technology during the second week after reporting to the University, corresponding to a time just before they were introduced to the programme. This new entry class was considered to be the sample for this survey, which corresponds to a method described by Stutely in (2003), who argued that regardless of the population size, a sample size of 30 is the bare minimum required for data collection and analysis. Additionally, Saunders et al. (2007) emphasized that a sampling intensity of 30 respondents was regarded as reasonable in social sciences studies and statistical analyses using this population size are sufficiently large to draw scientific conclusions. For these reasons, the group was considered representative of the population of Tanzania due to the different backgrounds of the study participants. The questionnaire comprised a mix of item types including open and close-ended items with alternative responses and using rating scales. The questionnaire covered two aspects: if the career future is known to the student and speculation on the students' knowledge about SJUT as an institution offering SLT programmes during the application process. Secondary data were retrieved from websites and online data bases. Blogs and online social media were also used for the survey on the perception of technicians in science and laboratory technology.

Both the qualitative and quantitative data from the questionnaires were coded, summarized and analysed. All the primary data obtained from the survey were analysed using the Statistical Package for Social Science (SPSS), version 16.0. The chi-square statistical test was used in some data-processing to investigate associations between the descriptive data. Descriptive statistics were used to obtain frequency counts on the various coded responses and to compare means of qualitative variables. Cross tabulation was used to determine joint frequency distributions for cases of categorical variables.

3. Results and Discussion

The data record and analysed in this survey set out to answer three specific research questions. The first question was "What are the students' perceptions about the SLT program?" The second question was "What knowledge do students have on the career future for a Diploma in SLT?" The third question was "What knowledge does a student have on the institution offering a diploma in

SLT programs?" Therefore, demographic data and other descriptive information is presented here to capture characteristics that might be associated with them towards perception about of SLT, thus representing the entire population in Tanzania.

The information on the gender, level of education, and work experience of the respondents was important, as it helped in gaining a clear understanding of the characteristics of the survey respondents. This information sought to investigate individual perceptions on the SLT programme and knowledge on SJUT's programme.

3.1 Students' demographic information

Of 33 respondents, 18.2% were female, and 81.8% were male. These data showed the same trend for females as observed previously, with fewer in science and technical fields, especially the natural sciences. For example, a study conducted for the scientific technical staff in selected Tanzanian institutions in 2013/2014 showed that 15.0% were females and 85.0% were males (Sumary & Ngoma, 2015). In contrast, in developed countries, the trend is towards more females in science-related fields. For example, according to Hackling (2011) studies from Australia showed that a majority of Australian technicians in the study sample were female. In terms of age, only 22% were less than 40 years of age, and 40% were over 50 years of age (Hackling, 2011). In Tanzania, the surveyed sample showed that none of the female respondents were above 40 year of age, but 66.7% were between 25 and 30 years of age. A total of 40% of the males were above 40 years of age (Sumary & Ngoma, 2015).

According to Beede et al., (2011), the relatively few females who receive STEM (science, technology, engineering and math) degrees are concentrated in the physical and life sciences, which is in contrast to males, who are concentrated primarily in engineering. The findings also show that females who do receive STEM degrees are less likely to work in STEM jobs than their male counterparts and that females working in STEM jobs earn less than their male counterparts. Moss-Racusin et al. (2012), examined if science faculty exhibit a bias against female students and reported that both male and female faculty judged a female student to be less competent and less worthy of being hired than an identical male student, in addition to offering a smaller starting salary and less career mentoring. This may be the reason why in many settings, females feel inferior.

When investigated for the level of education, the survey had to consider that students may join the diploma programme in SLT from a secondary school setting, vocational training qualifications, or a technician certificate qualification or equivalent. The survey showed that 76% of the respondents were Form Six leavers, of which all the females were Form Six Leavers. A total of 12% were NTA level 5 (Technician Certificate in SLT), and 12% were Form Four leavers. When asked about experience in any form of employment, only 18.2% of the respondents had work experience in either formal or informal jobs.

3.2 Students' perceptions about the SLT program

The purpose of this research question was to examine the students' perception about SLT to understand the group, help strengthening their positive perceptions and address any misconceptions. This approach is essential to develop competent professionals with positive mindsets. Since academic or career advancement relies on background experience, the survey looked at associations between the respondents' previous education system (curriculum) and how former schools may have promoted careers in science and laboratory technology worked out through chi-square. The survey showed that there was an association between the education system and the schools in promoting a career in SLT, and the association was □□(1, n=33)=19.3, $p=0.001$. As $p<0.05$ and cell analysis indicated these two variables had an impact, we can say that the education system and the respondents' former schooling had an impact in promoting careers in science and laboratory technology. The cells analysed were those in which the respondents strongly agreed or agreed for the variables.

These findings suggest that if recruitment of more technicians is required, then it must be promoted through the support of the education system (curricula) and the schools to provide student awareness about this career choice. The Ministry of Education and Vocational Training clearly stated in SEDP II (2010) that among the challenges faced that the ministry planned to address over the 2011/2015 period include improving the teaching force and teaching process. The key area was a focus on attracting, training, and retaining adequate numbers of high quality teachers via incentive systems and rationalization of ratios between natural science and social sciences/arts subjects and diploma and degree holders. Similarly, according to Osborne et al., (2003), the single most important change that could be made to improving the quality of science education is the recruitment and retention of able, bright and enthusiastic science teachers.

Students' general comments about their perception of the SLT programme were also surveyed. To seek unbiased responses, open-ended questions were used to allow expression about perceptions on the SLT programme and future careers. A total of 31.3% of the respondents stated that they had ambitions to perform well and looked forward to prospering in an SLT career. Similarly, 18.8% of the respondents were proud to have been admitted to pursue a Diploma in SLT. However, they also suggested other attributes regarding the SLT programme, including a need to advertise the programme, improve laboratory facilities, and establish a degree programme in SLT. Confirming the needs for advertising the programme, 3.1% of the respondents were not aware of the programme. Through individual discussions with the respondents, it was learned that some respondents chose the programme without knowing what was included in the programme, as it sounded like a medical laboratory-based programme. However, other respondents did not respond to this question.

Further analysis on gender revealed that 66.7% of females were ambitious to perform well, and none of them responded to being proud of the programme, whereas only 19.2% of males were ambitious to perform well and were proud of the programme. However, this does not prove that females were not proud of the programme, as it was an open-ended question and there are different ways to express one's ambitions and pride.

3.3 Student's knowledge on career future for a diploma in SLT

The survey questions for this section were designed to capture the respondents' knowledge about the areas where SLT graduates can be considered for a job or to have expertise. The survey investigated the areas in which the respondents are expecting a future career, including environmental sciences, agricultural sciences, research assistantship, material development industries, secondary schools, research institutions, higher learning institutions (college & universities), further studies/career development, fuel, gas & mining industries, pharmaceutical industries, health related research, and food & beverage industries. These areas were pre-selected, since they are reasonably covered in SLT careers and a basis exists for a future career. The respondents were allowed to choose any from five on the list. It should be recalled that the survey was conducted before these respondents commenced classes and when the respondents had no clear knowledge of the depth of the programme. The survey showed that most respondents, 63.6%, chose food and beverage industries as their future career in SLT, and 54.5% of the respondents selected the pharmaceutical industries, with the same percentage also selecting health-related studies. Environmental sciences was the least chosen item, with only 9.1% of responses. Other areas examined by this survey included how the respondents will choose secondary schools and colleges & universities. A total of 36.4% of the respondents chose secondary schools as an SLT future career, whereas 45.5% of the respondents chose college & universities. Other areas chosen included material development industries (18.2%), research assistantship (15.2%), agricultural sciences (12.1%), and environmental sciences (9.1%).

Since 9.1% of the respondents expected a career in environmental sciences, it seems most of the population is not aware of the role of environmental science technicians and the employment opportunities. Environmental technicians are professionals who deal with the protection and monitoring of the environment in a scientific way by assisting researchers through the expanded use of complex laboratory instrumentation and procedures. The key issues addressed in this career are; pollutants in water, soil, air and other environmental components. In this aspect, a technician plays a role in producing appropriate data that can be used by policy makers as they are disseminated by the researcher. The environment sector is expanding, meaning that some technicians will be responsible for waste management operations, controls and management of hazardous materials inventories, or general activities involving regulatory compliance.

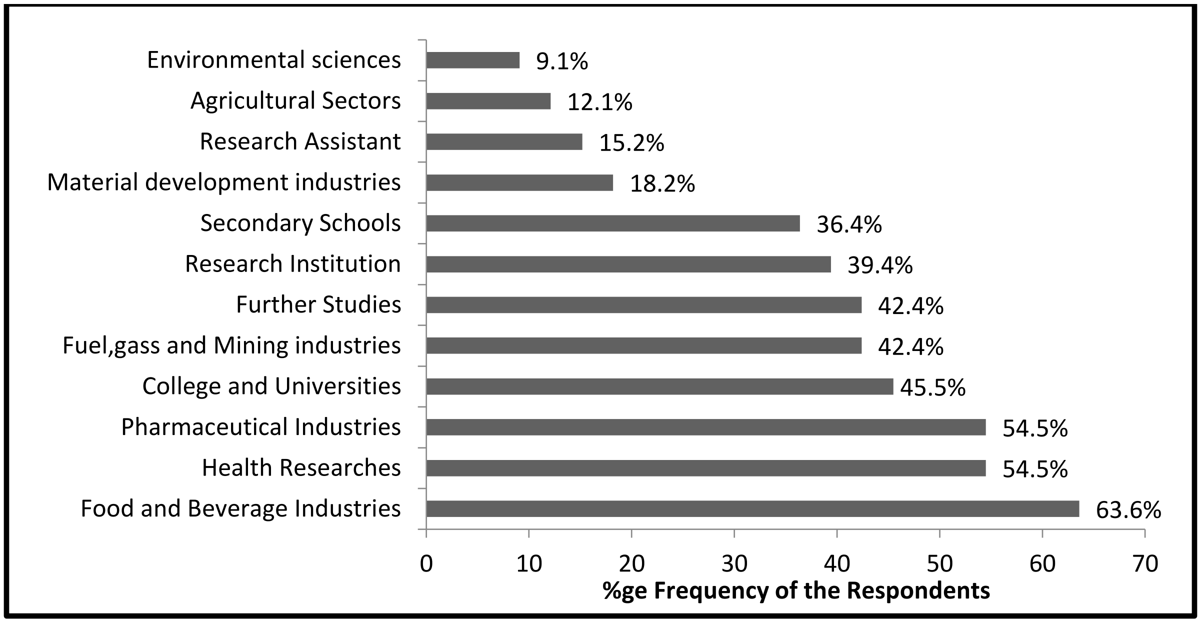

Figure 3: Students expectation on SLT career areas (Researcher's survey data, 2016)

Material development industries have been an active area since the 5th term Tanzania government insisted on building capacity for an industrial economy. Thus, as any nation needs a sustainable industrial economy, a science technician is essential component to operate different forms of technology. Specifically, in the material development industries, materials such as fertilizers, cement, gypsum, steel, aluminium, plastics, paints and others are areas of rapid economic growth.

Technicians graduating from a Science and Laboratory Technology programme are recruited in both the natural and applied science fields. All students must pass through basic sciences, including biology, chemistry and physics. These courses fit in both research laboratories and industries for processing and quality control. Therefore, these findings suggest that there is a need to address the breadth of the SLT programme not only at SJUT but nationwide to be in line with market demand.

3.4 The SLT technician challenges and opportunities

There are many challenges facing these technicians in schools. Most technicians are uninterested in finding employment in schools, but still, it is an area where employment (including self-employment) may be promising. School challenges are similar across nations, as reported by Hackling for Australia, who argued the following:

> *The main two reasons given for not having a technician were budgetary constraints and that the school was too small. In most cases, the science teacher performed the duties of a technician. As indicated by the LTAV (2007, p. 5), the skills required are not normally possessed by most teachers, and this is not a task that can be safely and efficiently carried out by an untrained person. Given the pressures on teachers' time, it is likely that*

> *teachers in these circumstances can only prepare limited resources for practical work and the quality of the curriculum will be compromised. This view is supported by data from these schools, indicating that having a technician would improve the quantity and quality of practical work in the curriculum as implemented.* (Hackling, 2011, p. 38)

Opportunities for further studies and training in SLT programmes are quite obvious, as some science technicians have credentials ranging from a bachelor's degree to PhDs in chemistry, biology, physics, forensic science, environmental science, etc., which qualifies them for many management positions in the science and technology fields. When the respondents were asked whether they are aware of training opportunities countrywide, only 69.7% said they were. Only 3% of the respondents disagreed that there were training opportunities in SLT countrywide.

3.5 Students expectations on SLT career quality

It was the intention of this survey to probe the respondents' expectations of the career quality in SLT. Among the given alternatives, 57.6% of the respondents said that SLT is a highly skilled career, and 33.3% said it is challenging. Additionally, other questions addressed that the expected qualities in SLT were rewarding (15.2%) and required exposure to risk (15.2%). These observations suggest that the respondents understand that the technician career in SLT is demanding and challenging. However, the respondents are limited in understanding whether this is a rewarding career and that they may be exposed to various risks. Other reports show that students confronted with a choice that is high risk, although potentially providing high financial gain (i.e., doing science with its associated risk of failure) and one of lower risk (i.e., the greater certainty of success with arts-based courses), will choose the low-risk option even if the financial rewards may be less (Osborne, Simon, & Collins, 2003). Simultaneously, the survey investigated how respondents would rate opportunities for SLT related jobs. A total of 85% rated opportunities excellent, and 15% rated them as good. In this case, there was no significant gender difference for the ratings in this category. No one responded to whether the career is isolated, oppressive or considered of low prestige.

3.6 SLT career driven factors

The present survey sought to test for factors that most SLT technician graduates may weigh when considering employment and the kind of a job they will take. Six factors were selected, and the respondents were allowed to rate these based on the degree of importance for job consideration. The following variables (factors) were assessed: salary, working conditions, opportunities, benefits, job satisfaction and employment location. The hypothesis was that the factors are independent and biased to the respondents' knowledge about the career placements. The survey revealed that salary was the most important, with a response of 72.7%, followed by working conditions and opportunities each at 66.7%. Only 48.5% responded that employment location was the most important. Thus, over 50% of the respondents' views show that these factors were the most important factors when considering a job. However, some of the respondents did not respond to some factors.

Since the hypothesis was that these factors were independent for job consideration, some factors were chosen to analyse the association between the factors: opportunity against job location, salary against job satisfaction and salary against working conditions. A chi-square test was performed to examine the relation between the factors. The analysis showed that there was a significant association between working conditions and opportunity, which was the most important □2(1, n=33) =23.5, p = 0.024. When the association between salary and working conditions was analysed, it was observed to be significant and the most important □2(1, n=33) =16.0, p = 0.030. Similarly, opportunity and job location had a significant association at □2(1, n=33) =17.3, p = 0.044. The same applied to the association between salary and job satisfaction at □2(1, n=33) =24.7, p = 0.055. There was no association between the respondents who said location is most important with a preference for any region in Tanzania by zones. The survey factors can be used as an indicator for training technicians in SLT. In the same way, respondents were asked to pick any three zones as their priority for job location. A total of 33.3% of the respondents chose the central zone, followed by coastal zone regions (24.2%), with the least selected being the lake and south eastern zone regions at 3.0% each.

As in most professions, professional training is motivated by opportunities and benefits, especially economically driven benefits. This survey assessed the respondents' opinions about the salary range that they expect when they get a job. Additionally, it assessed if there is an association with the salary need. The findings showed that there was no significant association between gender and expected salary. However, 100.0% of the females preferred a salary range from TZS 550,000-750,000, whereas 55.6% of males preferred this salary range, and only 25.9% reported being happy to earn the low proposed salary range between TZS 450,000 and 550,000. Hackling in 2011 reported that 40% of schools had difficulty in recruiting technicians due to poor service conditions, particularly poor matching between salary levels and responsibility, which made it difficult to attract suitable applicants. In Tanzania, for public servants classified as Technician II in July 2015, the salary scale for TGS C was TZS 410,000-520,000 and for TGS D was TZS 510,000-693,500 (The Citizen, Tuesday, May 19, 2015).

3.7 Students' knowledge on SJUT as an institution offering a diploma in SLT

It was essential to investigate the level of respondents' knowledge about SJUT as an institution offering the SLT programme, since applications are made online (NACTE Central Admission System).

It was believed that if respondents were well informed about the SLT programme and SJUT as well, then they would consider SJUT as their first choice. From this survey, it was expected that respondents would have been informed through various media and local people. The means that applicants were informed through flyers, SJUT staff, social media advertisements, family members, NACTE Admission System and websites. The survey revealed that 51.5% of the responses knew SJUT through friends, 33.3% through websites and 30.3% through NACTE-CAS. The survey did not investigate how respondents' friends knew about SJUT, but this knowledge was likely obtained through similar ways. Other was defined as SJUT being made known to respondents through: family members (18.2%), media advertisements (9.1%), SJUT staff (6.1%) and flyers (3%). In this survey, social interactions were observed to be strong, which facilitated individuals passing information to each other quite easily. Although some other means of information can be very expensive, they can contribute to channel information through peer groups. Nevertheless, when the relationship between respondents' knowledge about SJUT and selecting SJUT as their first choice during the application process was assessed, the analysis showed that 72.7% said "Yes" that SJUT was their first choice. Of the remaining 27.3% who said "No", they knew about neither SJUT nor the programme.

From a social aspect, this survey investigated if there was any significant information that would indicate that the respondents were encouraged to apply for an SLT programme. These responses allowed the respondents to choose more than one way that they were encouraged or advised to pursue the SLT programme. From the survey findings, 39.4% of the respondents were encouraged by their family members, 36.4% of the respondents were encouraged by their school teachers, whereas 15.2% claimed that they chose the SLT programme as it was the only alternative. For the question of choice based on limited alternatives, this may be due to performance or subject specializations; however, there was no further investigations. Similarly, 15.2% of the respondents claimed that nobody encouraged them to apply for the SLT programme. Surprisingly, only 6.1% of the respondents were encouraged by friends. Through previous data, where 51.7% of the respondents knew SJUT through friends, one would expect these friends to encourage them to attend SJUT as their first choice. This suggests the contrary, meaning that knowing the institution and knowing the programme are two different things. Therefore, the results show that despite how they might be informed about an institution offering a certain programme, family members and school teachers have a vital contribution to advice students on their career. This agrees with the significant association between the education system and the school teacher that guides a students' career choice.

These results suggest that there is a need to place more emphasis on how schoolteachers and prospective students are informed and involved to better know of the existence and potential of the SLT programme.

4. Conclusion

This survey revealed a gap in students' knowledge of the technician professions, which is present in most of the examined applicants and is attributed to the poor involvement of the education system (curricular) and the schools, which should encourage choosing technician careers in science and laboratory technology. There are still a small number of female candidates. In the same way, we observe that marketing by the respective institutions and government organizations is insufficient to advertise future career opportunities and benefits. Therefore, students need a basic education and sensitisation to the role of technicians in science as part of the national development strategies and priorities. Nevertheless, the government of Tanzania should strengthen provisions for the technician class to support established science laboratories in secondary schools and for the upcoming demands that will be part of "industrialized Tanzania".

5. Recommendations

1. The government of Tanzania should give priority to science technicians by providing general curricula to schools, colleges and university colleges.
2. The government should help the private sector to train technicians in science and provide partial scholarships or loans to students.
3. Schools and respective academic institutions should emphasize generating and maintaining a positive image for technicians in science and laboratory technology.
4. Industries and other stakeholders should support training for their respective needs by complying with education providers on market demand, as "Tanzania ya viwanda" (industrialized Tanzania) is not a separate entity.
5. Females should be encouraged to pursue a profession in science and laboratory technology by the involvement of female technician role models.
6. Respective institutions should advertise the programmes and career benefits using various media and physical visitation.
7. An in depth survey should be conducted to determine strategic plans for the recruitment of multidisciplinary technicians in science and laboratory technology to keep up with changes in technology and industrialization.
8. There is a need for research further by involving stakeholders in the possibility of streamlining technicians into disciplines, such as fuel & gas, geo-minerals, environmental, industrial, and pure research & academics.

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Addressing Gender Inequality on Construction Sites in Bloemfontein: An Exploratory Study

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Abstract

The need to cater for diversity across various economic sectoral facets remains topical in contemporary developmental discourse. Although the benefits and disadvantages associated with diversity remain unclear, given the presence of equally diverse opinions concerning it in state-of-the-art literature, advocacy for implementation compliance has attained feverish pitch. Globally, the construction industry, serves as an exemplar of an economic sector wherein diversity issues remain contentious. This is particularly so as it pertains to gender equality as instances reflecting women underrepresentation persist. Accordingly, studies have been conducted in developing and developed countries to proffer solutions to such anomaly. Yet, a multiplicity of these studies seem fixated on the industry, professions and trades, not taking cognisance of the need to elicit views from construction sites. This is the gap which this study seeks to contribute towards obliterating. A qualitative case study approach was adopted for this investigation. Three (3) construction sites were identified and selected within Bloemfontein. Data was collected through site observation and 22 semi-structured interview sessions with interviewees recruited through purposive sampling. The accruing data was analysed using thematic analysis. Not only did the findings confirm the incidence of women underrepresentation on construction sites, it identified the reasons for such levels of underrepresentation despite known policy interventions. It is expected that these findings will contribute to the growing literature on this phenomenon in developing countries.

Keywords: Bloemfontein, construction sites, gender equality, women

1. Introduction

Strife, hunger, adverse climatic conditions and a plurality of other factors have been described as making salient contributions towards unprecedented migration of individuals to other climes in the

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quest for survival. Of course, such quest for survival can only be made possible through advanced levels of social cohesion in host communities, as this will help taper acrimony resulting from differences in languages, cultures and beliefs. Therefore, issues pertaining to diversity have assumed topical dimensions within the realm of developmental discourse. It appears to have been accentuated by the plethora of global developmental challenges facing contemporary society. In what may seem as a recognition of the need for diversity to be catered to in the quest for sustainable development, the United Nations has consistently included it as a significant milestone both in the now-rested Millennium Development Goal (MDG) as goal number 3 and as Sustainable Development Goal (SDG) as goal number 5 in the current global development regime. Accordingly, successive governments across the globe have initiated legislations and policies to drive the attainment of this goal across all economic facets (McDonald, 2012).

Whereas considerable advancements appear to have been made in creating certain aspects of diversity in society, some aspects have proven problematic. An example of such aspect is the gender equality in certain economic sectors (Denissen and Saguy, 2014). These economic sectors hitherto considered as male-dominated sectors, have refused to yield to an increased gender-parity with the female (Ness, 2012). The desire to attain gender equality across all economic sectors remains a focal point which must be addressed comprehensively if SDG goal 5 is to be achieved.

The construction industry has acquired notoriety as being unreceptive of the female gender (Maclsaac and Domene 2013, Munn 2014, French and Strachan 2015). In consideration of the vast employment potentials as well as the low-skill entry levels associated with the industry, scholars have investigated the cause of such skewed representativeness (Clarke et al, 2015, Abrey and Smallwood 2014). Yet, after decades of continued advocacy through scholarly publications, reports, legislations, charters and policies, evidence from developed economies still point to the industry's underwhelming performance in this regard (Clarke et al. 2005, Clarke et al, 2015).

Although commendable improvements have been witnessed in recent times in the number of female enrolment into construction-related programmes at universities and colleges, this has failed to reflect in a change in the numbers of females working in the industry, and especially on construction sites (Clarke and Wall 2014). Scholars have reiterated the potential for gender equality to make significant contributions towards boosting productivity in the industry (Urwin et al. 2013). The construction industry in the developing country context has not fared any better either, despite a far-ranging list of studies on the subject (English and Le Jeune 2012). A cursory look at these studies reveal that a majority sought to explore and engage the incidence of the phenomenon from an industry-wide perspective whilst others have adopted an organizational perspective in tackling this challenge. A paucity of studies seeking to engage with the subject at the construction site environment has been observed.

In addition, a need to elicit the views of the female construction trade-persons working on the project site has become imperative. It is expected that this will allow for context-specific information to be accessed. It is along these lines that this study seeks to contribute to the wider corpus of relevant state-of-the-art concerning the subject-matter. Suffice to state that the study will report on the status-quo ante concerning women representation on construction sites in the case study area through personal perspectives of those involved in hiring at the construction site level and the (female) workers.

To achieve its objective, the rest of the paper will be structured accordingly: a review of extant literature concerning gender equality in the construction industry; identification of barriers to gender equality in construction; gender equality in the South African construction space; a justification and rendition of the research methodology deployed; the findings and discussion section, and; conclusion

2. Benefits of Gender Equality in Construction

Although the advocacy for diversity and gender equality in construction dates to several decades, it only appears to have gained momentum in the past three decades. This is evident in the concentration of studies which have been carried out and reported within this period (Clarke et al. 2015) McCarthy et al. 2013, Martin and Barnard, 2013, Bagilhole, 2002, Crompton and Sanderson 1990). Yet, organizations working within and outside the construction industry in developed counties seem to have performed underwhelmingly in this aspect. As a result, tales of discrimination and harassment, low retention rates by industry employers against the female gender has continued to resonate in these contexts.

Across the globe, efforts continue to be directed towards facilitating gender equality in the construction industry. For example, in the United States, a recent study points towards the deployment of initiatives like the Women's Employment Programme (WEP) as a tool for encouraging women participation in construction projects (Clarke et al. 2015). According to Clarke et al. (2015), the WEP served to provide among other things; consistent liaisons with unions, clients, and contractors on apprenticeship schemes and increment of work hour allocations for women and funds for childcare support. The same study alludes to the well manged performance of the Olympic Development Authority (ODA) during the preparation of the 2012 Olympic games. It was reported that the ODA, besides setting incredible targets to enlist women and other minority groups into an apprenticeship programme during the delivery of the Olympic park and the Athletes' village, did indeed surpass the set targets. Such minority groups were listed as comprising of: women, ethnic minority groups, disabled people and local people. In this project, a Women-in-Construction initiative was set up to monitor and assist women to prepare for the tasks associated with the industry as well as its nature. Closer home, the advent of labour-intensive construction (LIC) practices initiative in South Africa being promoted through the Expanded Public Works Programme (EPWP) by the public-sector departments seeks to achieve increased gender equality (DPW, 2004). As a cardinal requirement of the LIC, contractors are mandated to promote trainings on relevant skill sets to employees, especially women with the expectation that such trainees can proceed to starting their own construction businesses. Furthermore, the LIC initiative prescribes the employment of male and female in the ratio of 40:60. This serves as a practical means of addressing the imbalances existing within such sectors.

Mixed reactions trail expected benefits accruable from the institutionalization of gender equality in the global construction industry as the jury is still out on most of the initiatives discussed previously. Urwin et al. (2013) admit to the existence of a school of thought that opines that the phenomenon will lead to an-all round transformation of the industry, providing as it were, a paradigmatic shift in the extant employment conventions therein and yet another school of thought which believes that an unbridled embrace of gender equality can portend danger for the industry which is already suffering an image problem. Continuing they categorize the benefits into two distinct categories. Accordingly, benefits are categorized into external and internal business benefits respectively. Whereas the former relates to the benefits accruable when firms serve as a reflection of diverse cultures and gender through their staffing and products, the latter refers to improvement of internal processes because of the strengths of a diverse workforce being deployed towards problem-solving and decision-making activities. However, they stress the influence of certain factors in determining the degree of equality that will bring about such benefits. These factors include: the economic and organizational context of firms, the nature of diversity, the internal workplace context and the external environment (Urwin et al. 2013). From this, the absence of a consensus pertaining to the management of gender equality initiatives within firms, markets and sectors can be deciphered.

In their contribution to the debate on the utility of gender equality in the construction industry, Clarke et al. (2015) cite Cox and Blake (1991) as having identified certain aspects where a gender-balanced, diverse compliment of an organization’s workforce can bring about value additions. These aspects include: cost effectiveness, resource-acquisition, marketing, creativity, problem-solving, and system flexibility. Continuing, English and Le Jeune (2012) identify certain attributes women-hood which possess the potential to contribute immensely to construction industry performance if gender equality is achieved. These attributes include their nurturing instinct, their proclivity towards quality control, cooperative and collaborative working, excellent listening skills, etc. Some scholars have sought to attribute the burgeoning construction accident statistics to the tendency of the male-folk to be involved in accidents, especially when compared to the carefulness of the women-folk in this regard (Blues, 1993; Kelsh and Sahl, 1996). However, such claims have since been discountenanced by Chi and Wu (1997) who argue that accidents on construction sites do not result from gender-based traits but rather, because of non-compliance to established health and safety conventions on site.

From the foregoing, the viewpoints of academic commentators highlighted in preceding parts, concur that attainment of optimal levels of gender equality in construction will bring about improved productivity from an industry, firm and project perspective respectively. Such benefits are expected to result from a compliment of the positive attributes of both genders within the industry environment. Yet, the question remains: If industry stakeholders are aware of such benefit potentials, why does the gender-imbalanced nature of the industry persist? And, how can the trend be reversed?

2.1 Challenges affecting gender equality in construction

According to Clarke and Wall (2014), women have not always been excluded from the construction industry and activities associated with the industry. Clarke and Wall (2014) observe that the underrepresentation being witnessed today gained prevalence in the post-war era, where a lot of the male-folk -war returnees – sought for employment. Continuing they aver that the construction industry was a natural choice owing to the low skill levels required to gain entry as well as the time-honoured legend that the male-folk was physically stronger than their female counterparts.

Besides this narrative, other scholars have provided a diverse range of narratives each identifying various causes of the seeming under-representativeness of women in the construction industry. Prominent among this plethora of causative factors is the macho nature of activities carried out in the industry and the pre-historic socio-cultural norms which makes it attractive for hirers to engage male-folk who are perceived as having the capabilities to execute assigned tasks (McMahon et al. 2012, Baril 2005). This notion skewed the entry requirements adopted for apprenticeship schemes towards men as against women. Other factors identified include: the lack of explicit government legislations, poor working as well as employment conditions, unfair recruitment processes which are based on referrals and word of mouth as against technical competencies achieved through educational qualifications (Clarke and Wall, 2014). Bagilhole (2014) states that certain acts condoned by the male-folk, but which are unbearable for female-folk are often common-place in the construction industry work environment thus making the environment unconducive for women. As such, women are made to face direct and indirect discrimination and harassment in the work place.

Another coterie of scholars emphasizes the place of construction organizations in preserving this anomaly (McCarthy et al. 2013, Martin and Barnard, 2013). Martin and Barnard (2013) for instance, insist that the organizations need to act expeditiously in legitimizing women’s characteristics, peculiar behavioural patterns as well as values through the provision of a platform for them to compete effectively with their male counterparts in the work environment. Unfortunately, they assert that it will be difficult for organizations to achieve gender equality with the prevailing organizational structures in the industry. Similarly, McCarthy et al. (2013) identify the need for the adoption of organizational justice in reviewing the participation of women in construction. This, they opine, will open vistas for stakeholders to understand the negative impact of the continued underrepresentation of women in the sector and other male-dominated sectors.

2.2 The South African construction context

Like other governments across the world, the South African government is explicitly pursuing an agenda that is supportive of gender equality in all ramifications. This much is not only enshrined in its bill of rights (Aneke et al. 2017) but also prevalent in the liturgy of government policies which seek to engender radical transformation.

The South African construction industry makes a considerable contribution to the national GDP- 3.9% (PWC, 2016), providing employment to a significant proportion of its citizenry. Happenings concerning gender inequality in the local construction does not differ from what obtains in other climes. This is evident in number of studies investigating this phenomenon over the past decade or so. Martin and Barnard (2013) express reservations concerning the optimal attainment of gender equality in the local construction industry despite numerous incentives available to women to venture into hitherto male-dominated professions.

Hinderances faced by women in the South African construction industry do not differ significantly from that faced by their peers across the globe. English and Le Jeune (2012) mention some of these encumbrances to include: poor liaison between industry and communities, absence of female role models in the industry, perceived weaknesses associated with female attributes, working conditions, site conditions as well as physical strength. These barriers are analogous to those expressed earlier, the policy interventions notwithstanding. Also, the authors observe that there was no difference between the experiences of women in professional and trade employment in the construction industry as it concerned the challenges to entry.

However, it will seem that these studies remain fixated on the industry as a systemic whole. The issue of gender equality appears not to enjoy sufficient reportage in the local literature. Evidently, the foregoing sets the stage for the attainment of the study’s objective. Albeit relying on construction sites situated within a city within South Africa, Bloemfontein.

3. Research Methodology

A qualitative case study research strategy was adopted in this study. This came across as a natural choice to the authors, considering its usefulness in enabling an in-depth study of a phenomenon through a juxtaposition of different data collection techniques (Yin, 2009). In this instance, a mix of semi-structured interviews and site observations were deployed towards data elicitation. A case study selection protocol was developed collaboratively with inputs from the authors. Prominent among the criterion was the need for construction work to be on-going. Afterwards, some of the authors visited several sites to identify those that were congruent with the predetermined selection criteria. Upon an identification of 7 sites within Bloemfontein, permission was sought from the project managers for observation and semi-structured interviews to be held. Out of the lot, permissions were obtained from 3 construction sites. Unfortunately, the sites belonged to public sector clients thus inhibiting theoretical replication (Yin, 2009). The choice of Bloemfontein was predicated on several factors, chief among which were convenience and paucity of funds. Yet, it is hoped that a future study will be far-reaching and all-encompassing in scope, hence enabling analytic generalization.

Having secured permission to observe site activities, interviewees were purposively recruited from the sites. Interviewees were informed of the confidential nature of the process and their right to disengage from the process even after the conduct of the interviews. The interviews were conducted between July and September 2017 by three of the authors- each assigned to a distinct site. Site observation visits occurred concurrently during this time. The interview questions were centred on the need to actualize the study's objective. Therefore, questions were asked to elicit opinions concerning the experience of gender inequality amongst interviewees, an identification of the factors responsible for such imbalances, and probable ways of curbing the incidence of gender inequalities on the construction site. Interviewee demographics are provided in Table 1.

Table 1: Interviewee demographics

Position	Gender	Code	Case Project
Project Manager	Male	D1/ D2	CP1/ CP3
Site Agent	Male	SA 1-3	CP1-CP3
Foremen/Supervisor	Male (3)/Female (1)	F/S1-3	CP1-CP3
Masons	Male	M1-2	CP1/CP4
Labourers	Male (3)/Female (9)	L1-L12	CP1-CP4

Source: Authors' fieldwork (2017)

The interview sessions were recorded, mostly in vernacular and translated to English during transcription. The transcripts were analysed in a manner suggestive of thematic analysis. Pre-set themes analogous to both the questions posed and the study's objectives were adopted as codes. The coding was done in vivo, i.e. within the contexts of the transcripts. Afterwards, the authors came together to review the codes allocated to different excerpts and after slight adjustments, arrived at a consensus. This process allows for credibility and has been referred to as multi-investigator triangulation by Patton (1999). Also, notes (memos) resulting from the intermittent site observation visits were extracted and reviewed. Excerpts from this were synchronized with the findings from the interviews, prior to data analysis proper.

4. Discussion of Findings

Findings from the study will be discussed concurrently according to the themes (codes). It is expected that this presentation format will aid easy comprehension. Based on the study's objectives, three themes were selected. They include: the experience of gender inequality on construction sites, an identification of factors responsible for gender inequality on construction sites, and possible recommendations on how to curb the menace.

4.1 Theme 1: Experience of inequality of construction sites

Several studies have alluded to the male-dominated nature of the construction industry (McMahon et al. 2012, Danson 2012). Yet, such allusions have derived mainly from an industry-wide perspective without direct recourse to the construction project site. This study seeks to contribute towards eliciting first-hand information concerning the routine encounter of relevant stakeholders with gender inequality in their work environment. However, a cursory look at Table 1 reveals the extent of gender imbalance experienced on sites in the study area. Of the 22 interviewees, women constituted less than 50% (10 out of 24) of the sample. Also, only one woman belonged to the supervisory cadre. Others were labourers- hence not requiring any specialist skill set. This puts a lie to the notion that the demand for physical strength was a hindrance to engagement of women in the industry as the female labourers were observed carrying out similar tasks with their male counterparts without being any preferential treatment whatsoever.

There was a consensus among the interviewees on gender inequalities. D1 maintained that this was becoming a norm as most women did not want to be seen working as labourers unless as a last resort. An interviewee (F/S1) maintained that most of the contractors were undermining women by assigning them to tasks which were not challenging such as cleaning the offices, doing housekeeping and taking record of materials. He opines that allocating such tasks to women will inadvertently encourage continued imbalance in the industry and on site. A similar view was expressed by Lingard and Francis (2006) wherein it was reported that women were facing several challenges such as discrimination and limited working network in the workplace. Another interviewee working on an EPWP project (SA3), explained that he does not understand why female workers are undermined in the construction industry stating that they should be employed if they are willing and able to work in construction. But he added that the women should not expect special favours as this was wont to undermine the productivity desired from the industry.

However, some interviewees (D2, F/S 1, SA3) averred their preference to work with women due to their reliability and ability to respond well to instructions, unlike men. Furthermore, another interviewee explained that they do need women to manage site because male workers behave better under the instruction of a woman than of men. An interviewee (SA3) observed the significance of political influence in empowering women through programmes such as EPWP. SA1 stated that he had full respect for female workers because they make the men to behave properly and attain higher productivity on site. Furthermore, he averred to having selected a female worker to control and take records of the plant operations because he discovered that the plant operators respect women.

4.2 Theme 2: Probable factors leading to underrepresentation of women on construction sites

Whilst admitting that gender imbalance remained a reality, another interviewee F/S 2, a woman, bemoaned the perception of the public towards her as doing a man's job. She opined that such impressions may be responsible for the non-interest of women in the construction industry. This notion has been buttressed in various studies wherein the industry's image has only served to further the legend concerning its male-centric nature.

Most of the female interviewees blamed the inability of the contractors to improve their working conditions on site. As a result, they are compelled to use the same conveniences with their male counterparts. They bemoaned the poor state of such facilities because of the unkempt nature of their male counterparts. Furthermore, contractors were accused of failing to provide skills training or workshop for the female staff on the site besides those bothering on health and safety, yet they were expected to be as productive as the male employees who has spent years in the construction industry. One of the female interviewees (L5), stated that when she indicated willingness to acquire bricklaying skills, which according to her was less strength consuming when compared to activities associated with being a labourer, her male counterparts mocked her, ceaselessly. However, a sense of gratitude was felt on the part of the female labourers to the contractors for giving them an opportunity to work and earn a living.

F/S2 admitted that most contractors expected women to be as tough as the men: arguing that it was their choice to work in a male-dominated industry and that it was up to them to prove that they are as active and resourceful as male. While another interviewee responded that he does not believe in providing training to the workers, especially women because it is a waste of money, most of the female workers are working in construction because they are struggling to get employment of their dreams, as soon as they get a better employment they do not waste time to resign, others are not even serving a notice they just pack their backs and go without saying good bye.

Another interviewee (D2) working on a labour-intensive project stated that the employment of his labourers is handled by the ward councillor and the community liaison officer (CLO). After receiving the appointment letter, there was an instruction that he must hire 18 women and 12 men workers, and he forwarded the instruction to the CLO to communicate with the community and organize people to be hired. Unfortunately, they could not find the required number of women to recruit. He opines that this may have been influenced by the industry's image. Somewhat, none of the interviewees mentioned historic socio-cultural dimensions as posing a barrier to their entry into the industry. Rather, they bemoaned the lack of skills, whilst expressing their continued willingness to carry out any assigned tasks. It was observed that the female labourers on site did not refuse to carry out any assigned tasks on the account of physical strength.

Yet, most of the supervisory staff interviewed asserted that the shortcoming experienced with engaging women on site concerned their poor and inconsistent attendance records. According to one of such interviewees, F/S 3 described a situation that he had where his female labourers disappeared from site, proffering excuses relating to the need to execute some household chore. This influenced productivity, they averred.

In a nutshell, most of the factors mentioned here are congruent with factors identified in similar studies reviewed.

4.3 Theme 3: Recommendations on how to address gender inequality

4.3.1 Effective implementation of extant policies

Various policies have been put forward in the bid to engender optimal gender equality in South African construction sites. One of such policies is the EDWP programme. This programme makes the recruitment of certain percentage of women mandatory for construction works. It also provides modalities for monitoring and enforcing compliance. When asked how they were recruited, most of them said that the councillor and the CLO asked them to come to the wall and submit their names and next thing they were called to report to the construction site and the contractor sent them to the hospital to do medical checks and thereafter they were given contracts to sign by the contractor. This suggests that the extant policies were gradually making an impact within the South African context. Furthermore, this shows that the recruitment process has been simplified for women. This was identified as a problem by Botcherby and Buckner (2012) wherein they posited that the transition of female graduates with academic qualifications into the industry had been observed to be difficult when compared their male counterparts.

4.3.2 Increased training

Female interviewees declared interest in gaining specialist skill sets through apprenticeships on site. However, they maintained that the contractors did not provide any opportunities for such to occur on site. According to them, the contractors' representatives had admonished them to go to the technical colleges to obtain skills or even engage specialists at their spare time to learn such skills. Obviously, most of the women interviewed do not possess the required entrance qualifications to enter the technical education colleges. There is need for the government, unions and contractors to facilitate apprenticeship schemes for these individuals. It is advised that apprentices should be paid during the apprenticeship period as this would serve as an incentive.

4.3.3 Improved site conditions

Another issue that was raised pertained to the working and site conditions. Although some interviewees referred to the non-consideration of gender in the provision of conveniences on site, on the three sites visited the toilet facilities were clearly delineated. Contractors should try to ensure that this remains the norm. Gender should be considered when providing facilities on sites but not in a manner that depicts one gender as being inferior to the other.

Based on the views espoused by the interviewees and observations made by the researchers, issues concerning gender equality remain the same at various industry subsystems: sites, and firms. In furtherance to this, findings from this study confirmed that the same challenges were being faced by professionals and tradeswomen in the construction industry, a view elucidated by English and Le Jeune (2012) and Moir et al. (2011). It is expected that industry stakeholders will endeavour to achieve gender equality in the industry.

5. Conclusion

Achieving gender equality in the construction industry remains a daunting task, globally. South Africa is no exception. This study set out to explore the underrepresentation of women on construction sites in South Africa. Given its embryonic nature, this exploratory study focused on a few sites in Bloemfontein. The decision to focus on sites emanated from the seeming paucity of studies in this area studying that subsystem of the construction industry. Interviews and observations were used to elicit data from purposively selected interviewees from previously identified sites.

Findings confirmed that gender inequality was indeed a reality. Furthermore, findings from previous studies were confirmed in the cases studied. Impliedly, different subsystems of the industry faced similar challenges which negate the principle of gender equality. This study proffers recommendations on how to curb the burgeoning instances of gender inequality on construction sites based on the views of the interviewees.

Although the findings from this stud will contribute to the ever-growing corpus of literature in this aspect, it is fraught with significant limitations. Such limitations will include the inability of the study to achieve analytic generalization of its findings and the number of interviewees as data saturation was not observed.

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Assessing the Training Needs and Competencies for Quantity Surveying Graduates in the Zambian Construction Industry

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Abstract

Training is critical in achieving sustainability in infrastructure delivery, most importantly in the provision of the right skills and training to would be graduates. This research therefore focused on assessing the training and development in skills of Quantity Surveying (QS) graduates in the Zambian construction industry. The research adopted both quantitative and qualitative methods. Primary data was collected through questionnaires. Findings revealed that core competences needed for QS graduates include quantification/measurement, economics and costing and construction technology. On the other hand, health and safety is one area given little attention while sustainability was not mentioned. Further, it was found that the industry remains dissatisfied with performance of QS graduates, largely due to lack of collaboration between the industry and the academia and limited training facilities. In order to meet the training needs of QS and more importantly achieve sustainability in the delivery of infrastructure in Africa, the industry and the academia must collaborate in developing and reviewing the training process.

Keywords: construction industry, training, quantity surveying graduates, Zambia

1. Introduction

In the recent past, the Zambian Government has embarked on a number of developmental projects which include the construction of roads, health and educational facilities (Zambia Development Agency, 2013). Realizing that every government is faced with limited resources, it is imperative that the available resources are utilized efficiently. Essentially sustainability is encouraged. Hence, this calls for concerted efforts by all project professionals in ensuring that projects are managed efficiently, in order to meet the project requirements. One such critical profession is Quantity Surveying (QS) whose main responsibility is cost control and financial management. Professional Quantity Surveyors (PQSs) have emerged as respected financial specialists and advisers in the

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construction industry in countries where their expertise is recognised (Nkado, 2000). Therefore, one critical area through which project management and sustainability can be improved is training and education of professionals such as QSs who form part of the project management team. To achieve this, learning institutions need to obtain feedback from professional bodies and the industry regarding performance of QSs in order to ensure that their fresh graduates meet the industry's expectations (Perera et al., 2011). However, complaints coming from industry pointed to the universities for not providing the appropriate curriculum and course content (Ayarkwa et al., 2011). This implies that the training and development of the fresh graduates is unsatisfactory with communication and interpersonal skills as some of the deficient areas. Aguinis and Kraiger (2009) define training as the systematic approach to affecting individuals' knowledge, skills, and attitudes in order to improve individual, team, and organizational effectiveness while development is defined as systematic efforts affecting individuals' knowledge or skills for purposes of personal growth or future jobs and/or roles. Past research has investigated professional competencies specifically the training and practice of QS profession (Nkado, 2000; Nkado and Meyer, 2001). It has generally been found that QS profession is constantly confronted with challenges and opportunities in new markets (Chan et al., 2002). Hence this paper sought to assess the important competencies for training of graduate in the Zambian construction industry with the following as objectives:

a. Compare competencies perceived to be important between industry and academia
b. Recommend collaborative training and development in QS skills for graduates

2. Quantity Surveying Training and Education in the ZCI

Many definitions for education and training exist however for this research the following definitions were adopted. According to Alshawi et al., (2007) education implies that people develop skills, such as creativity, critical analysis of accepted practice and understanding of theoretical concepts. Training, on the other hand, implies that emphasis be placed on a person's ability to perform productively on their employment duties (Chan et al., 2002). Training essentially addresses how specific tasks are done (Haltenhof, 1996), whilst education mainly emphasizes critical thinking and analysis which tries to answer why we perform certain tasks. Therefore, QS education and training is an applied science which tries to prepare students in analysis and critical thinking and application or performing their duties on a project. Thus, QSs' training and education covers various areas such as engineering (civil, electrical, mechanical, among others), pure and applied economics, finance, accounting, sociology, administration and law to name but a few (Mogbo, 1998).

In the ZCI it takes at least five (5) years of training in order to obtain a bachelors degree in QS. This is offered at the Copperbelt University (CBU), in the Department of Construction Economics and Management (CEM). CBU is the only institution in Zambia offering QS training (The Copperbelt University, 2014). The department offers two specializations; Bachelor of Science in

Construction Management (BSc. CM) and Bachelor of Science in Quantity Surveying (BSc. QS). The aim for the university is to produce graduates with sound academic background that will equip them with the necessary knowledge to fit into the ever developing construction market world over.

2.1 Challenges in quantity surveying education in Zambia

There are several challenges (Pima, 2012) currently facing not only CBU, but also other higher education institutions in Zambia and Africa in general. Some of the major ones include: limited funding, facilities and equipment, and lecturing staff. At CBU the government's financial support to the university has been inadequate due to its limited resources. Hence more financing is needed in order for the institution to be at par with other international institutions offering QS training (Mwape, 2008). The financial inadequacy has also affected availability of facilities and equipment**.** There is insufficient office space, laboratory facilities and other necessary equipment for ensuring the successful running of the institution. Furthermore, the financial inadequacy affects the staff levels at the institution. The number of employed academicians qualified in various areas of teaching at the University is limited. Therefore, if the ZCI is to improve the training and education of QS, this hugely depends on overcoming these challenges and the private sector must be involved since the government's resources are limited.

2.2 Roles and importance of competent quantity surveyors

Traditionally, QSs are in charge of preparing construction contract documents, offering cost advice and monitoring construction costs and providing appropriate advice on procurement systems (Ngulube, 2009; Mahbub, 2001; Ashworth, 2006). They also conduct initial cost planning and control costs throughout the construction phase, prepare financial documents, and valuations (Ashworth and Hogg 2007). Essentially, most of the important functions traditionally carried out by QSs are based upon the measuring and costing of construction and contract management (Olatunji et al., 2009). Fanous (2012) also notes that other roles have emerged from the changes that are taking place within the profession and the industry, which include; contractual dispute resolution, insurance valuations and providing insolvency services, measuring environmental costs and sustainability. Hence, competent QSs are inevitable for any project since they are able to provide these services which enables client satisfaction as they enjoy several benefits which include; cost-effectiveness and value-for-money, improved product quality and performance, minimal variations in estimate and final cost of a project (Ayarkwa et al., 2011). However it is important to note that QSs do need input from various professionals in the industry. As such a competent design team is crucial for any building project (Lee et al., 2005). Further, QSs are employed in both the public and private sectors in project management and either work as consultant or contractor's QS. The common requisite among these organizations is that they all want QSs who are capable of contributing to the organization's performance and its growth instantly (Adelina, 2005). Ultimately competent QSs will also give a competitive edge to the construction firms.

2.3 Quantity surveying graduates' job requirements

According to Love et al. (2001) before employment QSs are required to have three essential attributes, namely: practical experience so that they are familiar with the workings of the industry; knowledge of the tools and techniques for planning, scheduling and controlling construction operations, and the personality and insight that will enable them to work harmoniously with other people. Back and Sanders (2008) added that QSs are required to possess various skills summed up as personal, business and technical. Love et al. (2001) further contends that job advertisements show that employers are looking for people who can communicate well, write reports and work well in teams and build up networks and relationships both in the workplace and with customers. In addition, the ability to stay abreast with the latest managerial and technological developments within the industry has also been found to be important skills that graduates should possess.

2.4 Core study areas of quantity surveying

In order to meet job requirements, QS studies encompasses a number of elements (Ashworth and Hogg, 2007; Awodele, 2003). The aim is to produce graduates equipped with the necessary skills for the profession of QS (Badu and Amoah, 2003). The core areas of quantity surveying study include:

Construction Technology - This equips QSs with knowledge to: Identify, select and supervise application of construction materials, read and interpret drawings and specifications (Lee et al., 2005; RICs, 2017). This helps them survey and investigate construction sites, which reinforces their take off for quantities and estimate costs. It also emphasizes the importance of health, safety and environmental management when selecting materials, equipments and construction techniques (Ashworth and Hogg, 2007).

Construction Economics - QSs are trained to ensure the judicious allocation of the construction resources of materials, manpower, machinery, money, methods and management with the overriding aim of ensuring value for money spent on construction projects (Awodele, 2003). Construction economics is therefore one of the main subjects undertaken by students studying to become professional QSs (Badu and Amoah 2003, RICS, 2017).

Estimation, Measurements and Costing - This equips candidates with adequate knowledge for managing costs of projects from inception and end with the agreement of the final account of the project (Canadian Institute of Quantity Surveyors, 2012, RICs 2017). This is through the development of estimation, quantification and costing of construction works (Lee et al., 2005).

Construction Law and Contract Practice - These studies help students understand the principles of law in construction since construction involves contracts and other legal obligations (Badu and Amoah 2003). Major aspects covered include; contractual arrangement, contract documentation, tendering procedure, communication, measurement and valuation of works, variations, claims, and preparations of certificates (Seleey 1993).

Procurement and Tendering - Knowledge on available construction procurement systems and tendering procedures is also vital for their roles in ensuring that appropriate choices of construction procurement methods for particular projects are made (Ayandike, 2004).

Accounting principles and reporting – This enables QSs to keep the client informed at all stages of the project on the financial position of the contract at agreed regular intervals by producing project financial reports, usually on a monthly basis (Ashworth, and Hogg, 2007). These include quotations set against prime cost and provisional sums, variation orders, day work sheets and contractor's claims (Badu and Amoah 2003).

Conduct rules, ethics and professional practice - QSs are required to conduct themselves in a manner befitting professional values set in the Code of practice by membership regulatory institution such as RICS and CIOB (RICS, 2007). Others include ASAQS in South Africa and Surveyors Institute in Zambia. Professional practice and procedure focuses on imparting useful skills on the students in order to prepare them for professional work after graduating from university. This includes the ethos and culture of the profession. This makes them identify key principles and values that should guide day to day practice and emphasises the core values that are to be followed by QS professionals to ensure that they behave in an ethical manner by acting professionally inside and outside work, and always abiding by the law (Registration Body for Quantity Surveyors, 2008; Chua, 2000; RICS, 2007).

2.5 The need for collaboration

It has been agreed that education needs are mainly met by the university which are interested in producing a graduate with the basic foundation in knowledge for further development. The understanding is that the training aspect will have to be met by the industry which is interested in graduates who instantly contribute both to the daily functions of business activity and to its growth (RICS, 2009; Shafiei and Said 2008). This leads to many problems, with greater levels of employer and graduate dissatisfaction and obstacles to early career development of the QS graduate (RICS, 2009b). Hence if the industry is to appreciate the performance of the fresh QS graduates, the two parties will need to combine their efforts. Importantly, Perera et al., (2011) recognizes that the level of industry and academic collaboration in the delivery of QS programmes is vital to the success of graduates. This was also echoed by RICS (2009b) which argued that greater levels of university and industry collaboration should be made an essential part in developing and delivering QS programmes (RICS 2009b). Nevertheless, it is unclear whether in the ZCI the academia and industry have come to understand the need for collaboration so as to produce the desired QS graduates.

3. Research Methodology

The research used a pragmatic approach in the design as the nature of the problem seems to be of practical nature. Survey and interviews were the strategies used to collect data. Questionnaire comprising open and closed questions posed to QS consultancy firms (16) and Contractors (64) from grade 1 to 4. The industry comprises about 32 QS firms and 753 contractors registered in grades 1-4 in total. Though the contractor categories go up to 6 only grades 1-4 are likely to have a QS as per National Council for construction registration guideline. The nature of sample for contractors was arrived at using stratified random sampling while simple random sampling was used for the QS firms (Kumar 2007). Semi-structured interviews were conducted with purposively selected academicians since there is only one institution offering QS training. There was need to mix the methods of data collection due to the nature of the populations involved. Only the traditional roles of the QS were investigated in this study using a cross sectional approach. The roles were ranked using a 5 point likert scale which can be interpreted as 4-5 high importance 3 moderate importance and 1-2 low importance.

The response rate for the Quantity surveying firms was 50%, 60% academics and less than 10% for contractors. The small number of contractors was also due to the fact that some contractors do not have QSs. The interviews and survey were conducted concurrently. The analysis mainly made use of means and frequencies all methods of data collection were suited for further statistical analysis due to lack of randomisation.

4. Results and Discussion

From the data collected from the questionnaire survey, the following were the main findings:

4.1 Perceived important QS competencies

Table 1 shows the ranking of different QS competencies by Academia and industry. From Table 1 it can be noted that most competencies were ranked as highly important by both industry and academia though the ranking for academia seemed higher in most cases. However, the competencies for health and safety were ranked to be of moderate importance by both the industry and academia. Additionally, dispute resolution and programming and planning are other competencies ranked as being of moderate importance by industry. Finally, accounting principles were ranked as being of low importance by industry despite these being seen as core or mandatory requirements by RICs.

Table 1: Perceived important QS competencies

Importance of Competences	Academia			Industry		
	MEAN	SD	Importance	MEAN	SD	Importance
Construction technology and environmental services	5.00	0.00	High	4.91	0.29	High
Procurement and tendering	5.00	0.00	High	4.96	0.19	High
Design economics	5.00	0.00	High	4.17	0.78	High
Quantification and costing of construction works	5.00	0.00	High	5.00	0.00	High
Communication and negotiation	4.67	0.58	High	4.09	0.86	High
Conduct rules, ethics and professional practice	4.67	0.58	High	4.00	1.07	High
Construction project management	4.67	0.58	High	4.00	0.94	High
Risk management	4.67	0.58	High	4.03	0.99	High
Project financial control	4.67	0.58	High	4.88	0.36	High
Contract practice and administration	4.33	0.58	High	4.36	0.85	High
Team working	4.33	1.15	High	4.00	0.97	High
Dispute Resolution	4.33	0.58	High	3.31	1.14	Moderate
Accounting principles	4.00	1.00	High	2.78	1.15	Low
Programming and planning	4.00	1.00	High	3.55	1.04	Moderate
Health and safety	3.33	0.58	Moderate	3.05	1.33	Moderate

4.2 Satisfaction with the QS education curriculum and improvement areas

From the findings, 67% of the academia indicated that they were satisfied with the education curriculum while the rest were perfectly satisfied. For contractors and QS consultants, 30% and 36% respectively indicated that they were satisfied while the rest were not. Notably, a large sector of the ZCI was not satisfied with the curriculum. This calls for collaboration among the key parties in order to improving the performance of QS graduates. All respondents indicated that limitations in skills or performance were noted in measurements, management and in road construction technology. This was attributed to the fact that measurements were introduced in the later years of the study period for the degree in QS. However, most students do not have early exposure to practice measurements which is the role of industry to provide an opportunity for practical training. Additionally, areas such as BIM (Building Information Modelling), Lean Construction and sustainability are currently not part of the curriculum.

4.3 Performance of fresh quantity survey graduates

Nearly half of the contractors (44%) and approximately half of the consultants (50%) from the industry rated the job performance of fresh graduates as being fair with only 30% contractors and 29% of consultants indicating good performance and the remaining being unsatisfied. This further reinforced the need for the training content and system to be reviewed and further improved upon. Those who rated low performance of QS graduated cited inadequate industrial experience which is considered to be the role of industry and not academia. Further, the limited in resources by the learning institution was also a factor noted for low performance. Communication being an area which was recommended for improved including practice. This was in line with the findings by previous researchers.

4.4 The role of universities and the industry in producing a graduate quantity surveyor

By and large the industry (contractors and consultants) respondents indicated that the university should offer 60% education and 40% training. This basically illustrates that universities produce graduates with overall knowledge and a good foundation in QS (Education). On the other hand, academicians indicated that universities should offer 67% education and 33% training. Clearly each party transfers responsibilities to the other, were the academia insists that it should only educate and training to be done by the industry, while the industry expects to have fully trained QS fresh graduates. However, what can be inferred from the above is that both the academia and the industry acknowledged that they all have roles to play in order to have well trained and educated fresh QSs. Both parties have to be involved in the training and education of QSs. Essentially, the education system must take a practice oriented teaching instead of focusing on theories.

4.5 Willingness to collaborate

From the findings, 67% of the academia was willing to collaborate and only 51% of the industry's respondents willing to collaborate. This shows the likelihood of a synergy being formed between the two parties in ensuring that the best learning information is given to the fresh graduates. Further, the low level of willingness of the industry to participate in the collaboration was attributed to their busy schedules in managing projects, bidding for prospective jobs and projects being located in remote areas. Other reasons advanced by the industry were that there was no clear outline of how and when they would be engaged as guest lecturers and seminars hosted by industry practitioners is one way in which the collaboration could work. Further, more approaches such as experiential learning could be used to bridge the identified gaps.

5. Conclusion

Presently, the industry still remains dissatisfied with the performance of fresh QS graduates, calling them half baked, whilst the academia is satisfied. This contradiction can only be equalised through collaboration which has been noted to be low among the key ZCI parties involved in the training of QSs. Importantly for the academia, this calls for a shift from basically focusing on traditional QS roles of cost control and embrace a wider range which must also include health and safety which was found to be among the least important competencies for QS, despite it being one of the success factors for a project. Further communication and management skills should be improved while measurements should be introduced in the earlier stages of the learning period so that more time can be spent on imparting this skill to the students to make the profession sustainable. The industry must also be encouraged to partner and collaborate with the academia through guest lecturing and seminars. Importantly, the involvement of the QS professional body could act as synergy for collaboration. In collaboration with the industry, the curriculum must be reviewed to include and adopt new AEC improvement themes such as BIM, Lean Construction and sustainability to name but a few which have been noted to be inconspicuous in the teaching curriculum. More importantly, sustainability has become a major theme or concern on projects and notably, there has been no mention of it being a key area of training for QSs. Hence it is recommended that the industry and the academia must consider integrating sustainability in the training of QSs. With ICT taking a leading role in the business world, such training must be encouraged. These areas are recommended for further research since this paper mainly focused on the traditional training and competencies of QS. Unarguably, for the industry and the academia to see improved performance and sustainability on projects from the QS the two should collaborate more.

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Multi Stakeholder Consultative Framework for Construction Health and Safety: Role of Client and Project Manager

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Abstract

The paper is an output of a larger study that purposed to design a multi stakeholder consultative framework for the construction health and safety (H&S). The designed Multi Stakeholder consultative framework shows the relationships that exists between key stake holders on a construction project in order to attain close monitoring and supervision of H&S management. The intent of the framework was to improve and strengthen H&S responsibility and accountability through involvement, network building and structural engagements among stakeholder affected by the construction development. A composition of key stakeholders of the planned framework proposed the client, the project manager, designers, H&S practitioners, the main contractors, subcontractors and the community. A consultative committee was convened. The constructability review and H&S planning stages were proposed including multi stakeholder consultative committees. The proposed framework presents consultations of stakeholder, encourages development and strengthens stakeholder engagement. The framework recognises the importance of equity and accountability in dealing with H&S of the construction project.

Keywords: client, construction safety and health, multi stakeholder, project manager

1. Introduction

In its 1992 Code of Practice 'Safety and Health in Construction', the International Labour Organization (ILO) outlined the responsibilities of different groups that influence a construction project. The ILO (1992, 5) advised that the national laws of different countries should include the input of clients, designers, engineers and architects, who all have a duty of care to include H&S

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considerations in their contribution to a project. Section 2.1.7 of this code further prescribed that national H&S regulations should be part of the general duties of different participants in the construction process. These ILO recommendations were then mirrored by the United Kingdom's (UK) Health and Safety Executive (HSE), which released a code of practice for good working relationships and stakeholder responsibility entitled 'Respect for People (RFP)'. In it, a need for Health and Safety (H&S) to be considered in all aspects of the design and construction processes was highlighted (HSE, 2010).

Various scholars have echoed similar views that there is need for a shift from focussing on the contractor as the cause of the ills of the industry. According to Winch (2010) and Rwelamila et al. (2000), construction H&S is not the responsibility of the contractor alone, but rather the responsibility of all stakeholders involved in the project. Justifiably, any construction project has its longest phase at project implementation stage onsite, a stage which leaves H&S management to the contractor. However, Clients, project managers, designers and quantity surveyors are identified as having both direct and indirect influence on construction H&S (Lopes et al., 2011). Smallwood and Haupt, (2006) further asserts that construction H&S remains the concern of all individuals and organizations involved in construction projects and that all parties to a construction project must communicate their expectations of site H&S roles throughout the duration of a project. It is therefore necessary that industry stakeholders' influence on construction H&S is reviewed.

2. Influence of Project Stakeholders on Construction Health and Safety

Various scholars and organizations agree that all project stakeholders have either a direct or indirect influence on the projects H&S performance. However, influences differ according to each profession or trade and other factors. For instance, Abootorabi et al., (2014) found that, under the traditional procurement method, while subcontractors heavily influenced the root causes of accidents, general contractors retained a moderate ability of influence. On the other hand, architects and engineers exercised little influence over the root causes of accidents. Atkinson and Westall (2010) assert that industry stakeholders directly influence H&S through general design, type of structural frame, plan configuration, details, specification of materials, method of fixing, and constructability. Conversely, the construction key stakeholders indirectly influence H&S through site coverage, project duration, type of procurement system, contract documentation, pre-qualification of contractors, and reference to H&S during site handover, meetings, inspections and discussions.

Further, the influence of stakeholders has an effect on the costs related to H&S. The direct costs that affect the project include those that result from accidental equipment damage or personal injuries such as lost production time, insurance costs, penalties for breach of H&S legislation and litigation costs (Lopes et al., 2011). On the other hand, indirect costs are identified as those that incur indirect financial impacts resulting from schedule disruptions, increases in insurance and workers compensation premiums. Boshoff (2012) further added that the indirect costs of poor H&S have heavy impact on organizations through:

- Interruption in production immediately following the accident;
- Morale effects on co-workers;
- Personnel allocated to investigating and documenting the accident;
- Recruitment and training costs of replacement workers;
- Reduced quality of recruitment pool;
- Equipment and material damage;
- Product quality reductions following accidents;
- Reduced productivity of injured workers on light duty;
- Overhead costs of spare capacity maintained in order to absorb accident costs;
- Market share reduction/customer retention;
- Reduced goodwill;
- Higher insurance premiums/difficulties in obtaining insurance; and
- Financial problems/stock exchange prices.

Therefore, everyone involved in construction should be responsible for H&S. Those cited as having a greater responsibility include clients/principals and designers/advisers, particularly architects, engineers, employee consultants, head contractors, subcontractors and employees (Boakye et al., 2011).

3. Initial Key Stakeholders in Managing Construction Health and Safety

In this section, the focus is on the initial project stakeholders, viz., the clients and project managers and the role they play in multi stakeholder management of H&S.

3.1. Client’s role in construction health and safety

Striving for enhanced H&S performance remains elusive if the client is not actively involved in the construction industry. Mwanaumo and Thwala (2011) argued that the involvement of clients is an essential requirement for the achievement of the zero injuries objective. This is because clients are sources of finance of construction project as well as the primary consumers of the construction product and services (Musonda, 2012). Thus the clients’ participation in project H&S can significantly influence project H&S performance.

The European Union‘s Construction Site Directive regards the client as being responsible for H&S. The majority of the European Union member states note the client as being responsible for the H&S outcomes of a project by (1) the financial specifications and contract negotiations that determine employment conditions and (2) the allocation of funds needed to implement H&S

measures in a comprehensive fashion (Winch, 2010). Given that clients invariably appoint designers or project managers as the principal agent, the specific ILO (1992) recommendations relative to clients should be noted. The recommendations indicate that the client should coordinate or nominate a competent person to coordinate all activities relating to H&S. The recommendations suggest that the client should inform all contractors of special risks to H&S of which they are or should be aware. The client should further require contractors submitting tenders to make provision for H&S, and consider H&S requirements when estimating dates for stage and overall completion of the project.

Atkinson and Westall (2010) demonstrated this principle when they observed that the client responses were the actions or failure to act in response to constraints that emerge during the development of the project scope. They argued that reducing the project budget, adding new project criteria, changing project objectives and accelerating the design or construction efforts of the project are factors that impact on H&S and are directly influenced by clients.

A proactive management of H&S as argued by Musonda (2012), requires that a H&S approach be adopted that is not dependent on the monitoring of injuries after they occur. Rather than basing H&S actions on measures of failure, a shift in thinking is needed whereby the focus is on those actions that can lead to good H&S performance (Musonda, 2012). Leading indicators and management of these is what will contribute greatly to H&S performance improvement. Among the list of activities which are essential for client influence on H&S are setting H&S objectives, selecting suitable contractors in terms of H&S, provision of financial support, inclusion of H&S as a prequalification criteria, issue contract documentation that is structured to allow for H&S and conducting audits in H&S.

Mwanaumo and Thwala (2011) assert that the client should provide necessary information to enable designers to prepare safe designs, take lead responsibility for the pre-construction phase coordination activities, and provide sufficient pre-construction phase resources – especially cost and time. The clients' commitment to H&S should involve his commitment of funds to enhance H&S, input adequate resources into H&S, balancing H&S and cost during negotiations, employing fulltime H&S representatives on site, funding H&S recognition programmes and support H&S orientation. Mwanaumo and Thwala (2011) argue that commitment to H&S by the clients is demonstrated by their adequate provision of resources for H&S initiatives, communicating H&S in a timely manner, and selecting an active H&S participating contactor. Clearly, the client must establish H&S as an integral project component before any onsite construction work is initiated. This would enable each contractor and sub-contractor to develop H&S programs at the tendering stage of operation, enabling clients to monitor the implementation of these programs following the commencement of onsite construction work.

3.2. Construction project manager's central role in coordinating health and safety

Zambia's construction industry is slowly shifting from principal agency role to adopting the Construction Project Manager (CPM) as the coordinator of the project stakeholders. The CPM is thus expected to be involved from project conception to completion, (including commissioning) on behalf of a client. However, a fault with the understanding the CPM's role to H&S lies in the definition of project management which focuses on 'managing a project' and not making specifically managing people to achieve a project.

Internationally, the project manager's performance in general is based on the Project Management Institutes (PMI) internationally recognised Project Management Body of Knowledge (PMBoK). Of the ten areas of knowledge in the PMBoK, no specific section deals with H&S. The only chapter under which H&S is briefly mentioned is project human resource management. However, individual associations which are affiliates of the PMI include only safety (and not health) in the responsibilities of the project manager. For instance, the UK's Association of Project Managers (APM) (2010) defines project management as, "the planning, organising, monitoring and control of all aspects of a project and motivation of all involved to achieve the project objectives *safely* and within agreed time, cost and performance criteria". It is clear from this definition that safety is expected to be among the responsibilities of a Project Manager, even though health is completely omitted.

However, according to Wild (2005), the poor H&S performance of the construction industry is not a result of time, budget, and quality issues (which are traditional project parameters), but is attributable to a lack of commitment on H&S. In addition to the demonstration of management commitment to H&S, Boakye et al. (2011) postulates that project managers should concern themselves with H&S leadership. This suggests that the CPM, being the principal leader, coordinator and link among the designers, contractor and the client, has a higher leadership responsibility in ensuring that both the client and the designers meet the contractor's expectation regarding H&S. This calls for the CPM to make reference to H&S during construction phases, including site handovers meetings, inspections and discussions, to ensure that there is synergy among H&S, productivity, quality and time (Lopes et al., 2011).

4. Multi Stakeholder Consultative Framework for Health and Safety

The Multi stakeholder consultative framework in figure 1 shows the important relationships that exist in order to attain close monitoring and supervision of H&S management that includes key stakeholders. This multi stakeholder consultative framework describes relationships which aim to bring together all key construction industry stakeholders in a planning and decision making process on issues relating to health and safety of the project, project participants and the beneficiaries (the public and the community).

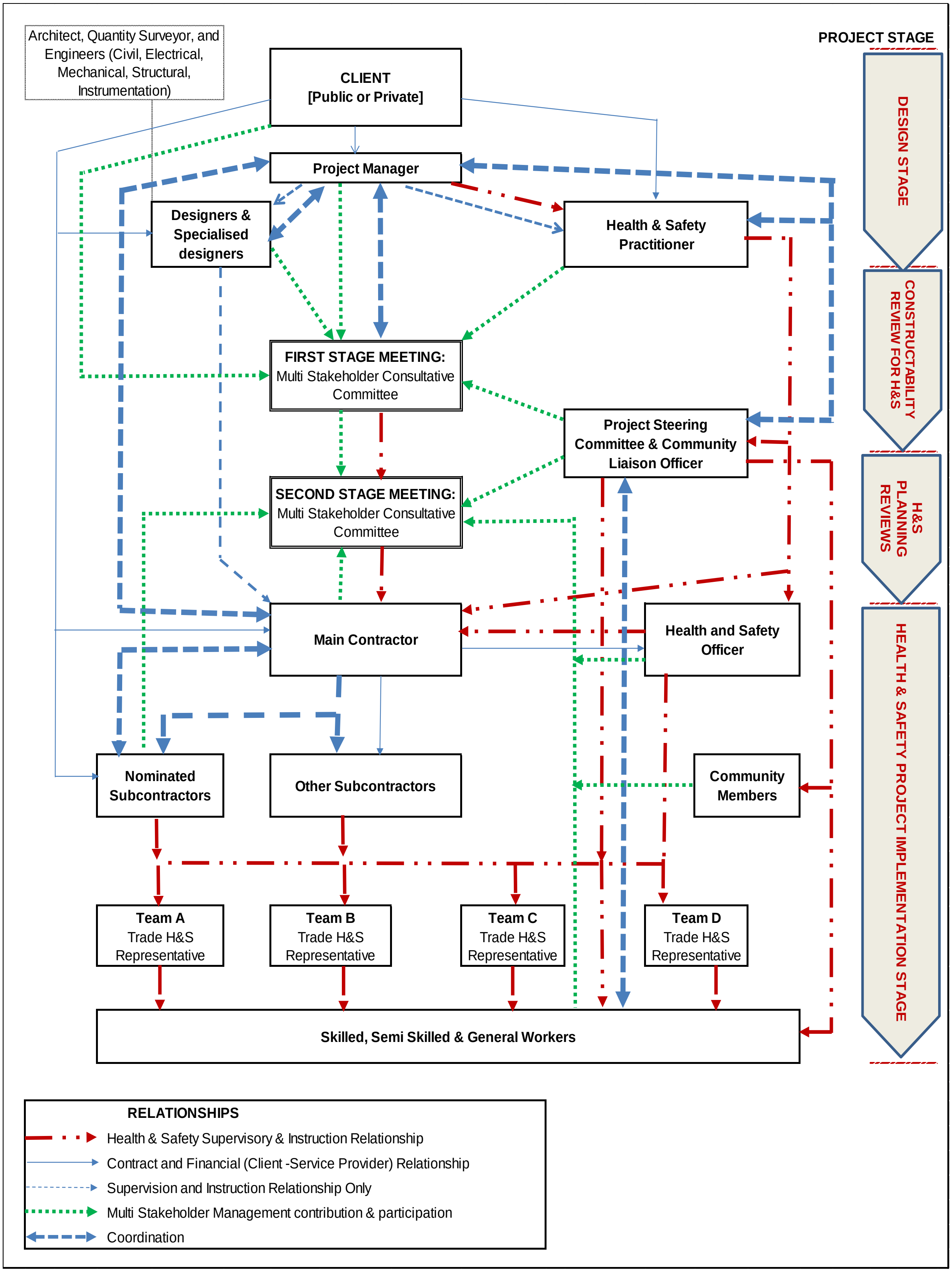

Figure 1: Multi stakeholder consultative framework

This framework intends to improve and strengthen H&S responsibility and accountability through key industry stakeholder involvements and build networks and structures of engagements among stakeholders. It introduces equitable representation of the four groups of stakeholders that are directly affected by the construction of any development.

Ideally, the groups comprise (1) the Client, who fund the project or initiate the development (2) designers, who conceptualise the client's needs and come up with workable specifications according to the client's needs (3) the contractors (Main, domestic subcontractor and nominated subcontractors) who implement the actual construction works and (4) the beneficiaries who either are employed from the community as worker, or will use the product being constructed.

The details of composition of the key stakeholders for this proposed framework are the client (public, quasi government or private), the project manager (as the client's lead representative), the designers (which include the architect, quantity surveyor, civil engineers, electrical and Instrumentation engineers, mechanical engineers, structural engineers), health and safety practitioner (employed by the client specifically to address project H&S) and the main contractor, the nominated and domestic subcontractors, the community (represented by the project steering committee) and the community Liaison officer (usually recommended by the project steering committee but employed directly by the contractor). The consultative committee will be convened in two stages as followed by the procurement stages within the traditional procurement methods.

In the traditional procurement process, the client procures the services of the designer to produce documentation for the project. The second procurement stage is done after the documentation is complete and the contractor is procured usually through a tendering process. Upon appointment of the contractor, the project is implemented/constructed. However in this proposed multi stakeholder consultative process, two stages will have to be introduced between the design and implementation stages. The constructability review stage where the build ability of the design will have to be discussed to ensure that all major identifiable risks are eliminated in the design and specifications. The H&S planning stage will follow the constructability review process immediately after the construction drawings have been completed, but before the contractor can submit the H&S file and plan of work. This section will focus on eliminating risk and incorporating all mitigation measure on the H&S of the project participants and the public.

Multi stakeholder consultative committees will form the centre of this framework. First stage consultative meeting will be convened when all designers/consultants have been appointed. The purpose of the first stage meeting is for the client to, among other things:

- Brief the consulting professionals of the project objectives;
- Establish project team members required;
- Client expectations of project H&S goals are set;
- Arrangements for monitoring and review of health and safety;
- Preliminary project health and safety plan;

- Conduct pre-planning Hazard Identification and Risk Assessment (HIRA) – including identifying health hazards, hazardous specified materials, and materials/chemicals requiring special precautions;
- Advise on the concept of design for H&S and control measures;
- Identification of significant hazards and residual hazards during design; and
- Co-ordinate on-going design work and develop methods of dealing with design variations and how such changes should be accommodate H&S throughout the project.

Where legislation is not adequate and lacks construction industry duties and responsibilities of stakeholders, this first stage consultative meeting will guide, provide and explain the duties and responsibilities of appointed consultants so that they could be incorporated into the project specifications and documentation for implementation stage. This stage will also provide amendments to the existing general conditions of contracts to incorporate H&S where it is not included or specified.

The first stage consultative meeting will be convened after the conceptual design is complete and ready for constructability review process. The nature of events to be carried out indicates that after the constructability review process is complete, preliminary H&S issues would have been identified and taken into consideration for the final design of construction works. All members of this stage consultation committee will automatically become part of the second stage consultative committee.

The second stage consultative meeting will be convened immediately when the contractor has been appointed, and he has appointed his H&S representative. This stage will inter alias conduct project implementation HIRA, stakeholder contractual and legal H&S obligations, Project H&S plan and file as well as communication relationships. The contractor being the main implementer of H&S on site will have to contribute to the committee during which all HIRA is conducted from the documentations presented. At this stage, the community should be represented. Broader community issues arising and affecting the project should also be included within the specification. Changes can be made to the H&S specifications before the contractor can finally produce the H&S plan which is all inclusive.

4.1 Clients role in the framework

Clients will have an influence on construction H&S as they have contractual & financial relationship with all key stakeholders. They will therefore have an overall responsibility and control of the project. As figure1 shows, clients will have to manage their projects through the project manager who has the responsibility of coordinating all key stakeholders and project activities. Clients, however will have to ensure that clear and appropriate arrangements related to H&S are in place by appointing the H&S practitioner. The client will also ensure that designers have considered H&S during their design phase. Clients should do a project/activity H&S analysis where:

- Aspects of a project / activity are selected for analysis;
- These aspects should then be broken down into logical steps in sequence;
- The hazards in each of these steps should be identified;
- Means to eliminate or reduce the hazards should be considered; and
- The findings of this process should then be recorded, reviewed and updated from time to time.

Risks need to be ranked in terms of their relative importance. There are many ways in which risks can be quantified but generally combinations of the following should be adopted:

- Consequences of exposure;
- Number of persons that will be exposed;
- Duration of exposure; and
- Probability of harm with and/or without control measured in place.

The client must establish the criteria to prequalify potential tenderers, firstly for the designers and secondly for the contractor. Tenderers must demonstrate that they have the competence and resources to execute the project in a health and safe way. The procurement method used determines the number of tendering to be done on a project. For instance, traditional method will have firstly tendering for professional consultants (designers) who will be involved in design and project document production while second tendering will be for contractors.

For government projects, procurement follows three successive stage committee- Specification committee, evaluation committee and bid adjudication committee. Health and safety should form part of the specification committee. Specifications should be prepared, budgeted for, evaluation criteria clearly indicated or scored and H&S approved together with other project specifications.

4.2 The role of the project manager in the framework

The project manager is the project leader and assumes the role of coordinating all project stakeholders and project activities. The project manager's role spans from pre-tender and tender phases of construction through to project practical completion and close out. The project manager is the first professional/consultant employed on the project and the last one to leave the project. He is by virtue of position, the leader in practicing most of the functions of the H&S practitioner. As a result, the project manager should not just exhibit good project management proficiency, but must be the competent and resourceful leader where project H&S management is concerned. He ensures that the design is cost effective and that construction H&S cost considerations do not compromise H&S performance and exposure to hazards. The project manager is to lead in production of tender documents and attend the pre-tender site inspection to verify information contained in the H&S Specification and any other H&S matters that might have been overlooked.

5. Discussion

The Procurement method determines the contractual and legal responsibilities and duties of project stakeholders. Each standard form of contract provides for an amendment before tendering so that the tenderer is familiar with the amendments to the general conditions. Therefore H&S should be incorporated into the contract at that stage. As indicated in the formulation of the framework, duties and responsibilities of project stakeholders should be established and included. These documents should include the H&S specification as well as any further H&S pre-qualification submittals. It is the client's responsibility to ensure that the tender documents contain section for which H&S can be priced. If tender documents do not have bills of quantities, separate specifications indicating price items should be incorporated for pricing purposes. When tenders contain bills of quantities or schedule of rates, a separate section clearly indicating H&S should be included for pricing. Obviously, this calls for an H&S competent quantity surveyor and project manager.

Additionally, during evaluation H&S should have a section on its own within the evaluation report. Competence levels and resources of service providers are expected to have been assessed and scored in order to form part of the evaluation criteria. A competent H&S practitioner or project manager should be used to assess the competency levels of the bidding firms and their allocated (or proposed allocated) resources for evaluation. The previous project H&S performance score could form as a basis for evaluating performance, competency and resources.

Through both stages of the multi stakeholder consultative meeting, the project manager will chair the discussions. The project managers' construction background enables them to review any H&S method statements submitted by contractors as part of their tender/bid submittals. The evaluation of these method statements should be included in the tender adjudication process. This exercise should be done in conjunction with the H&S practitioner who will be responsible for evaluating submissions not only on the basis of financial and technical potential to execute the project but also on the basis of H&S competence and resources.

During the construction phase, the approved H&S plan forms the basis of the management of H&S on the construction project. The H&S performance of the contractor should be audited monthly. This function should be performed under the supervision of the project manager rather than the H&S practitioner performing the audits independently. The project manager together with the H&S practitioners will ensure that they conduct regular inspections and that problematic areas identified during H&S inspections by the project manager need to be followed up and addressed by the main contractor within a minimum time period.

6. Conclusion and Recommendations

There have been many studies addressing roles and responsibilities of various stakeholders in the construction industry. A large number of these studies are focussed on the developed countries or developing countries with advanced construction industries. In these studies, models or frameworks have been developed, adapted or improved. This has assessed the role of construction industry health and safety multi stakeholder interventions in developing nations, particularly in African countries and specifically in Zambia. It was established that in Zambia, there is no one body that includes all the organizations involved in the construction industry in their representation, while some groups are not represented at all in the bodies that do exist during project implementation or outside the project.

This framework introduces consultations of stakeholders, encourages development and strengthening of engagement among stakeholders while at the same time providing a platform for communication, planning and decision making that includes clients, designers, contractors and community members of the project. The framework recognises the importance of equity and accountability in dealing with H&S of the construction project.

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INNOVATION IN INFRASTRUCTURE DEVELOPMENT

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A Systems Thinking Model of the Impact of Dwelling Internal Heat on Carbon Emissions within the South African Housing Sector

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Abstract

There is documented evidence within literature suggesting that the housing sector is one of the highest consumer of energy (be it clean or unclean) thereby contributing as high as 26% to the total carbon emissions. There is relatively limited research evidence to suggest that many studies have been conducted in the area of carbon emissions reductions within the South African housing sector, especially in relation to the impact of dwelling internal heat. As such, this paper develops a systems thinking model of the impact of dwelling internal heat on carbon emissions within the South African housing sector. The study made use of the systems thinking approach, an approach that takes its philosophical foundation from the pragmatist research strategy. The findings from the study show a population of variables of dwelling internal heat and how they are affecting the carbon emissions from dwellings. The findings of the study further suggest that the identified variables in the model intrinsically interact in a complex manner as demonstrated by the causal tree generated for the model. The study concludes that this is the first stage of the modelling exercise towards the quantitative simulation within the system dynamics approach.

Keywords: carbon emissions, dwelling internal heat, housing sector, South Africa, system dynamics, system thinking

1. Introduction

There is documented evidence within the body of literature to suggest that the housing sector is one of the highest consumer of energy (be it clean or unclean) thereby contributing as high as about 26% to the total carbon emissions (Macleay et al., 2009). The issue of climate change because of carbon emissions has made different Governments around the world to engage with the ways towards reducing energy consumption in dwellings thereby resulting in reduction in carbon emissions profile from the housing sector (Georgiadu, Hacking & Guthrie, 2012; Anisimova,

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2011). Undoubtedly, the climate change effects have shaped the way people live. According to Nicol (2007), this has led to an increase in the cost of living or what could be termed as a reduction in the standard of living of some, while the overall health of others has been badly affected due to fuel poverty. This is evidenced in the fact that occupants of dwellings are striving hard to get their energy consumption reduced. Evidently, this has direct effect on the thermal comfort standards of occupants of those dwellings.

Indoor thermal comfort of occupants is one of the key components of studies relating to energy consumption and carbon emissions in dwellings. Importantly, South Africa is one of the signatories to the Copenhagen Accord, and as such committed to cut emissions by 34% from business as usual by 2020, and by 42% by 2025 through the "intended nationally determined contribution" plan. Reduction of the energy consumption patterns in dwellings is one of the targets to cut the emissions. So meeting the legally binding target of carbon emissions reduction is key and as such, many policies/strategies have been initiated by the decision makers. For example; fabric insulation improvement, energy tariffs, initiatives on fuel poverty, amongst others. These policy initiatives have influence on how occupants respond, especially in terms of occupants' thermal comfort predicated by the dwelling internal heat.

The dwelling internal heat moderates the indoor thermal comfort of occupants of dwellings as well impact on the carbon emissions profile of those dwellings based on the way occupants responds to the challenges posed by the internal heat in the dwelling. The thermodynamics of building physics involving dwellings internal heat as illustrated in CIBSE (2006) shows that there are quite a number of parameters that can be used to model the dwelling internal. Among those parameters as indicated in the study of Motawa and Oladokun (2015) are natural and artificial heat transfers, dwelling temperature, dwelling setpoint temperature, dwelling heat gains, amongst others. Previous research efforts involving modelling the dwelling internal heat have immensely benefitted from building physics and numerical simulation models, which are purely quantitative. However, this study advocates a research paradigm shift towards the use of qualitative means. This study, therefore, used the system thinking approach to model the impact of dwelling internal heat on carbon emissions within the South African housing sector.

This paper is structured in the following order. The next section discusses the internal heat gains in dwellings and then the research methods used for the study. This is followed by the outcome of the model in terms of the system development. Then, the conclusion and future research directions.

2. Internal Heat Gains in Dwellings

The importance of correct estimation of carbon emissions in dwellings cannot be overemphasised. As such, a correct estimation of the internal load contributing to energy consumption in dwellings will aid the correct computation of carbon emissions profile in dwellings. According to Lubina and Nantka (2009), the main sources of internal heat gains into the dwellings are sources related to occupants; artificial lighting; hot water usage; appliances like household equipment, TV sets, computers, amongst others), cooking of meals; and solar gains into the dwellings; amongst others. It is equally crucial to note that occurrence and values of internal heat gains in a particular dwelling depends on the kind of such a dwelling (Lumina and Nantka, 2009). Methods demonstrating the estimation and computation of the gains are well documented in literature among which are Building Research Establishment (2011), Motawa and Oladokun (2015). Additionally, there are standards or handbooks that provide an estimation of the nominal quantity of the internal heat gain loads above (ISO 9164, 1989; ASHRAE, 1997; CIBSE, 2006).

Previous studies have laid the foundation for modelling the thermodynamics of dwellings' internal heat, in terms of artificial and natural heat gains into the dwellings. Majority of those studies have emphasised the use of numerical simulations based on building physics (Shorrock and Dunster, 1997; Johnston, 2003; Mhalas *et al.*, 2013). However, a few studies have suggested a more robust approach that is capable of capturing both hard and soft data relating to the thermodynamics of dwellings' internal heat (Hitchcock, 1993, Motawa and Oladokun, 2015). The work of Motawa and Oladokun (2015) developed a comprehensive model for analysing the complexity of household energy consumption of which the internal heat of dwellings played a prominent role. The study proposed the use of the system dynamics approach. Owing to the veracity of the approach utilised by Motawa and Oladokun (2015), this study therefore proposed the use of the system thinking technique of system dynamics in capturing the thermodynamics of dwellings' internal heat.

3. Research Methods

The system dynamics approach is being used as both the research methodology and tool for the system thinking approach in this study. The system dynamics approach is enunciated in Figure 1 as suggested by Ranganath and Rodrigues (2008). The system dynamics method itself is hinged on the pragmatist research paradigm involving triangulation of different research strategies including quantitative and qualitative research strategies. In an attempt to understand the system under study, Figure 1 suggests that there is the need to first articulate and formulate the problem through the situation analysis. This is followed by the system conceptualization in terms of identification of the variables in the research problem and relate those variables to one another using causal maps to depict the kind of complexity involved based on the feedback structure within the system under consideration. It is worthy of note that the time-based policy parameters, which influence the dynamics of the system under study are identified as well at this stage. Having completed the system conceptualization stage, the causal maps are converted to the stock and flow diagram, where all the variables in the model are related together with equations and algorithms written. After this has been successfully done, the simulation can then be run and the developed model can be validated before policy analysis. Policy implementation concludes the process.

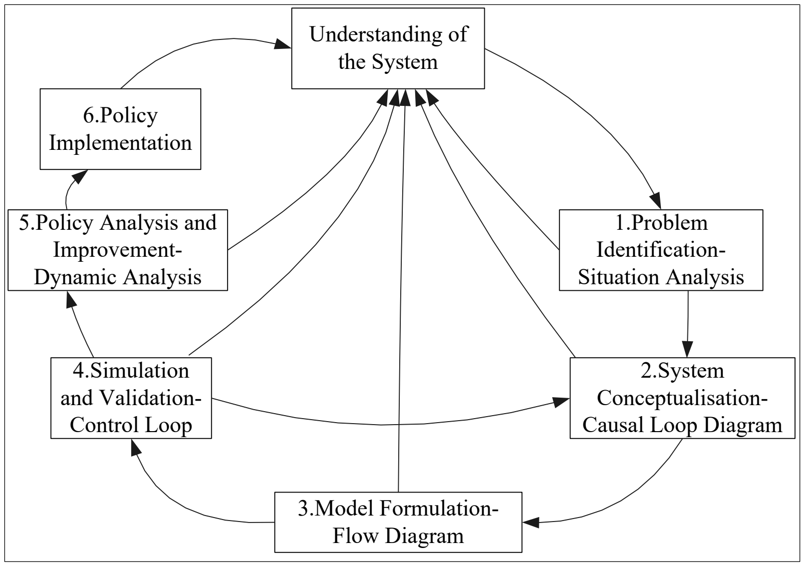

Figure 1: Systems dynamics approach (Ranganath and Rodrigues, 2008)

For the purpose of this paper, Stages 1 and 2 in Figure 1 were completed, since the system thinking aspect of the system dynamics approach was used for this study. As such, Stages 1 and 2 in Figure 1 were expanded and captured in Figure 2. This by implication means that after the research problem for the study has been carefully formulated, the model variables were identified likewise the model boundary and the reference modes of the key variables in the model. This then leads to the development of initial causal map. The initial causal map was developed by the authors of this paper based on the evidence from the literature and this was validated from the experts/practitioners in the subject. After the validation exercise was successfully done taking into cognisance the comments by the experts/practitioners, the final causal maps were drawn. The causal tree for policy analysis was extracted from the causal map. The model was implemented on ‘Vensim’ platform.

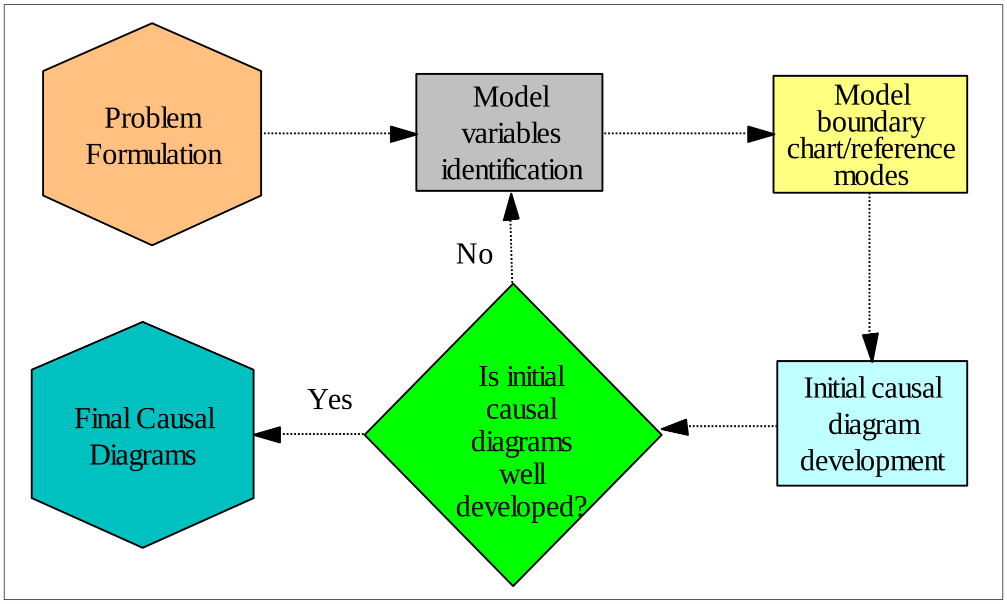

Figure 2: Systems thinking flowchart

4. System Development

In an attempt to model the impact of dwelling internal heat on carbon emissions profile of dwellings in South African homes, the study explored the kind of interrelationships among variables that are purported to influence energy consumption and that of carbon emissions. Within the housing sector, available evidence from the literature suggests there are basically three systems influencing energy consumption and carbon emissions. These systems are the dwelling system, occupants' system and environment system. These systems interact and work seamlessly to account for energy consumption and carbon emissions. There are quite a number of variables that can be considered within the three systems identified above. For example, those that can be considered for the dwelling system in terms of dwellings' physical properties are space heating, lighting, and ventilation. Also, dwellings' dynamic variables like temperature setting/regulator are being considered under the dwelling system. Variables within the occupants' system may be in terms of occupants' biophysical variables; behavioural variables as well as dwellings' household characteristics. Also, variables related to the environment system in terms of climatic and economic variables can be included in the model.

For the purpose of this study, the impact of dwelling internal heat on carbon emissions is illustrated diagrammatically in Figure 3. The Figure disaggregates the dynamics of energy consumption and carbon emissions in South African homes into six main modules comprising of the population/household module, the dwelling internal heat module, the occupants' thermal comfort module, the climatic-economic-energy efficiency interaction module, the household energy consumption module, and the household carbon emissions module. These modules interact with one another and work seamlessly in a complex manner. The interrelationships between the dwelling internal heat module and household carbon emissions module are evident with some intervening modules moderating the impact of dwelling internal heat on carbon emissions profile within the South African housing sector.

It is important to mention that the variables within each of the modules in Figure are further developed individually before integrating all of them together. For example, the causal map for the dwelling internal heat module is developed likewise that of household carbon emissions module. As an example, Figure 4 shows the preliminary causal loop developed for the dwelling internal heat module. The causal loop diagram (CLD) depicts the thermodynamics of dwelling internal heat in terms of the variables hypothesized to influence the dwelling internal heat. Within the dwelling internal heat system, the CLD in Figure 4 indicates that the dwelling internal heat is being driven by a combination of natural and artificial heat transfers and dwelling heat gains. A change in the internal and external temperatures within the dwelling creates a temperature gap which are fluctuating around the set-point temperature as provided by the occupants. It is important to make clear that within the dwelling system, temperature set-point and dwelling internal temperature modulate the artificial heat transfer and this in turn moderates the dwelling internal heat. The dwelling heat gains play a very important role in the model.

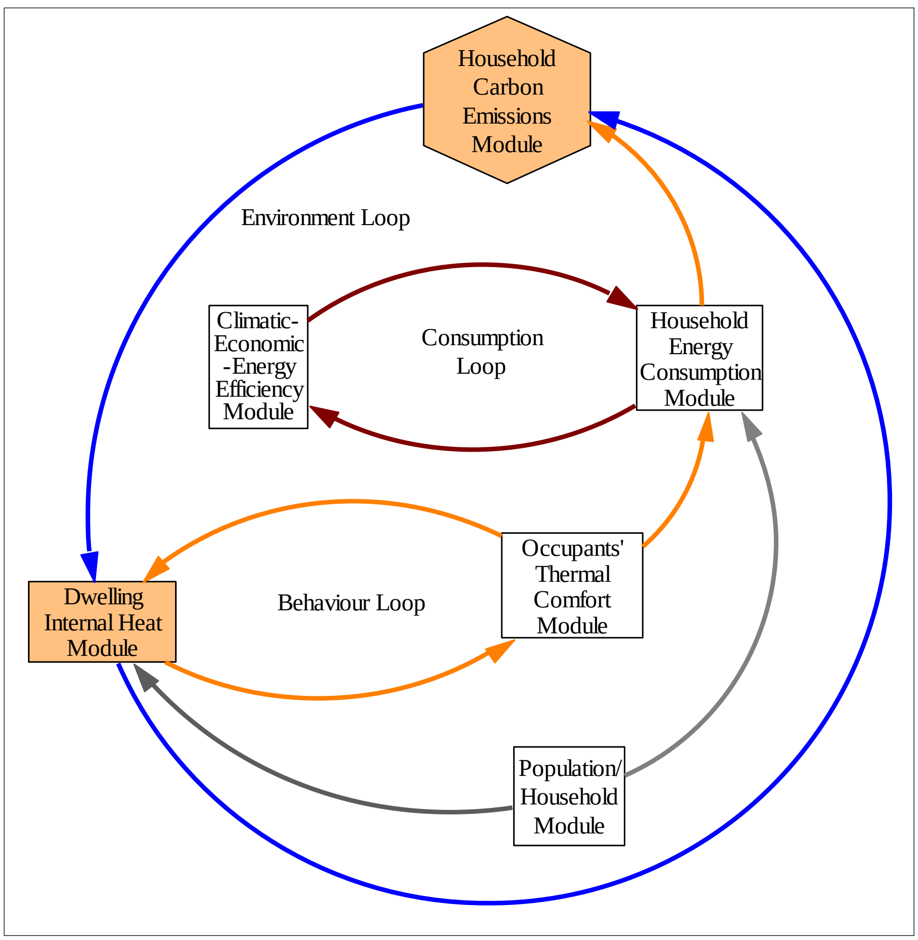

Figure 3: Impact of dwelling internal heat on household carbon emissions

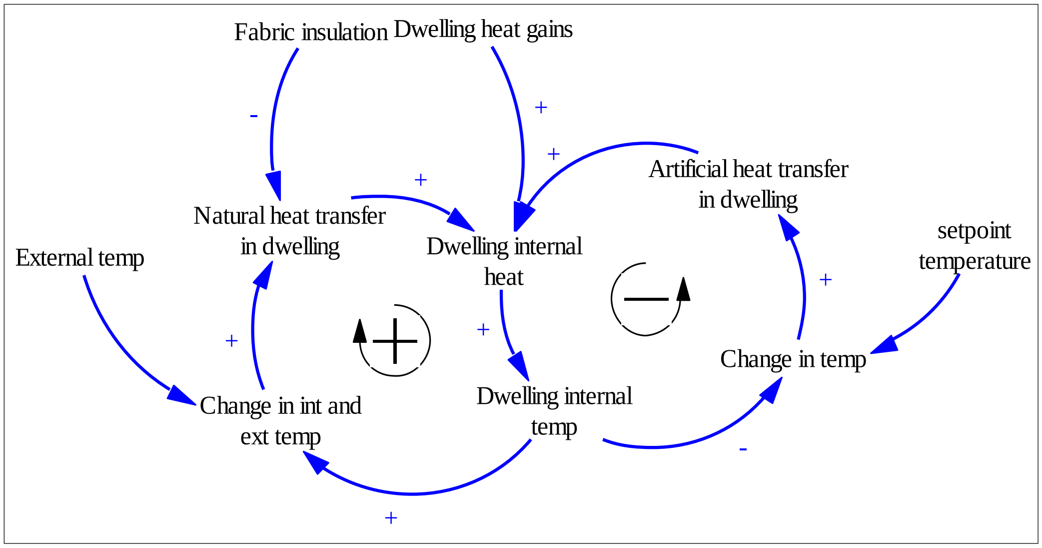

Figure 4: Preliminary causal loop for the dwelling internal heat module

Because of the space constraint, the CLD for the household carbon emissions cannot be presented. However, Figure 5 presents the causal tree of the impact of dwelling internal heat on the carbon emissions profile of the South African housing sector as generated for the model. The causal structure shows how different variables within the model interrelate. This causal tree can be used to make informed decision regarding the factors influencing dwellings internal heat as well as household carbon emissions and their respective impacts.

6. Conclusion

This paper has developed a model illustrating the impact of dwelling internal heat on the carbon emissions within the South African housing sector. The developed model made use of the system thinking approach, which is capable of enriching the understanding of the stakeholders on the causal variables impacting on carbon emissions from dwellings based on the internal heat structure of those dwellings. The findings from the study show a population of variables of dwelling internal heat impacting on carbon emissions in dwellings. The outcomes of the study further indicate that the identified variables in the model intrinsically interact together by revealing the complexity involved as demonstrated by the causal tree generated for the model. The study concludes that this is the first stage of the modelling exercise towards the quantitative simulation within the system dynamics approach. Further studies would involve translating the causal maps developed into stock and flow diagrams in readiness for quantitative simulation.

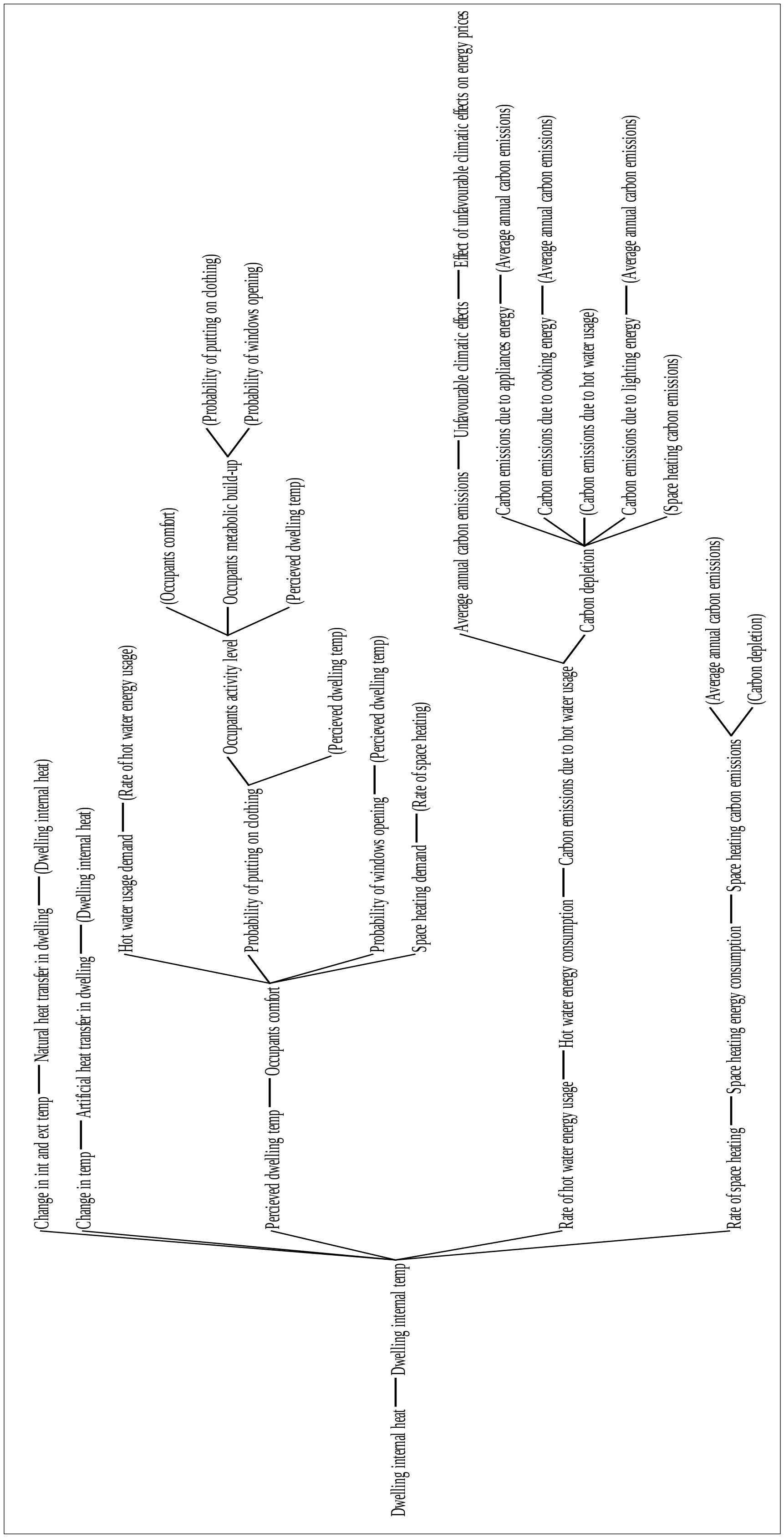

Figure 5: Causal tree for the impact of dwelling internal heat on household carbon emissions

7. Acknowledgement

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Bamboo an Alternative Wood to reducing Tropical Deforestation in Ghana

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Abstract

The United Nations' interest in the promotion of green environment is for countries to grow plants that aids in reducing deforestation which is essential to low carbon emission. The global tropical forest in recent years has experienced numerous setbacks resulting from climate changes affecting nations. Bamboo has been identified as a potential plant to help achieve the UN's goal of reducing deforestation across the globe. The current situation on Ghana's tropical forest indicates a decreasing trend of growing stock production areas of timber compared to the increasing gap between timber demand and supply. The study investigated the adoption of bamboo as an alternative wood in Ghana's tropical forest due to the dwindling of tropical wood species such as Mahogany, Wawa, Teak, Odum and many others. The study seeks to assess the benefits/merits of cultivating bamboo with the aim of reducing deforestation. Further, the study sought to investigate the trend of tropical forest resource development in Ghana, consider forest transition pathways and its significances. 100 structured questionnaires were administered to stakeholders including forestry commissioners, farmers, landowners and other users of wood, on bamboo as an alternative tropical plant via relative importance index (RII) to analyse data. The result showed high significant approval by stakeholders for its implementation as the factors were computed and ranked. The findings revealed a high acceptance rate of bamboo as an alternative plant in the tropical forest due to its fast growth and high yield. The reasons cited for its high acceptance rate included that it is regenerative, is a windbreaker, reduces soil erosion and has a high CO_2 sequester compared to hard/softwood. Bamboo matures within 3-5 years from cultivation. Its implementation in the tropical forest can help reduce over-dependence on soft/hardwoods since annual harvesting is inevitable and will help to reduce/prevent deforestation.

Keywords: bamboo, deforestation, forest transition, reforestation, tropical forest

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1. Introduction

Deforestation of Ghana's tropical forest (TF) has led to several environmental and economic problems notwithstanding the climate change and loss of biodiversity. There were large areas of forest lands which have been cleared for agriculture or a building project leading to the deforestation problem in the country. The conversion of forest lands to non-forest land uses referred to as deforestation. Ghana's total land cover is about 23.85 million hectares (ha) with about one-third of the land area being covered with a high forest of (9 million ha). The remaining two-thirds (14.85 million ha) of the land cover made of savanna woodland (FC, 2013). The forest has been affected over the past ten decades, reducing the country's forest to about half its total area. A survey on the state of forest from (1900-1950) and (1990-2010), indicates high deforestation reduction from 9 million to between 4.4 and 4.9 million ha (FC, 2013). Forestry Commission (FC), stated the current deforestation-rate in Ghana as 2% amounting 65,000 ha per year and the rate is still increasing due to the high demand of soft/hardwoods such as Mahogany, Wawa, Teak and Odum for infrastructure works (FC, 2013, 2009). However, soft/hardwoods take over 30-50 years to maturity. In the case of bamboo, it takes 3-5 years to mature within cultivation period, and as a renewable plant, it is prudent to adopt and promote its plantation for sustainable afforestation and rehabilitation of the soil. The work seeks to assess the benefits/merits of bamboo cultivation as an alternative plant and how it will help in reducing deforestation. Also to investigate the trend of TF resource development in Ghana, consider forest transition pathways and its significances.

1.1 Causes of deforestation in Ghana

The causes of deforestation in Ghana are numerous, interrelated, complex and categorised into direct and indirect causes. The main traits of Ghana's deforestation include harvesting of wood as a source of income, developmental pressure, agriculture expansion and increase in population (Farley, 2010). The secondary causes that prompt the real causes include; weak institutions, lack of law enforcement policies, land tenure issues, lack of concern by local communities, are among other factors. The direct causes of deforestation in Ghana include timber logging (legal and illegal), construction of roads, factories, mining, buildings, schools, dams and irrigation farming (Farley, 2010). The construction of Lake Volta alone covers about 45% of the central part of the nation's total land surface area causing colossal deforestation in the country. The current threat to the nation's TF is illegal chainsaw operator's activities which are depleting the forest due to high demand for timber. Also, the activities of farmers clearing parts of the forest for crop cultivation, bushfires, fuelwood, and illegal mining activities are some of the leading causes of deforestation (Anyomi et al., 2011; Hansen et al., 2009).

1.2 Benefits of bamboo cultivation in the tropical forest

The fear of Ghana losing its forest in addition to other factors have influenced the adoption and cultivation of bamboo in Ghana's TF. A benchmark of bamboo cultivation in Ghana's TF is the China Republic that made use of bamboo as alternative wood to improve its TF and as a result, help reduce deforestation. Bamboo matures within 3-5 years from the time of cultivation with annual harvesting as compared to soft/hardwood which takes over 50 years. The bamboo plant is regenerative, sustainable, light in weight and has high mechanical properties for infrastructure works such as buildings, furniture and joinery industries. Bamboo's advantage of being a regenerative plant demonstrates its ability to be an alternative plant to reducing deforestation in the TF of Ghana. It is a sustainable material with less carbon footprint, and its cultivation commercial in the TF will help reclaim if not all degraded vegetations. When adopted as an alternative plant, it will aid reduce deforestation and reclaim degraded lands (Akinlabi et al., 2017; Brown et al., 2016). Bamboo, when employed in TF will help limit the amount of CO_2 and enhance oxygen in the atmosphere and contributes to reducing deforestation. The FC in evaluating the viability of bamboo plantation in the TF has planted between 50,000 - 100,000 ha seedlings in some selected degraded TF to augment the supplies from natural stands for the next 25 years (Brown et al., 2016). The supply of bamboo seedlings and finance support for its plantation in the TF will provide a sustainable supply of building material and help to reduce over-dependence on soft/hardwoods leading to a reduction in deforestation. The success of this projected will serve as the base for further development of its plantation across all deforest and degraded TF's in the nation. With an appropriate policy on the bamboo plantation as an alternative plant, deforestation will reduce to its minimum in Ghana.

1.3 Forest transition pathways

Forest transition (FT) is defined as a shift from a shrinking to an expanding forest area and provides a framework for understanding scenarios in which a country shifts from a decreasing forest cover to an increasing forest cover in a period (Farley, 2010). Primarily, deforestation gets fast, and the forest area declines because of factors which are related to population growth, agricultural expansion and demand for timber and wood fuel. Due to climate changes, the tropical forest is fast decreasing (MoFA 2007). Ghana has lost most of its forest species and covers with high impacts on land, soil fertility loss and land degradation (Bamfo 2008, Damnyag 2012). Deforestation remains a prime concern to Ghana as well as the global community (Damnyag et al. 2011, Culas, 2007). Some developing and developed countries like China have experienced FT: a shift from net deforestation to net reforestation (Meyfroidt and Lambin 2011). FT result from multiple trends: natural forest regeneration, the establishment of forest plantation and implementation of agroforestry systems. The process implies the long-term development of forest cover that is expected to change in a country as it follows a trajectory of decline and regrowth (Figure 1) and can only be delayed or accelerated by policy implementation (Barbier et al. 2010).

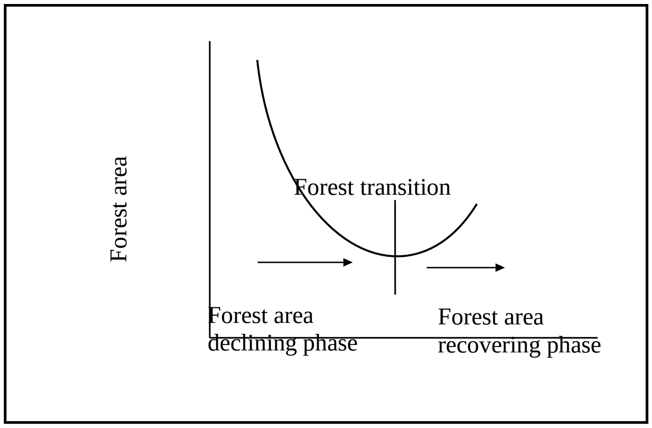

Figure 1: Phase of the forest transition (Barbier et al., 2010)

Currently, the government of Ghana in a move to tackle deforestation in the country has tasked agencies to assess FT document, degraded forests, and put emergence of sustainable forest exploitation practices, taking into consideration forces that drive these transitions (McCay and Rudel 2012). Table 1 shows pathway that ultimately drives forest transition and its significance for the design implementation policies that aim at halting deforestation and ensure forest recovery. The trends in Ghana suggested processes of rehabilitation and restoration of degraded lands, which seem consistent with specific FT pathways. In FT pathway policies, the plantation of bamboo in the TF was one of the measures to adopt as a sustainable alternative to reducing deforestation in the country. A benchmark for Ghana's FT using bamboo as the alternative in the TF is the China Republic. China's approach to FT was by cultivating bamboo in its TF as an alternative wood to reduce deforestation in its tropical forests.

2. Methods

A comprehensive review of related published works to find the used of bamboo in FT to minimise deforestation in the TF of Ghana. The various identified information was adopted and modified to meet the conditions of Ghana TF regarding bamboo cultivation and the trend of TF resource development. A closed-end questionnaire was employed to reduce biases to responses from stakeholders. However, respondents were also asked to give suggestions on factors influencing bamboo cultivation as an alternative in TF, its benefits/merits to reducing deforestation and views on the trend of TF resource development in Ghana using bamboo, considering FT pathways and its significances. The purposive sampling approached was used to select 100 stakeholders which include farmers, landowners, FC and other users of wood to ensure that the respondents with the relevant knowledge and experience on the topics are adequately selected. Fieldwork to observe pilot projects going on in deforested areas and a one on one interview was used to administer the questionnaire for first-hand information from stakeholders and also to minimise the response rate.

Table 1: Summary characteristics of forest transition pathways (***Lambin and Meyfroidt 2010)***

Forest Transition pathway	**Characteristics/explanations**
Economic development	agricultural intensification on most productive land.
	labour scarcity drives reforestation.
	marginal land abandonment.
	service sector growth and creation of enough non-farm jobs in urban areas.
Forest scarcity	existing or anticipated scarcity raises the value of forest products resulting in investments in tree planting, forest management and restriction on exploitation.
Globalization	national economy integrated into global markets for commodities, labour, capital, and tourism
	a local manifestation of international conservation and forest management ideologies
	sending of remittances to marginal rural areas to relieve pressure on land
State forest policy	national forest policies often influenced by factors outside forest sector, e.g. willingness to modernise the economy, greening image of the country; integration of marginal groups; tree planting not motivated by the scarcity of forest products
Smallholder, tree-based land use intensification	Help in decreasing of vulnerability, economic and environmental shocks, and to generate livelihoods through economic and ecological diversification
	involves expansion of woodlots, agroforestry systems and secondary succession; rural communities restore degraded lands and their ecosystem services
	forests have different composition and structure from primary forests - associated with fragmented landscapes

The questionnaire was categorised into two sections. The first section focused on factors influencing bamboo cultivation as an alternative in TF and its benefits/merits to reducing deforestation. The second section looks at the trend of TF resource development in Ghana using bamboo, considering FT pathways and its significances. The 5-point Likert scale ranging from 5 (most accepted) to 1(most unaccepted), the higher the number, and the higher the influence of its cultivation as an alternative TF plant to reducing deforestation. The cultivation of bamboo as an alternative plant in TF of Ghana and its benefits/merits to reducing deforestation, was rank on the Likert scale of 1 to 5. They were to accept its execution as an alternative plant in TF as its benefits/merits to reducing deforestation are stated, where 1= most unaccepted 2= Unaccepted, 3= Neither accepted nor unaccepted, 4= accepted and 5= most accepted. On the trend of TF resource development in Ghana using bamboo, considering FT pathways and its significances in afforestation, 1= Highly ensured, 2= Unsure, 3= Neither sure nor unsure, 4= Sure and 5= Highly sure. From the total of 100 questionnaires distributed to identify respondents, ninety-one (91) were returned which represents 91% which were used in the analysis.

The Relative Importance Index (RII) method of analysis was employed to help identify the significance of the factors influencing bamboo cultivation as an alternative to TF and its benefits/merits to reducing deforestation in Ghana. It is also to looks at the trend of TF resource development in Ghana using bamboo, considering FT pathways and its significances. For this study, any factor with a relative importance index of 0.5 or more was considered significant.

3. Results

3.1 Bamboo cultivation as an alternative Tropical Forest (TF) plant

Table 2 shows the result of various factors that have contributed to the adoption of bamboo as an alternative plant to solving deforestation problem in Ghana. The table shows a summary of the views of the respondents on the factors influencing bamboo cultivation as an alternative in the TF of Ghana. The first category of stakeholders involving persons from FC, NFPDP, and NGO's, Ministry of Food and Agriculture (MoFA) the policymakers who see its implementation. The results from this group on the factors influencing bamboo cultivation as an alternative in the TF indicates that all the factors are critical to bamboo adoption and cultivation. The most critical being that bamboo matures within 3-5 years compare to over 50 years for hard/softwood (RII = 0.8017), bamboo is regenerative and sustainable (RII = 0.8001), and training and education on the properties and benefits of bamboo cultivation (RII = 0.7363). Addition, the seedling was made available to all stakeholders (RII = 0.7332), high yield of bamboo wood production within 3-5 years (RII = 0.7031), annual harvesting is assured after its first harvest (RII = 0. 6255), and high mechanical properties for structure works (RII = 0.6139). Furthermore, bamboo plantation helps to prevent soil erosion (RII = 0.5581), harvesting of bamboo does not destroy young plants and the environment (RII = 0.5269), and bamboo sequesters more than 36% of CO_2 as it releases oxygen into the atmosphere (RII = 0.5019). Hence, the second group which involves those who implement the policies also indicates that all the factors are critical to bamboo adoption and cultivation. The most critical being that bamboo is regenerative and sustainable (RII = 0.8563), bamboo matures within 3-5 years compared to over 50 years for hard/softwood (RII = 0.8250), and training and education on the properties and benefits of bamboo cultivation (RII = 0.8206). Addition, bamboo sequester more than 36% of CO_2 as it releases oxygen into the atmosphere (RII = 0.8201), harvesting of bamboo does not destroy young plants and the environment (RII = 0.8200), and high mechanical properties for structure works (RII = 0.7953). Furthermore, the seedling was made available to all stakeholders (RII = 0.7892), annual harvesting is assured after its first harvest (RII = 0. 7633), high yield of bamboo wood production within 3-5 years (RII = 0.7585), and bamboo plantation helps to prevent soil erosion (RII = 0.6925). The results affirm that the stakeholders approve of bamboo cultivation in the TF of Ghana as an alternative to reducing the deforestation situation in Ghana due to its high renewable properties. It will serve as a raw material to timber industries to reduce over dependency on hard/softwoods such as teak, mahogany and iroko.

Table 2: Factors influencing bamboo cultivation as an alternative in the TF

S/No.	**Factors**	**FC, NFPDP, MoFA, NGO's**		**Farmers, Landowners**	
		RII	Rank	RII	Rank
1	Bamboo matures within 3-5 years compared to over 50 years for hard/softwood.	0.8017	1st	0.8250	2nd
2	Bamboo is regenerative and sustainable.	0.8001	2nd	0.8563	1st
3	Harvesting of bamboo does not destroy young plants and the environment.	0.5269	9th	0.8200	5th
4	Bamboo sequesters more than 36% of CO_2 as it releases oxygen into the atmosphere.	0.5019	10th	0.8201	4th
5	Training and education on the properties and benefits of bamboo cultivation.	0.7363	3rd	0.8206	3rd
6	The seedling was made available to all stakeholders	0.7332	4th	0.7892	7th
7	Bamboo plantation help to prevent soil erosion	0.5581	8th	0.6925	10th
8	Annual harvesting is assured after its first harvest.	0. 6255	6th	0.7633	8th
9	High yield of bamboo wood production within 3-5 years.	0.7031	5th	0.7585	9th
10	High mechanical properties for structure works.	0.6139	7th	0.7953	6th

Table 3 shows the result of the trend of forest transition pathways in Ghana. The table shows a summary of the views of the respondents on the trend of forest transition pathways in Ghana's TF. The first category of stakeholders involving persons from FC, NFPDP, and NGO's, and MoFA. The results from this group indicate that all the factors are critical to the trend of forest transition pathways in Ghana. The most critical being forest scarcity (RII = 0.7852), smallholder, tree-based land use intensification (RII = 0.7311), economic development (RII = 0.7237), globalization (RII = 0.6269), and state forest policy (RII = 0.5203). The second group also indicates the most critical as smallholder, tree-based land use intensification (RII = 0. 6207), economic development (RII = 0.6154), and forest scarcity (RII = 0.5637). The results show that the stakeholders acknowledge there is a trend of FT pathway activities being practice in Ghana.

Table 3: Trend of forest transition pathways in Ghana's TF

S/No.	Forest transition pathway	FC, NFPDP, MoFA, NGO's		Farmers, Landowners	
		RII	Rank	RII	Rank
1	Economic development	0.7237	3rd	0.6154	2nd
2	Forest scarcity	0.7852	1st	0.5637	3rd
3	Globalization	0.6269	4th	0.4010	5th
4	State forest policy	0.5203	5th	0.4221	4th
5	Smallholder, tree-based land use intensification	0.7311	2nd	0.6207	1st

3.2 The economic development pathway trends

The economic development pathway trends in Ghana relates to an increase in gross domestic product (GDP) per capita, increase in urban population and increase in service sector's contribution to GDP. The population percentage of urbanization has increased from about 36.4% in 1990 to over 51.5% in 2010 (Figure 2). Because of population increment, there is a high demand for timber for infrastructure works resulting in illegal harvesting causing deforestation as most trees being harvest are not fully mature.

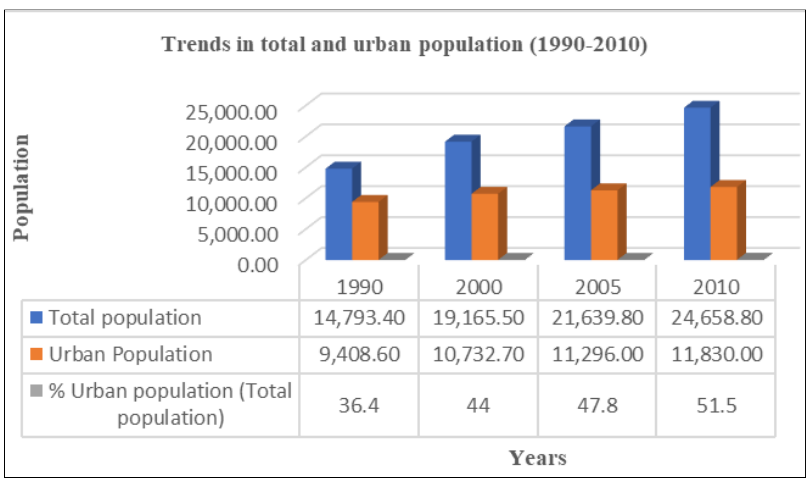

Figure 2: Trends in total and urban population 1990-2010 (GSS, 2012)

Table 4 shows results of the nation's GDP between 2000 – 2010 that the service sector contributes about 50% of GDP with the agricultural sector contributing 28% as at the end of 2010. The economic development pathway for afforestation has always had setbacks: as rural employment is mainly agricultural, and the land is not abandoned for renewal of its fertility hence leading to many lands being degraded. As agricultural activities continue to expand with most lands not being allowed to get fertile in rural areas, farmers instead turn to cut portions of forest reserves for crop cultivation contributing hugely to deforestation.

Table 4: Trends in GDP per capita and percentage distribution of GDP by sector (2000-2010)

Sector	GDP per capita (US$)	Agriculture (%)	Industry (%)	Services (%)
2000	260	39.6	27.8	32.6
2001	270	39.6	27.4	33.0
2002	306	39.5	27.4	32.6
2003	370	39.8	27.2	32.8
2004	420	40.2	27.2	32.9
2005	495	39.5	27.6	32.9
2006	920	30.4	20.8	48.8
2007	1085	29.1	20.7	50.2
2008	1226	31.0	20.4	48.6
2009	1090	31.6	18.9	49.5
2010	1319	27.8	21.8	50.4

Sources: GSS (2010); World Bank (2012)

3.2 Forest scarcity pathway and the related trends

An annual 2% deforestation in Ghana forest has led to the (NFPDP) establishment to response to the decline of forest resources and anticipated scarcity of forest products since 2001. The programme was meant to help in the restoration of forest cover in degraded areas and establish a sustainable timber resource base to meet future demand for industrial timber. The NFPDP was implemented under different schemes including the Modified Taungya system (MTS), large-scale private commercial plantations development, and the government expanded plantation programme with a projection of 20,000 ha per annum. The initiative yielded 149,260 ha of plantations established under the government program (NFPDP) from 2002 to 2010. The outcome maintains 40% share of revenue to farmers, 40% to government, 15% to landowners and 5% to communities respectively. Between 2002 to 2010, almost 54% of the total area (80,700 ha) of plantations established by the NFPDP was through MTS.

Under the large-scale private commercial plantations scheme, 2% share goes to the government, 6% to landowners, 2% to the community and 90% to private investors respectively under which about 23,360 ha forest plantations were established. In 2010, the government launched an expanded plantation programme under the NFPDP, to include degraded areas outside forest reserves aiming at commercial timber plantation. The program by the end of 2010 yielded a total of 14,186 ha of plantations. The annual target of the plantation program was 10,000 ha as well as maintaining existing plantations over a five-year period (FC, 2013). There was a ban on harvesting and exportation of rosewood (Pterocarpus erinaceus) in the country in 2014 to preserve this species as well as prevent deforestation due to the high demand for its product. The outcome shows that there is a trend that relate to forestry scarcity pathways since reforestation programmes are being implemented in response to the fast declining and scarcity of forest resources. The government has enacted policies to restrict the forest exploitation as well as to ban the exportation of certain timber species, by promoting sustainable management practices.

3.3. State forest policy pathway and its relating trends

In 2012, the Forest and Wildlife policy to promote tree planting and forest management were intensified through awareness creation on understanding the role of wildlife, trees, forest and the importance of conservation. The policy also supports tree planting for environmental improvement including shade trees in public parks, and erosion control on hilly slopes. The government established the Savanna Accelerated Development Authority (SADA) to coordinate a long-term comprehensive development strategy (2010-2030) for the northern savannah ecological zone. The SADA initiative is part of government's strategies to bridge the increasing development gap between northern savanna and the southern sector of Ghana. Through SADA, the government launched a 5-year afforestation project aimed at encouraging tree planting to green the SADA zone. The project sought to plant and maintain an original five million seedlings of different trees in 2012-2013. Using the vision of a **"**Forested and Green North by 2030**"**, the strategy stimulates economic growth and sustainable development. The programme ensures that small-holder families and poor farmers develop a long-term stake in agriculture by inter-cropping with commercial tree species. But, the state forest policy trends include policies on urban greening as well as integration and development of peripheral savanna regions of Ghana.

3.4 Trends relating to smallholder pathway, tree-based land use intensification

In the year 2000, local community's involvement in tree planting on farms (agroforestry system) was implemented as part of the process of addressing concerns over soil erosion, reduced soil fertility and deforestation. The result shows that by the close of 2003, there were more than 30,000 people engaged in smallholder plantation of trees on farmlands with an estimated 10,000 ha trees. By 2010, there were more than 37,500 ha farms planted with trees in over 108 farming communities across the nation, reflecting farmers' efforts to increase trees across the farm landscape to enhance economic gains, improve agronomic productivity and contribute to biodiversity conservation. Thus, the trends relating to this pathway in Ghana involve tree establishment in the agricultural landscape either alone or in combination with crops.

3.5 Globalization pathway and its relating trends

The globalization pathway can be group into international trade and agreements, international support for reforestation projects, and remittances. The growing emphasis in Ghana forest law enforcement and governance highlights the country's commitment to sustainable management of forests. Recent trends in Ghana's timber products export indicate the international trade in wood products from Ghana. In this aspect NGO's, timber companies, forestry commission and several institutions have had supports from international bodies to engage in tree planting, reforestation and rehabilitation activities across the nation's deforested and degraded lands (Table 3.3). The recent policy on global climate is creating new markets for carbon credits with the establishment of tree plantation. There is about 14,000 ha of timber plantation and non-timber forest products under the guidance, of FORM Ghana Ltd, a timber company the (FC, 2013).

Table 5: International support for reforestation activities in Ghana

International organization	Activity	Type of support	Output	Location
International Tropical Timber Organization (ITTO)	Projects on community rehabilitation and management of degraded forest sites	Funding, technical assistance	Over 250 ha of degraded forest areas rehabilitated	High forest zone (HFZ): 3 regions in southern Ghana.
ITTO	Rehabilitation of degraded forest lands	Funding, technical assistance	1,350 ha of degraded lands rehabilitated in the Volta region of Ghana.	HFZ
Ricerca e Cooperation (Italian NGO)	Tree planting on farmlands under a European Union-funded 'forest resources creation project' with local communities	Technical advice, training, seedlings, equipment, other farming inputs	Formation of communities tree grower associations, made up of over 1,000 farmers in about 60 communities plant trees on farms, over 1,500 ha of farms planted with trees	HFZ
International Institute for Tropical Agriculture	Sustainable tree crop programme	Training of farmers on timber tree planting and management of cocoa farms	More than 33,000 ha of cocoa farms planted with timber trees	HFZ

4. Discussion

4.1 Contribution of trend and Bamboo plantation in Ghana forest transition

In Ghana's FT pathway, some trends partly relate to the five pathways that exist. Similar processes function in Ghana as in FT countries such as China, Indian, South Korea and Vietnam, yet with essential differences in scale, effectiveness and characteristics of each FT pathway. Presently, forest transition trends in Ghana, such as reforestation programmes 'tree planting initiatives' are too small. There is no reliable force driving an overall forest transition in the country through any of the generic pathways. The current widening gap between demand and supply of wood for infrastructure works, continuous degradation of natural forests and the low rate of forest plantation establishment makes a forest transition in Ghana challenging to achieve. In summary, Table 6 shows the result and emerging key trends relating to the FT pathways. The outcome shows deforestation of 2.5 million ha between 1990 to 2010, representing a 33.7% of the total forest in Ghana. Moreover, the total annual reforestation between 2000 and 2010 was 115, 000 ha constituting 13% of the total forest area of Ghana. Deforestation is about three times the afforestation notwithstanding all the major efforts to help minimise the situation due to the high demand for timber for infrastructure works since hard/softwood takes over 30-50 years to fully mature.

Table 6: Summary of key trends and conditions in Ghana relating to FT pathways

FT pathway	**Trends**	**Spatial level observed**
Economic development	GDP per capita has increased	Country
	Increase in service sector contribution of 50% to GDP compared to 28% by agricultural sector	
	Percentage urban population has increased	
	High unemployment in urban areas	
	Employment still mainly agricultural based (56%)	
	Rural land is not abandoned, and labour is not scarce	
Forest scarcity	The rapid decline of forest area	
	Government initiates and invests in forest plantation development in response to the scarcity of forest resources	Country
	Government institutes yield formula, export levy and other restrictions to control timber exploitation; launches wood fuel substitution programme	High forest zone (HFZ), Savana zone (SZ)
Globalization	Increasing international organizations involved in reforestation projects	
	Economy integrated into global markets for products	HFZ SZ
	Commitments to international trade agreements	
	Emerging carbon credits market opportunities	Country
	Low remittances	
State forest policy	Government policies promote urban greening	HFZ/ SZ
	Government agency established to integrate and develop marginal savanna regions of the country	Country
	Government promotes tree planting as economic development activity in rural areas	Country SZ
Smallholder, tree-based land use intensification	Increasing community involvement in smallholder on-farm bamboo/tree planting	HFZ/ SZ
	Land retention using trees to improve soil fertility	HFZ/ SZ
	Increased use of indigenous tree species in bamboo/tree plantations or woodlots	HFZ/ SZ

The situation of Ghana shows consistency with the conclusion that FTs are contingent upon the local's socio-economic, ecological and political contexts of the country (Bae et al. 2012; Meyfroidt and Lambin 2011). There is about 150,000 ha of forest plantations established in Ghana mainly in response to the scarcity of forest products, especially timber. Because of these numerous challenges confronting the reserve forest, NFPDP decided to introduce the cultivation of a more fast-growing, regenerative, and sustainable plant such as bamboo to help minimise/eliminate the rate of tropical deforestation in the country. The government policies under national plantation programmes that respond to both scarcities of forest resources and tree planting for urban greening have advised stakeholder on a bamboo plantation in the TF projects. After years of piloting with bamboo in some selected deforest and degraded lands, bamboo is seen as a more potential plant to help reduce deforestation in the TF due to its numerous advantages. Bamboo matures within 3-5 years and can be alternative wood in the construction and infrastructure industry. Bamboo grows faster than hard/softwood, and it releases about 36 % more oxygen and sequesters tons of CO_2 from the atmosphere (Akinlabi et al., 2017; Yiping et al., 2010). Implementing bamboo cultivation in the tropical forest will help reclaim degraded and deforested lands. There are more than 100 local communities that are into bamboo growing actively with over 10, 000 ha indigenous and high yielding species. Urgent FT policy to shift from net forest deforestation to net forest afforestation movements through bamboo cultivation must be given acceptance to help salvage the forest.

5. Conclusions

In accelerating FT in Ghana, there is a need to intensify the establishment and management of forest plantations: the current rate of forest plantations establishment needs to be increased in the growing of bamboo plants with short maturity years on both degraded and deforested lands. There must be a commitment from the government on reforestation strategy in partnership with the private sector and local communities. The campaign for the cultivation of bamboo in the tropical forest and the savanna zone will accelerate the FT in Ghana. The forest resources development trends in Ghana has shown potential rehabilitation and reforestation activities under diverse contexts for the FT. The FC, NFPDP, NGO's and the government have implemented a sustainable forest management policy practices which encourage farmers and communities to go into commercial tree/bamboo plantation as a renewable plant in the forests. National policy options to support management intensification of forest plantation using the bamboo plant as an alternative to timber in reducing tropical deforestation. The FT trends of China using bamboo in the tropical forest as a benchmark to Ghana reforestation through the supply of material. Integration of bamboo into the country's forestry plant species will help eliminate or minimise tropical deforestation since it is a regenerative plant with short maturity years. Bamboo plantation will help conserve other timber species in the reserve forest, reduce poverty in rural areas and help accelerate the FT in Ghana. Chines, Indians and Vietnamese policies of implementation, is an example adopted by the NFDP to accelerate FT in degraded lands through appropriate policy reforms, incentive schemes, capital investments and strong government commitment. A sustainable forest plantation programmes should focus on meeting the industrial demand for timber through the growing of bamboo plant by farmers and policies must promote economic development for rural communities. The trend for achieving FT should have a policy that aims at reducing the current deforestation rate and instead increase the area and production of bamboo from the tropical forest. The policy should urge farmers and other NGO’s to go into commercial cultivation of bamboo to supply material for the construction industries in Ghana as well as policies to govern the forest reserves.

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Bamboo Application in Infrastructure Development of Ghana

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Abstract

The growing rate of bamboo integration into the infrastructure industry is on the rise. Bamboo development and application as an engineering material in Ghana is getting attention due to the challenges associated wuth depletion of some forest species such as timber. The other factors that influence bamboo application in the infrastructure industries include the quest for eco-friendly and sustainable material which bamboo is seen as an alternative to timber. This study investigated the various areas, trends, and constraints of bamboo's application in the construction industry of Ghana. The study employed structured interviews and questionnaire survey on factors influencing bamboo application on 100 building contractors and 100 civil engineers from small and medium scale (SME) construction industry responding to areas of bamboo application through literature review. The data gathered was analysed using relative importance index (RII) to identify significant areas of bamboo application trends and constraints in the construction industry. The general respondent's views showed a significant increase in the application of bamboo as a raw material in construction works. The result showed the eleven most significant areas of bamboo application in the construction industry as props, temporary shed, landscape, scaffolding, trusses, ladder, hoarding, formwork, furniture, bamboo floor, and bamboo reinforcement in the building. However, inspite of the significant patronage of bamboo in construction works, there is less useful in areas such as a ceiling, roofing, partition wall, footbridge, polymer composite and laminate composite. Further findings showed limited knowledge, and lack of modern equipment to process the culm as the two significant constraints to its usage in construction. National standardisation is required to support industrial bamboo applications due to its outstanding mechanical properties in tensile strength. There is a need for awareness creation on bamboo's potential in the construction industry as well as other engineering applications in Ghana.

Keywords: bamboo, Ghana, infrastructure, standardization

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1. Introduction

The infrastructure and construction industries across the globe have contributed hugely to the economic growth of nations', but most third world countries are lacking behind due to high demand and increase in the cost of sustainable materials for infrastructure development (Akwada and Akinlabi, 2015; Cardoso et al. 2007). Ghana depends mostly on imported materials for its infrastructure and construction works. However, in this few years the cost of imported materials for construction has increased more than 100% due to high duty cost on imported goods, the high energy cost for processing, the high cost of transport and many other factors. The other factors include high deficiency of infrastructure provision in mostly regional capitals where the population is more than the available facilities. One of the major areas affected is the building construction sector where the high cost of the materials has led to considerable deficiencies of affordable houses to dwellers. Due to these challenges facing the construction industry of Ghana, researchers have been working on other locally available but cheap material as an alternative for construction of houses to alleviate this deficiency across the country. The forest reserves in Ghana has suffered an over-exploitation in recent years from wood and timber industries for their business (Marfo, 2010). Most of this company in the country have indiscriminately exploited the natural reserves for exports to other foreign countries as well as to the local industries. The challenge of a declining timber species in the forest is fast affecting the productivity of the wood industries in Ghana. These challenges and other factors have led to exploitation of other regenerative and environmentally friendly material as an alternative to infrastructure development in Ghana (Oduro et al., 2012; FAO, 2015). The current trend of bamboo application in the construction industry of Ghana is mainly for scaffolding, props and for temporary sheds which mostly is unprocessed. However, some wood industries are currently exploring the prospects of this material and developing wood composites from it. Some of the products include strand woven bamboo, ply bamboo, bamboo laminate lumber and bamboo floor tiles. This study investigates the various areas, trends and constraints of bamboo's application in infrastructure works.

2. Literature Review

The discovery of bamboo as a readily available, cheap and as a potential alternative material with high strength properties compares to steel, concrete and wood. Bamboo is a regenerative and sustainable plant with 75 genera and more than 1, 250 species worldwide. Bamboo grows faster than hard or softwood, and it releases about 36 % more oxygen and sequesters tons of CO_2 from the atmosphere (Akinlabi et al., 2017; Vogtländer et al., 2014; Yiping et al., 2010). Bamboo is widely distributed across the globe including Africa, Asia and Latin and South America where the demand for infrastructure materials is rapidly growing (Akinlabi et al., 2017). Bamboo is a type of grass; its microstructure is significantly more than timber and is heterogeneous, consisting of small dense fibre bundles in a less dense matrix material. Bamboo matures for harvest within 3-5 years from the time of plantation and is regenerative annually (Akwada and Akinlabi, 2016; Yiping et al., 2010; Amada et al., 1997). It is cheap, less energy cost for processing, environmentally friendly and readily available in large volumes across the country Ghana (Akinlabi et al., 2017; Rassiah and Megat Ahmad, 2013; Dittenber and Gangarao, 2012). Bamboo has a renewing characteristic as well as possessing excellent mechanical properties since its fibre is a superior competitor as reinforcing material which promotes its application in both polymer and laminate composite (Bayerl et al., 2014; Dittenber and Gangarao, 2012). Bamboo has specific mechanical properties that are exceptional when compared to other natural fibre plants, having the highest flexibility and weight ratio compared to concrete, steel and timber but light in weight (Akwada and Akinlabi, 2015).

2.1 Application of bamboo

The application of bamboo was mainly found inside the building of mud houses, use as huts, fences, and footbridges for temporary structures in the countryside and considered as the poor man's wood. Though its application in the construction industry has been over centuries; its high potentials had been underestimated due to its small diameter of culms and the high variability of its mechanical properties. Also, because its culms are susceptible to insects and fungi attacks, its application has been neglected in the infrastructure industry. More so, the use of the whole bamboo culm for construction requires appropriate design techniques and some level of skill to bind the round culms together (Akinlabi et al., 2017; Minke, 2012). Bamboo requires an appropriate treatment before its application for any permanent construction works to help prolong culms lifespan as well as its quality for years (Akinlabi et al., 2017). In overcoming these limitations associated with the application of bamboo, there is rapidly developing research into new fields on its potential development (laminate and polymer-based composites) as an alternative to wood for structure works (Li et al., 2015; Correal et al., 2010). Bamboo has been tested and proven to have the qualities which make it a potential material for the infrastructure and construction industry. Bamboo has several multiple applications as a material in the construction industry over concrete, steel and wood. Bamboo has the advantages of being less energy consumed during processing, high strength and stiffness per unit area of material compared to steel and concrete for construction (Akinlabi et al., 2017). It possesses mechanical properties like high strength to weight ratio, high tensile strength and high specific load-bearing capacity for its application as a construction material (Tada et al. 2010; Ghavami, 2005). It new trend of the application as a material for construction is due to its possession of high residual strength that makes it absorb shocks and impacts compare to timber (Shyamasundar and Vengala, 2008). Its utilization as a potential material in the construction industry by China, Indian, Brazil, among other countries has contributed to their infrastructure developments in building construction. Bamboo application in the infrastructure industry includes its usage as automobile parts, furniture's, laminate board, fibre polymer composite, frames of electrical gadgets, bridges, bicycle, scaffolding, floor tiles, ladder, partition walls, reinforcement, windows, ceiling, trusses, houses and corrugated roofing sheets.

2.2 Bamboo species in Ghana

There are four common bamboo species known in Ghana with other foreign species also that have been introduced into the country. These species include Bambusa bambos, Bambusa vulgaris, Dendrocalamus strictus and Oxytenanthera abyssinica. They are distributed in the wild from the wet and moist evergreen and the dry and moist semi-deciduous forests across the country. Even though bamboo is readily available in Ghana, its full exploitation is yet to be attained. The current high increase of material cost in the country for construction works have led to research into bamboo's potential and further development into engineered products (Liu et al., 2016). Studies have shown that most of its applications in construction are mainly as scaffolding, trusses, walls, fences, props, poles and temporary shelter which does not imply any processing (Minke, 2012; Lobovikov et al., 2007). Also, in a study conducted by (Akwada and Akinlabi, 2015) reveal that engineered bamboo processing is not on a large scale in Ghana as most wood processing industries are faced with the challenge to purchase modern equipment for manufacturing over the years. A recent study by Akinlabi et al. (2017), indicates a new trend of processing of bamboo culms in Ghana into laminate composite on a small scale where with simple equipment. Also, other areas of its exploitation in the infrastructure industry include its application to construct bicycle frames (Agyekum et al., 2017). Bamboo has the potential to serve as alternative material to timber in the infrastructure industry when all the necessary treatment processes are performed. The lack of scientific approval, standards and government legislature on the bamboo application has limited its full utilization in the construction industry of Ghana, notwithstanding the lack of modern machines to process the culms which is a significant factor affecting its full application. Currently, there is a high demand for fresh bamboo culm application in the construction industry for scaffolding and reinforcement in concrete as well as other construction applications (Akinlabi et al., 2017). Table 1 shows summarised literature on multiple applications of bamboo in the infrastructure and construction industry of Ghana.

Table 1: Summary of bamboo applications in construction

Bamboo Traditional Application	**Source**	**Industrial Application**	**Source**
Hoarding	Jiang, (2007), Minke, (2012)	Bamboo floor tiles	Xiao et al., (2009); Sharma et al. (2015)
Fencing	Yu et al. (2011); Chaowana, (2013), Minke, (2012)	Corrugated Roofing Sheets	Mallick, (2007)
Trusses	Yu et al. (2011); Chaowana, (2013), Minke, (2012)	Plybamboo	Mahdavi et al. (2012)
Partition walls	Yu et al. (2011); Chaowana, (2013), Minke, (2012)	Bamboo Mat Board	Abdul Khalil et al. 2012
Footbridges	Yu et al. (2011); Chaowana, (2013), Minke, (2012)	Bamboo Plastic Composite	Mallick, (2007), Muller and Rebelo, (2015)
Ladder	Chung et al. (2003)	Oriented Strand Board	Malanit, (2009)
Landscaping	Sta. Ana, (2006), Minke, (2012)	Bamboo Chipboard	Mallick, (2007), Shi and Walker, (2006)

Bamboo Traditional Application	**Source**	**Industrial Application**	**Source**
Poles	Lobovikov et al. (2007)	Bamboo laminated Lumber	Muller and Rebelo, (2015)
Scaffold	Sharma, (2015), Minke, (2012)	Medium Density Fibreboard	Mallick, (2007), Muller and Rebelo, (2015)
Shelter	Lobovikov et al. (2007), Minke, (2012)	Beams	Lobovikov et al. (2007), Minke, (2012)
Woven Mat	Malanit, (2009)	Furnitures	Sharma, (2015); Rubio-Luna (2007), Minke, (2012)
Walls	Lobovikov et al. (2007), Minke, (2012)	Veneer	Muller and Rebelo, (2015)
House	Tistl and Vela´squezgil, (2001) Gielis, (2002), Minke, (2012)	Ceiling board	Haregewoin, (2007), Minke, (2012)
		Bicycle	Ras et al. (2016)
		Strand Woven Bamboo	Malanit, (2009)

3. Methodology

The study deployed a comprehensive review of related published works to identify the various areas of bamboo application in the construction industry and the identified information is then modified to suit the condition for construction industries in Ghana. A self-administered questionnaire was developed and distributed to stakeholders who works with SME's construction firms who assess the factors influencing bamboo application in these regions. A closed-end questionnaire was used to reduce biases to responses from stakeholders. The questionnaire made provision for respondents to suggest other areas of bamboo usage in infrastructure works while a field survey was also carried to maximise the response rate. The questionnaire was administered to 100 small and medium scale building contractors and 100 civil engineers on questions in the six regions of Ghana. The distribution of questionnaire was carried in the offices and active sites of the respondents. The question was categorised into groups with the first group seeking the respondent (Professionals) background information on bamboo application. The second group seek information on the various areas, of bamboo application in the construction industry and is ranked on a 5-point Likert scale ranging from 5 (most areas used) to 1(most areas unused), the higher the number, the higher the influence of its applications. On the various areas of application, respondents rank on the Likert scale of 1 to 5, which areas of application is bamboo mostly used, where 1= most unused 2= Unused, 3= Neither used nor unused, 4= often used and 5= most used. The third group looks at the trend of bamboo application in the construction industries in terms of the volumes and was ranked on the Likert scale ranging from 1 to 5, to identify the areas of high volume of usage, where 1= highly decreased 2= decreased, 3= Neither decreased nor increased, 4= increased and 5= highly increased.

3.1 Population

The study considers six regions namely the Ashanti, Brong-Ahafo, Central, Eastern, Greater Accra, and Western regions of Ghana comprising of building contractors and civil engineers involved in the application of bamboo for infrastructure development in Ghana. These regions were selected based on abundance of the bamboo resource; the high rate of bamboo applications in construction works and availability of professional and unprofessional stakeholders (i.e. building contractors, civil engineers in the small, and medium-scale enterprises involved in the bamboo application).

3.2 Sampling technique

The study used purposive sampling to select key informants from all the categories of respondents to ensure that the right respondents with the relevant knowledge, authority and experience on the topics are adequately selected. From a total of 200 questionnaires distributed to stakeholders considered for this study, building contractors (100 questionnaires) and civil engineers (100 questionnaires). A total of 163 was retrieved and this comprises of 96 representing 96% for building contractors and 67 representing 67% for civil engineers which is considered as sufficient for the study (Oladapo, 2005). The formula below was used to generate the required sample:

$$s = \left(\frac{p}{P}\right) * S \tag{1}$$

Where: **s =** the sample required from each participating work,

p = the number of key resource persons in each work,

P = the study population and

S = the total sample size.

3.3 Respondents' profile

The average years of experience of the building contractors and the civil engineers from the firms surveyed in the construction industry are between 5 and 20 years, implying that they all have significant experiences in the construction works. Two percent (2%) of the stakeholders had Senior High School Certificate, and six percent (6%) had Technical and Vocational Certificate. Twenty percent (20%) had Higher National Diploma, Forty percent (40%) had Bachelor of Science Degrees, thirty percent (30%) had Master of Science, and two percent (2%) had Doctorates Degrees. The results further showed that the respondents are from both the public and the private sector.

3.4 Data analysis

The Relative Importance Index (RII) method of analysis was computed using equation (2) to help identify the significance of the factors which influence bamboo in the infrastructure development in Ghana. In a study by Adnan et al. (2007), stated that in analysing a data on an ordinary scale, such as Likert scale 1 -5, Relative Importance Index (RII) is the most suitable tool to help come out with various rankings research. The areas, trends and constraints of bamboo application in infrastructure development as viewed by stakeholders is shown in (Table 2 and 3) respectively.

$$RII = \frac{\sum W}{A * N} \, (0 \leq RII \leq 1) \tag{2}$$

Where:

W = is the weight given to each of the factors by the respondents in the ranges of 1 to 5 (where "1" is "Most disagree" and "5" is "most agree");

A = is the highest weight (i.e. 5 in this case) and;
N = is the total number of respondents.

4. Results and Discussion

4.1 Areas of bamboo application

4.1.1 Views of building constructor

Table 2 presents the views of building contractors on the application of bamboo in the construction industry. For this study, any factor with a relative importance index of 0.5 or more was considered significant. The most critical areas of bamboo usage includes props (RII = 0.8646), temporary shed (RII = 0.6250), scaffolding (RII = 0.6146), ladder (RII = 0.6042), hoarding (RII = 0.5833), formwork (RII = 0.5729), landscaping (RII = 0.5625) and furniture (RII = 0.5417), among others. The views of the building contractors show that bamboo application cuts across multiple areas, hence the need for standardisation and development as well as improve on the identified weakness as an alternative to timber. This result implies that in the opinion of the building contractors, the use of bamboo in construction and infrastructure works in Ghana is still underdeveloped. Relating the outcome result to findings by Tekpertey, (2006), shows that the application of bamboo in props in construction had a significant increase in recent years being ranked the highest. The findings show that bamboo is largely used in props and for temporary sheds in construction in Ghana.

4.1.2 Views of civil engineer

The most critical areas of bamboo usage includes props (RII = 0.9198), landscaping (RII = 0.6531), trusses (RII = 0.6073), hoarding (RII =0.6042), scaffolding (RII = 0.5813), ladder (RII = 0.5781), bamboo floor tile (RII = 0.5719), among others. The views of the civil engineers show that bamboo application cuts across multiple areas, hence the need for standardisation and development as well as improve on the identified weakness as an alternative to timber. This result implies that in the opinion of the civil engineers, the use of bamboo in construction and infrastructure works in Ghana is still underdeveloped. Relating the outcome result to findings by Tekpertey, (2006), shows that the application of bamboo in props and landscaping in construction had a significant increase in recent years being ranked the highest. The findings show that bamboo is largely used in props and for landscaping in construction in Ghana assessing from this viewpoint.

Concluding from the views of the respondents considered for this study shows that there is a high demand for bamboo as a material for construction works, hence the increase in demand for its application. Averagely, respondents were indifferent (neutral) about the use of bamboo in areas such as roofing, bamboo floor and partition walls, artwork, bicycle, ceiling, footbridges, house, laminate bamboo, partition walls. According to respondent view, bamboo application in polymer fibre composite has seen no significant increase because this technology is now being introduced on the Ghanaian market as there is a shift to process bamboo into a more permanent wood and as a reinforced material construction works. Hence, the need to develop bamboo with the modern scientific technology and promote its application in the wood and construction industries of Ghana.

Table 2: Bamboo application in the construction industry of Ghana

S/No.	Areas of Applications	Building contractors		Areas of Applications	Civil engineers	
		RII	**Rank**		**RII**	**Rank**
1	Props	0.8646	1st	Props	0.9198	1st
2	Temporary shed	0.6250	2nd	Landscape	0.6531	2th
3	Scaffolding	0.6146	3rd	Trusses	0.6073	3rd
4	Ladder	0.6042	4th	Hoarding	0.6042	4th
5	Hoarding	0.5833	5th	Scaffolding	0.5813	5th
6	Formwork	0.5729	6th	Ladder	0.5781	6th
7	Landscape	0.5625	7th	Bamboo floor tile	0.5719	7th
8	Furnitures	0.5417	8th	Temporary shed	0.4688	8nd
9	Bamboo Reinforcement	0.4992	9th	Partition Walls	0.4656	9th
10	Bamboo floor tile	0.4981	10th	Bamboo Reinforcement	0.4235	10th
11	Trusses	0.4981	10th	Furnitures	0.4210	11th
12	Ceiling	0.4896	12th	Ceiling	0.4206	12th
13	Partition Walls	0.4792	13th	Roofing	0.4200	13th
14	Roofing	0.4583	14th	Formwork	0.4138	14th
15	House	0.3438	15th	House	0.4130	15th
16	Footbridges	0.3021	16th	Footbridges	0.3948	16th
17	Laminate Bamboo board	0.2292	17th	Laminate Bamboo board	0.3979	17th
18	Polymer fibre composite	0.0521	18th	Polymer fibre composite	0.1240	18th

4.2 The trend of bamboo application over the past five years

4.2.1 Views of building constructor

Table 3 above presents the views of building contractors on the trend of bamboo application in construction industry. The result shows a significant increase in bamboo application in props and is related to the finding of (Tekpetey, 2006) which prove to the fact that bamboo application in the construction industry in Ghana is mostly in the areas of the prop. Also, the application of bamboo as a temporary shed was ranked second by the respondents. However, the respondent was neutral about the use of bamboo in the areas such as scaffolding, ladder, hoarding, formwork, landscape, furniture, bamboo reinforcement, trusses, bamboo floor, ceiling, partition walls, roofing, house, artwork, bicycle, footbridges, and laminate bamboo board. The result also shows that the application of bamboo in the areas of polymer reinforcement composite has not received any increase in the past five years.

Table 3: The trends of bamboo application in construction industries in Ghana

S/No.	Areas of Applications	Building contractors		Areas of Applications	Civil engineers	
		RII	Rank		RII	Rank
1	Props	0.8646	1st	Props	0.9198	1st
2	Temporary shed	0.7250	2nd	Landscape	0.8531	2th
3	Scaffolding	0.5996	3rd	Trusses	0.5867	3rd
4	Ladder	0.5909	4th	Hoarding	0.5860	4th
5	Hoarding	0.5833	5th	Scaffolding	0.5813	5th
6	Formwork	0.5729	6th	Ladder	0.5781	6th
7	Landscape	0.5625	7th	Bamboo floor	0.5719	7th
8	Furnitures	0.5417	8th	Temporary shed	0.5688	8nd
9	Bamboo Reinforcement	0.5415	9th	Partition Walls	0.5656	9th
10	Trusses	0.5414	10th	Bamboo Reinforcement	0.5635	10th
11	Bamboo floor	0.5414	10th	Furnitures	0.5625	11th
12	Ceiling	0.5413	12th	Ceiling	0.5615	12th
13	Partition Walls	0.5413	13th	Roofing	0.5448	13th
14	Roofing	0.5412	14th	Formwork	0.5438	14th
15	House	0.5410	15th	Bicycle	0.5438	14th
16	Arts work	0.5410	15th	Arts work	0.5344	16th
17	Bicycle	0.5333	17th	House	0.5323	17th
18	Footbridges	0.5021	18th	Laminate Bamboo board	0.5319	18th
19	Laminate Bamboo board	0.5292	19th	Footbridges	0.5308	19th
20	Polymer fibre composite	0.1521	20th	Polymer fibre composite	0.1240	20th

4.2.2 Views of civil engineering

The views of civil engineering in table 3 above presents on the trend of bamboo application in construction industry. The result shows a significant increase in bamboo application in props and is related to the finding of (Tekpetey, 2006) which prove to the fact that bamboo application in the construction industry in Ghana is mostly in the areas of prop. Also, the application of bamboo as a landscaping, was ranked second by the respondents. However, the respondent was neutral about the use of bamboo in the areas such as trusses, hoarding, scaffolding, ladder, bamboo floor, temporary shed, partition walls, bamboo reinforcement, furniture, ceiling, roofing, formwork, bicycle, arts work, house, laminate bamboo board, and footbridges. The result also shows that, the application of bamboo in the areas of polymer reinforcement composite has not receive any increase in the past 5 years.

5. Conclusions

Bamboo as a building construction material is gaining worldwide recognition as an alternative to timber with multiple areas of application. This research looked at the bamboo resource base production in the selected regions, its infrastructure development and the socio-economic benefits for the construction industry in Ghana. The work identified the areas, trends and constraints that influence bamboo application in construction. The research outcome showed that bamboo has the potential to be an alternative to timber in the construction industry of Ghana, hence the need to exploit the areas where its applications are required. The outcomes from stakeholders response in the six selected regions for this research showed a significant increase in its application in the construction as a raw material. However, most of its application is for temporary works with the most area being props, hence the need to develop this valuable resource material to meet the modern trends of permanent construction material such as laminate bamboo board, and polymer reinforced composite. The study further showed that bamboo has a high potential for its application in the construction industry in Ghana, but these are yet to be exploited into fully. The research finding shows that bamboo application in the construction industry needs to be processed to meet the modern trends of construction. Finally, the government must promote bamboo industrial application in the less used areas in the construction industry in Ghana. Therefore the need to promote, exploit and develop bamboo potentials as a permanent commercial material for construction works through scientific and advanced technology. Finally, there should be research into bamboos usage to exploit its potentials in the construction industry to enhance its commercial application for infrastructure development. The development of bamboo resource would help reduce government spending on the importation of constructional materials.

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SMME Contractors' Business Survival Traits and Competitiveness

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Abstract

Uncovering the sources of competitiveness amongst the surviving Small, Medium and Micro Enterprises (SMMEs) is imperative; as the chronic failure of startups businesses is heightened globally. Thus, most country's economic prosperity hugely links to the competitiveness of their SMMEs. As such, this study aims to provide significant insights on the SMME contractors' survival traits and sources of competitiveness within the South African construction industry. These business insights are considered as the competitive factors amongst the active, surviving and sustainable SMME contractors. The study adopted an in-depth interview research approach, which was rooted in phenomenological paradigm. The research interviewed 34 successful medium-sized construction contractors in Port Elizabeth, South Africa, in order to uncover the business survival traits and sources of competitiveness. The findings revealed that survival traits and sources of competitiveness amongst SMME contractors include: owner's experience in business and qualification; contractor's capability to effectively coordinate overall business activities; capabilities and competencies to secure and deliver quality projects; leadership sense to formulate competitive and multi-skilled faceted project team; capability to harness competitive advantages in construction services. These survival business traits are the competitive factors for developing a sustainable business and are recommended for adoption by startups and economic struggling SMME contractors as a strategic means to survive and thrive in the industry.

Keywords: competitiveness, construction, Port Elizabeth, SMME contractors, South Africa

1. Introduction

The state of firms' competitiveness and economic success of any country is greatly linked to its capacity to survive and utilise their collective capabilities in creating competitive advantages; environment of business transformations and sustainable progress (Sewdass and Du Toit, 2014). Sewdass and Du Toit (2014) further observe that South Africa have been ranked low in terms of the worlds' competitiveness index record between 2013 and 2014. The World Economic Forum

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(2014) ranks South Africa's competitiveness 56th out of 144 countries in the Global Competitiveness index for 2014. The ranking was down from the 2013 ranking of 53rd out of a possible 148 countries. However, the South African (SA) records on Global Competitiveness performance index for 2014 were as follows: institutions ranked (36th), infrastructure (66th), macroeconomic (89th), health and primary education (132nd), higher education and training (86th), goods market efficiency (32nd), labour market efficiency (113rd), financial market development (7th), technological readiness (66th) and market size ranked (25th) (World Economic Forum, 2014).

The World Economic Forum (2014) further indicates that the most problematic factors for doing business in the South African market are: restrictive labour regulations, inadequate educated workforce, corruption, tax regulation, government instability, insufficient capacity to innovate, lack of access to financing, crime and theft. Consequently, building a skilled labour force and creating sufficient employment also present considerable challenges. This can be linked to insufficient quality of higher education and training (ranking of 86th) and labour market efficiency, which is ranked a very low 113th (World Economic Forum, 2014). Therefore, the South Africa (SA) education standards need calls for upgrades, in order to bridge the gaps within the labour market. This, in turn, would aid to reduce the country's high unemployment rate of over 20%, as well promotes its competitiveness (World Economic Forum, 2014).

The resultant of SA being ranked low in the World Competitiveness Index has a ripple effect towards growth of the Small, Medium and Micro Enterprises (SMMEs) in the South African construction industry. Martin and Root (2010) assert that internal and external constraints are the primary sources for the high bankruptcy rate amongst the SMMEs. The internal and external constraints can best be described as unprofitable tender prices in projects; a system of abuse by main contractors; poor general management skills amongst contractors; technological difficulties; problems in accessing finance; difficulties in securing contracts due to a high competition and legal barriers (Martin and Root, 2010).

Werner (2011) recommends that South African businesses (including SMME contractors) must prepare to deal with all types of business ramifications: including intense global competition, powerful information technology, innovation, competitive business strategies, the demands for new skills, political transformation, as well as intelligent clients demands and more sophisticated needs. Werner (2011) further elucidates that strategic business leadership is one of the most important key factors that could take South African businesses to greater heights. As an effective business leadership is required to capitalise on the market changes and opportunities; as well as to engage in continuous improvements, in order to overcome the market threats and weaknesses, such as a lack of knowledge of modern technology and poor business strategy (Werner, 2011).

In the view of McCabe (2012), construction industry is slow in embracing change, specifically towards the application of new Information and Communication Technology (ICT); and this has a significant impact on its competitiveness and sustainable progress. The above assertion flies in the face of many research commentators who have advised that the rate at which industrial change occurs in terms of engineering, innovation and technical capacity, business leadership and new skills are unlikely to slow down.

However, Dlungwana and Rwelamila (2004) opines that not all the local and SMME contractors would thrive and become successful in the industry. The SMMEs success would be limited to those organizations who strive earnestly to become more sustainable, globally competitive; and in readiness to enhance their competitiveness by expanding within the African continent and beyond. Martin and Root (2010) further said that SMME contractors in the construction industry need to gain strategic knowledge; have articulated business goals and objectives; and capability to develop competitive business strategies to foster their sustainability and competitiveness.

1.1 Research rationale

This paper aimed to determine the SMME contractors' survival traits and sources of competitiveness amongst surviving and competitive medium contractors (cidb grade 4-6 contractors) who have been in operation beyond five years. Therefore, this study intends to contribute strategic solutions towards capacity building in tackling the rampant business failure amongst SMME contractors in the South African construction industry.

1.2 Research question

What are the business survival traits and strategic drivers of competitiveness in the construction industry?

2. Theoretical Backgrounds

2.1 Brief on the concepts of contractors' competitiveness

Broadly, the World Economic Forum (2014) defines "competitiveness as a set of institutions, policies, and factors that determine the level of productivity of a country". The World Economic Forum (2014) also adds that the stability of the macro-economic environment within any country would enhance or deterred its overall business performances and national level of competitiveness. According to Orozco, Serpell and Molenaar (2011) the concept of competitiveness in the construction industry can be divided into four sections, namely the country, industry, firm, and project.

2.2 Country's competitiveness

The country's global competitiveness are determinants of their firms' overall competitiveness; as the World Economic Forum (2014) argues that a country's macro-economic performance, level of productivity and its competitiveness could be grouped into 12 pillars of competitiveness. These include: the institutional framework of the country; the infrastructure status of the country, the macro-economic environment; health and primary education; higher education and training; goods market efficiency; labour market efficiency; financial market development; technological readiness; market size; business sophistication, and innovation throughput of the country. These factors determine how sustainable a country's economy would be ranked globally (World Economic Forum, 2014). However, the World Economic Forum (2014) further indicates that the most problematic factors for doing business in South Africa is the restrictive labour regulations, inadequate educated workforce, corruption, tax regulation, government instability, insufficient capacity to innovate, lack of access to financing, and crime and theft.

2.3 Construction industry's competitiveness

The enhancement of the competitiveness of any construction industry should be one of the most important strategic tasks for construction players. As the construction industry has been recognised as an important venture for material production in South African and the global economy (ECORYS SCS Group, 2011). According to the ECORYS SCS Group (2011); and the National Research Council (2009), the construction industry plays strategic roles in delivering the needed building and infrastructures in the European countries and the USA, as well as a major source jobs and economic growth. In the South African economy, the construction industry contributes about 4.2% and 4.0% of the country's GDP in the year 2009 and 2013 respectively (Kumo, Omilola and Minsat, 2015). Therefore, the article reflects that it is vital to ascertain the survival rate and to chart strategic concept on how the SMME contractors within the construction industry would enhance their competitiveness.

However, the concept of competitiveness at the industry level is often considered as a result of the strategies and actions of organizations that operate in it. Momaya (1998) argues that competitiveness of an industry depends on its ability to obtain inputs at competitive terms. Siskina, Juodis and Apanaviciene (2009) added that the development of competitiveness in any country's construction industry would depend on its strategic positioning within the market, both in terms of local and international standards. Siskina *et al.* (2009) further pointed out that the strategic position refers to the competitiveness attributes, such as market sizes, activities (price, quality, technology) of the market, and regional location advantage.

2.4 The concept of firm's competitiveness

A country's levels of industrial development impacts on the firms operating in it. And so, a systematic evaluation of competitiveness would be of great importance to firms, especially the SMME contractors. According to Depperu and Cerrato (2005), a firm's competitiveness could be treated as a dependent or independent variable. The first approach considers competitiveness as a driver of a firm's performance, whereas the second approach considers competitiveness as an outcome of a firm's competitive advantage. However, the concept of competitive advantage is central in strategic management; as Depperu and Cerrato (2005) support the view that a strategic management approach underlines the importance of firms' specific resources in determining variance of performance within the particular sector. This approach relates to the resource-based, competence-based and knowledge-based views.

The focus shifts from external to internal sources of competitive advantage emanate from firm's competitive strengths through the accumulation, development and reconfiguration of its unique resources, capabilities and knowledge towards sustainability and competitiveness (Depperu and Cerrato, 2005). According to Momaya (1998) firm's competitiveness is its ability to add value to their business activities in a manner that satisfies the needs of its clients, employees and the economy. Ambastha and Momaya (2004) adds that a firm's level of competitiveness can be defined as its ability to design, produce and market its products and services that are superior to those offered by its competitors. Both price and non-price qualities are considered. This can be done through an integrated effort across different functions and has a close linkage with their business strategy process.

Moreover, an integrated strategic business process can boost a firm's competitiveness. Depperu and Cerrato (2005) observed that a firm's level of profitability, costs of operation, productivity and market share are all indicators of its competitiveness. It also includes other variables, such as innovativeness, quality, ethical standards, social responsibility and working conditions of employees. Bhattacharya, Momaya and Lyer (2009) assert that a firm's competitiveness is its ability and capability to achieve a sustainable performance and growth. This sustainable performance and growth can trace back to its strategic framework that consists of assets (resources), processes and performance. Ambastha and Momaya (2004) added that understanding a firm's level of competitiveness helps to provide richer and comprehensive views on the sources of competitiveness. Ambastha and Momaya (2004) further categorize the sources of competitiveness under asset, processes and performance. The *asset* includes firm brand, reputation, culture, management system, structure, human resources and technology; whilst *processes* involves strategy, innovations, competencies, capabilities, quality, persuasion power, flexibility, adaptability, IT applications, managing relationship, design and deploy talent, marketing and manufacturing; and *Performance* consists of value creation, customer/client satisfaction, market share, productivity, new product/service development, price and cost and profitability.

2.5 The concept of project competitiveness

An effective and efficient project delivery/ performance within the construction industry can be complex due to its nature and approach as Takim and Akintoye (2002) affirmed that the construction industry is becoming more complex and therefore, a more sophisticated approach is necessary to deal with initiating, planning, financing, designing, approving, implementing and completing a project; as well as maintenance and demolition. Thus, any contracting firm's competitiveness should reflect on its project delivery performance. According to Ibrahim, Costello and Wilkinson (2011) the success of a project and the performance of any organization within the construction industry depend largely on the available mechanism to integrate the knowledge and experience of many people within the organization into effective-project team(s). Consequently, for the SMME contractors to ensure that their project team are successful in completing its jobs, it is necessary for the them to stimulate and integrate collective effort and best practices within their organizations; an approach which, Ibrahim *et al.* (2011) described this integration as collaborative-working practices, methods and behaviours that promote a business environment and add a free exchanged of information amongst the construction parties. Ibrahim *el al.* (2011) further noted that the nature and knowledge of a competitive business environment within the construction industry, are also required to be implemented in a “unified strategic-integration approach” for all key players in any given construction project that consists multi-disciplinary team.

In addition to this, Takim and Akintoye, (2002) stated that the level of success in carrying out construction project development activities in an integrated approach would depend largely on the quality of the managerial, financial, technical and organizational performance of the respective parties. At the same time, due consideration must be given to associated risk management, the business environment, and economic and political issues. Takim and Akintoye (2002) further mentioned that performance appraisal and assessment towards construction projects would show if the project would be successfully delivered on time, within budget, according to technical specifications and delivering on client expectations.

Takim and Akintoye, (2002) added that a project’s competitiveness may consist of three major issues, namely: fulfilling criteria set as the project’s success factors; project performance; and project success. The success factors determine or affect the performance of project delivery, which in turn predicts the project success and competitiveness. However, the outcome of successful project delivery would have a strong link with the organization’s level of efficiency and effectiveness during the project implementation. Therefore, the project competitiveness would emanate from the organization’s efficiency and effectiveness.

2.2 The concept of contractor’s economic sustainability

The word sustainability has recently become a keyword in various fields of endeavours. According to Wikstrom (2006); and Doane and MacGillivray (2001), the sustainability of a business organization are built on a long-term foundation that consists of economic, social and environmental components.

2.2.1 Economic sustainability of SMME contractors

Presley and Meade (2010) opined that SMME contractors’ sustainability could involve a top-level strategic business and model. This approach could ensure a long-term business survival and financial viability. Wikstrom (2006); and Doane and MacGillivray (2001) noted that the concept of sustainability or sustainable business primarily defines how organizations (such as SMME contractors) achieve their business goals in a long-term approach with competitive advantage. Thus, Fahy (2000) argues that a firm’s sustainability does not account for a period of the calendar year, nor does it imply that competitive advantage persists forever; but rather the difficulty of imitating those sustainable advantages by competitors. Still, a firm’s level of competitiveness would determine its economic sustainability. Added to this, Vinayan, Jayashree and Marthandan (2012) state that an organization's future business sustainability would depend on continuous exploration of its competitive advantage.

Business sustainability in the perspective of Froschheiser (2015) refers to a firm's ability to acquire and implement competitive business strategies that would contribute to the long-term sustainable operation and continuous business improvement. According to Porter (1985), the core factor of business success and competitiveness is rooted in the levels of satisfaction a client receives from the services and products of an organization (Contractor). As such, SMME contractors must be clients' interest-orientated through continuous performance improvement of their strategic capabilities and competences.; as Orozco *et al.* (2011) suggested that business performance and sustainability indicators can be accredited to elements such as: financial indicators; non-financial productivity (reputation and trademark); project performance records; customer/client satisfaction; market share; institution satisfaction; future capabilities, strategic techniques (business strategies, strategic resource and strategic competencies) and bidding effectiveness. Moreover, Doane and MacGillivray (2001) add that the indicators of economic sustainability for an organization must reflect on the following: (i) the financial performance; (ii) how strategic resources and assets are managed; and (iii) influence on economic activities. In the same vein, Presley and Meade (2010) state that long-term financial viability and continuous business performance (sustainability) should be the top priority of SMME contractors' strategic business objective. Thus, these business objectives are organizations' business management aims for the effective and efficient competition in the 21st century business world.

According to Porter (1985) the fundamental bases of organizations (such as SMME contractors) to earn above-average-business profit and performance in a sustainable manner lies in their capability to develop and grow competitive business strategies that place them in an advantageous market position in the given industry. However, Carnall (2003) claims that an organization's managerial structure could be developed as a competitive business strategy that it is capable of creating a sustainable and competitive business performance. According to Goulding (2010), the process of assessing an SMME contractor's business performance can be ascertained through its current position in the marketplace. Goulding (2010) noted that it is imperative for SMME contractors to grasp the total concept and issues of competitive business strategy. This is an important aspect of business evaluation, which unveils the business performance measures, criteria, and indicators that would contribute to the strategic objectives of the organization.

3. Research Methodology

An extensive view of Creswell and Clark (2007) posit that the selection of research methodology and methods (qualitative and quantitative) in the discipline of management and social sciences is influenced by the researcher's assumptions about the nature of the social world and his experiences on the subject matter. This study adopted a qualitative research approach, rooted in the phenomenological paradigm and utilizing an in-depth interviewing method. This qualitative research method adopted an in-depth interviewing, in order to understand business survival traits and major sources of competitiveness amongst the surviving and competitive SMME contractors (contractors in grade 4-6 that are under the Construction Industry Development Board (cidb)) in Port Elizabeth, South Africa. Phenomenology is the philosophical name for the method of investigating or inquiring into the meanings of our experiences; as Miles, Huberman and Saldana (2014) state that phenomenological paradigm tends to look at data thematically, to extract essences and essentials of research respondents (SMME contractors) perceptions and its meaning. Mack (2010) claims that the phenomenologist advocates the need to consider human beings' subjective interpretations, their perceptions of the world (their life-world) as their starting point in understanding social phenomena and reality. Thus, phenomenology paradigm adopted was geared towards having a holistic understanding of the phenomenon about the medium contractors' perspective on business surviving traits that are considered as factors that contributes to their business competitiveness and sustainability for more than five years in the industry. This method was considered the most appropriate and effective to elicit useful and authentic information such as contractors'- experiences, opinions, and perspectives.

The collected data in this study were analysed thematically. This approach involves constant comparative analyses after the interview data has been sorted and coded, in order to generate knowledge about any common pattern observed from the interviewees' evidences, experiences, opinions and perceptions of the cardinal concepts towards the competitiveness and sustainability of SMME contractors in the South African construction industry. Thus, data were evaluated and repetitive information excluded; as only relevant data were succinctly grouped into themes and the interpretations on the themes were taken into account.

4. Research Findings and Discussion

4.1 The cidb contractors' grading of the participants

Table 1 indicates that the research participants (SMME Contractors) have strategic positions, insightful business knowledge and experience to make business decisions in their respective organizations, thus ensuring the validity and accuracy of their responses. Thus, Table 1 shows that out of 34 firms interviewed in the study, 8 (24%) were contractors with cidb grade '6GB and 6CE'- coded as E1- E8; 13 (38%) were contractors with grade '5GB and 5CE'- Coded E1-E13; and 13 (38%) with cidb grade '4GB and 4CE'- Coded as D1-D13 respectively.

Table 1: Research participants (The cidb contractors' grading)

Respondents	**Response**	
Cidb Grade in Port Elizabeth	Number	%
4GB & 4CE	13	38.00
5GB & 5CE	13	38.00
6GB & 6CE	8	24.00
Total	34	100.00

4.2 The interviewees' working experience in construction industry

The number of years' experience that the participants had in the construction industry ranged between seven (7) and thirty-five (35) years. Figure 1 reveals that 44% had a working experience in construction between seven (7) and fifteen (15) years; 32% had worked for 16 to 25 years; whilst 12% had worked for 26 to 35 and 36 to 45 years in the construction industry respectively. The data collected was insightful, significant and meaningful as most interviewees had vast levels of experience in the South African construction industry.

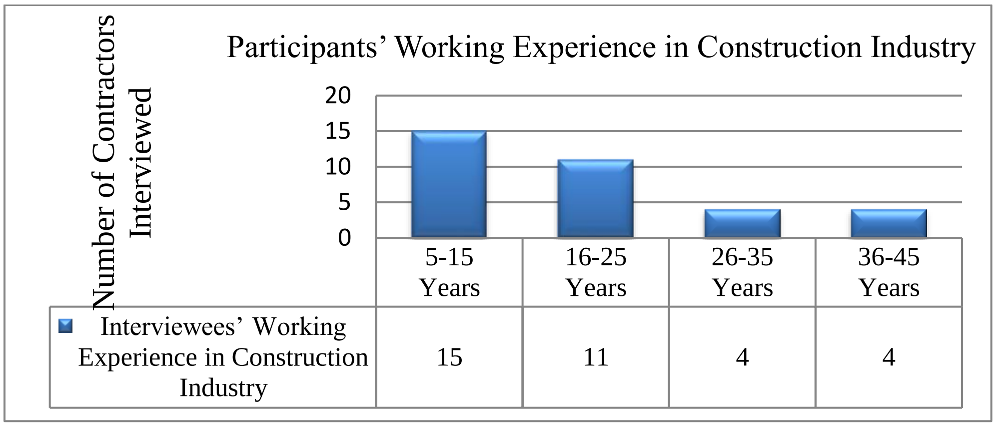

Figure 1: Participants' working years' experience in construction industry

4.3 Interviewees highest educational accomplishment of the interviewees

Upon analysing this study, Figure 2 reflects the educational attainments of the Participants, in which Diploma Certificates were the most common types of qualification attained. Thus, 50% of the participants held Diploma Certificates in areas such as building, civil engineering, construction management, quantity surveying and business management.

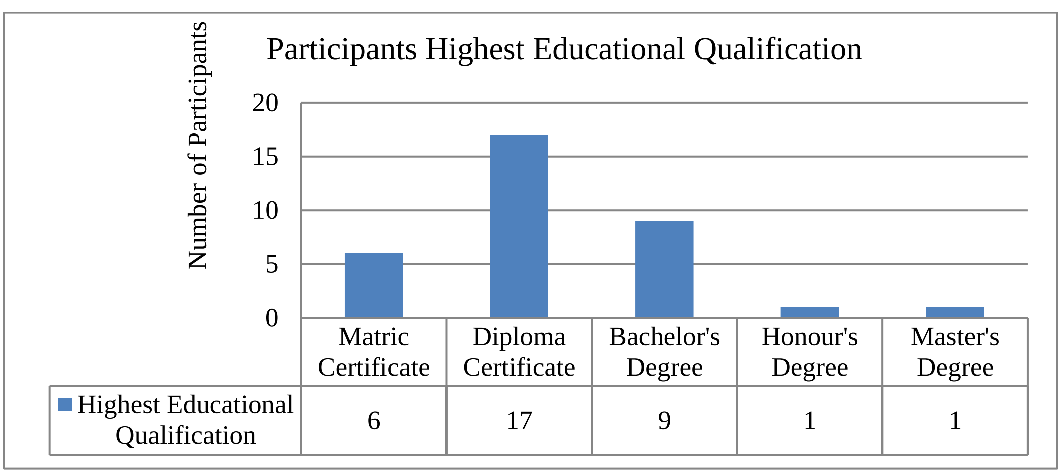

Figure 2: Educational accomplishment of the participants

The study indicated that 26% of participants held Bachelor Degrees in civil engineering, electrical engineering, and construction management and construction economics. 18% of participants held only Matric Certificates as their highest educational qualification, although most of them have vast hands-on experience in the construction industry. About 3% of participants held honours- and master's degrees as their highest educational achievement respectively.

4.4 Interview questions were based on contractor's competitiveness and survival characteristics

Interview Question 1: *Can you please describe how your organization survives the competitive environment in the construction industry?*

Interview Question 2*: What did your organization do within the first five years to ensure that the business thrived and does not fail?*

The interview questions 1 and 2 discuss and present the results related to the construction contractors' survival traits and techniques and their business competitiveness in the South African construction industry.

Theme 1: Organizations' Business-Survival Techniques and Processes within the Competitive Environment in the Construction Industry

Therefore, all the thirty-four (34) participants viewed "capability to plan and deliver quality project service and product to their clients" as one of the major business characteristics that enabled their survival in the construction market. Also, the findings explicitly indicate that SMME construction organizations would require techniques, processes, and the capability to plan, secure, and deliver quality project services to clients. These remain the major business characteristics that lead to the survival of businesses in the construction market.

In addition, the contractors' and their organizational abilities to structure, organise and coordinate the entire business activities also enhanced competitiveness in project pricing and delivery of quality service to the market and clients. As, D3 explained that: *"Our organizational ability to organise and structure our business activities has enhanced our competitiveness in our project pricing and delivery of quality service to market and clients."* Also, F2 explained that, *"our organization is well-structured and coordinated, and we are highly organised and project delivery result-oriented par excellent quality service, and this is our competitive edge in the market."* In addition, F1 stated that: *"My professional, technical and business management knowledge in general construction activities enhanced our organization survival. This enables me to assemble project organizational team, and to have the technical capability to assign responsibilities to employees; and to prudently measure their productive level against the performance benchmark."* These finding corroborate with the thoughts of Martin and Root (2010) and Werner (2011) that organizations such SMME contractors in the construction industry need to gain and exhibit strategic knowledge and leadership as well as to engage in continuous improvement; and to the capability to develop competitive business strategies that would foster their survival, sustainability and competitiveness.

Theme 2: Securing Project tenders and pricing systems

Due to the uniqueness of and price sensitivity within the construction industry, each contractor is concerned about securing project tenders and utilising the possibilities of making reasonable profit or breakeven in any project execution. On this basis, eleven (11) Participants (5Ds, 2Es and 4Fs) claimed that a competitive project pricing system within an organization remains one of their key sources of survival and competitiveness in the construction market. They acknowledged the fact that the pricing system applied during the project tender process and project cost control would determine the competitive strength of the organization in securing projects and determining its financial capacity in the long run. F4 stated that: *"We survived by just being very competitive on the issues of project tender process, and in that, we had to cut down all the unnecessary expenses, to enable us to reduce tender pricing. This approach (cost strategy) increased our chances of getting many jobs in the industry."* Also, participant F1 stated that: "*With our performance benchmark and pricing system, we are rest assured of making reasonable profit. On a holistic base, we have not encountered significant loss in our business in any of the project services we have engaged on"*. Some of these findings are line with the thoughts of Froschheiser (2015) that a firm's (such as SMME contractors) ability to acquire and implement competitive business strategies that would contribute to the long-term sustainable operation. Also, Sewdass and Du Toit, (2014) affirms that the state of firms' (such as SMME contractors) survival and competitiveness greatly linked to its capacity to survive and utilise their capabilities in creating competitive advantages; environment of business transformations and sustainable progress.

Theme 3: Contractor's Capability and Competence to Coordinate Overall Business Activities

Fourteen (14) respondents (8Ds, 3Es and 3Fs) believed that the following capabilities contributed to the sustenance of their market positions in the industry: having a "functional organization system"; highly developed negotiation skills; business and technical ability to tender competitive pricing; competent, qualified and experienced project team to deliver quality service and product to clients; adoption of both informal and formal-professional marketing strategies; a website for promotion of the organization's services to the public; strategic evaluation and assessment of project performance and identifying areas of improvement for delivery of better service; studying competitors' strategic moves; adopting project management techniques and differentiating services; and offering added-value to clients. Thus, E3 extensively explained that: *"We have in-depth knowledge and expertise on how the construction industry and related industries function. Taking that into account, we have highly developed business negotiation skills that speak to our strategy and technical know-how on most products and services from suppliers. Through this, we make lots of capital savings on purchasing of material, plant and equipment. Our organization's value proposition has not dwindled over 25 years; as our clients and competitors came to know us as efficient and proficient contractors that execute contracts right (according to scope) first time* *and deliver projects within the right quality, duration and within budget"*(E3). These findings are in line with assertion of Ambastha and Momaya (2004) that the sources business survival and competitiveness are strategically linked to a firm's strategic asset, processes and performance. Carnall (2003) affirms SMME contractors' managerial structure could be developed as a competitive business strategy as it serves as a capability of creating a sustainable and competitive business performance.

Theme 4: Techniques for Contractors' Business Growth from the cidb Grade 1 to the Current Grades (4, 5 or 6)

The most SMME construction organizations survived and grew from the lowest cidb contractors' grade to the medium category, through the creation of significant business relationships with suppliers, clients, and investor / sponsors; the capability to deliver construction works; the business competence to tender and secure viable contracts; and to successfully complete projects in accordance with specifications. Therefore, ten (10) participants (3Ds, 5Es and 2Fs) explained that their organizations survived and grew from the lowest category of the cidb contractors' grading to the medium category through strategically growing significant business relationships with suppliers, clients, investors and sponsors. The participant F7 stated that: *"We have grown significantly based on our business relationship with our clients, suppliers; and technical and management capability to complete most of our projects successfully. This has made us thrive as a construction business."* These results corroborate with the thoughts of Depperu and Cerrato (2005) that a firm's level of profitability, and market share are all indicators of its survival and competitiveness. Also, Momaya (1998) firm's competitiveness is its ability to add value to their business activities in a manner that satisfies the needs of its clients, employees and the economy.

The findings also reveal that SMME contractors survived as a result of their capability to deliver construction works (within the right time, cost and quality); hard work and dedication; the business competence to tender and secure viable and substantial project contracts within reasonable time lapses; as well as the ability to complete projects successfully without disputes. Therefore, employing competent and well-experienced staff; adopting innovative business methods; growing the organization's financial capacity; professional qualification and skills; and improving quality service and continually upgrading employees' skills through training; all these have significantly contributed to our business growth and led to our upgrade in to the medium sized contractors (D1, D2, D5, E1, E2 and E13). Some of these findings are in line with the thoughts of Vinayan, Jayashree and Marthandan (2012) that an organization's (such as SMME contractor) future business sustainability and competitiveness would depend on continuous exploration of its competitive advantage. In addition, Ambastha and Momaya (2004) affirms that a firm's level of competitiveness can be defined as its ability to design, produce and market its products and services that are superior to those offered by its competitors.

5. Conclusion

This paper aimed to explore and uncover the survival business traits and sources of competitiveness amongst the Small, Medium and Micro Enterprises (SMMEs) in the Port Elizabeth, South Africa. An all-inclusive review of the related literature study highlighted the business survival traits and sources of competitiveness in the construction industry. Thus, this research study was based on qualitative research, through which an in-depth interviewing was conducted with 34 medium contractors (cidb grade 4-6 contractors).

However the study findings corroborate with the related literature reviewed the business survival traits, and sources of competitiveness and economic sustainability amongst construction contractors. These factors are: business owner’s level of experience and qualification in construction; contractor’s capability to seamlessly and effectively coordinate overall business activities; ability to secure, complete and delivery quality project to clients on a regular basis; organization having a competitive project team and labour forces with multifaceted skills; and contractor’s capability to diversify its services.

Therefore, the results of this study uncover the business survival traits and sources of competitiveness amongst the surviving and competitive SMME contractors in Port Elizabeth construction market. Thus, in the line with the findings, the study recommends that the start-ups and economic struggling SMME contractors should strategically target to acquire these identified salient characteristics (capabilities and competencies) exhibited and expressed by the 34 medium contractors as their sources of competitiveness in the construction market. Consequently, when these recommendations are considered and adopted, it will contribute significantly to increase the survival rate amongst start-up and SMME contractors in Port Elizabeth, South Africa.

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Structural Health Monitoring of Highway Bridges in Zambia Using Sensor Technology: A Case Study of Nansenga Bridge

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Abstract

Structural Health Monitoring (SHM) of bridge structures, by use of visual inspections, can be subjective and inaccurate. Recent developments in sensing, communication and information technologies, however, have completely modernised the inspection procedures and significantly increased the efficiency and effectiveness in terms of cost, labour and time. With such advanced technologies, a vast range of infrastructure can be monitored in a timely and cost-effective manner. This research focused on developing an effective and efficient decision making tool for monitoring highway bridges in Zambia. The research involved literature review on improved and cost-effective SHM technologies for bridges that could be applied in Zambia. The research further demonstrates multi-scale SHM of bridges using wireless sensor technologies, with a case study on the Nansenga Bridge on the Kafue-Livingstone Trunk Road (T1). Non-destructive testing and evaluation (NDT/E) equipment was used to collect data on the current status of the Bridge. Due to non-availability of design data and as-built drawings on most old bridges, the Nansenga Bridge was redesigned to BS5400 to verify concrete strengths, rebar sizes, and placement in the structure. A Finite Element model of Nansenga Bridge was developed using FEM design 17 software, whereby moving loads were applied to study both linear and dynamic responses of the bridge.

Highly distressed regions from FE simulations agreed with onsite localised damage detected on the bridge deck, girders and piers. The detected cracks were in the range 1.000 to 1.748mm, exceeded the maximum allowable width of 0.3mm.. Ultrasonic pulse velocity tests indicated crack depths of 50 to 300mm on the Nansenga Bridge beams. The excessive damage requires immediate attention by the Zambian Road Authorities as this bridge is on a Trunk Road, linking Zambia to other SADCC countries (Zimbabwe, Namibia and Botswana).

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The research demonstrated that SHM using NDT/E and FE modeling can be applied to assess and monitor the state of bridge infrastructure in Zambia, upon which informed decisions can be based.

Keywords: finite element modeling, non-destructive testing and evaluation, structural health monitoring, wireless sensor technology

1. Introduction

Bridges are integral road transportation infrastructure networks, however, to realize the design life of bridges requires continuous assessment and monitoring, and appropriate interventions at various stages of its life. Some uncertainties arise right during the design and construction processes, creating structural behaviors that may not be predictable by design and simulations. Once in use, bridges are subjected to evolving patterns of loads and other actions. Often the intensity and type of solicitation are very different from the ones taken into account during its design and in many cases they are mostly unknown in both nature and magnitude. The sum of these uncertainties at various stages, pose a great challenge to the engineers and institutions in charge of structural safety, maintenance and operation. Further, defining service levels and prioritizing maintenance budgets relying only on models and superficial observation can lead to dangerous mistakes and inefficient use of resources.

The use of SHM sensor technologies improves the credibility of bridge inspections and subsequent ratings through less subjective techniques and data. Improves data consistence enabling the development of better decision-making tools; Use of finite element analysis with ICT techniques in SHM provides a better accurate and quicker understanding of the structures true response to deterioration and verification of control designs. Further establishing exact damage location, augmenting visual assessment, and providing early damage detection and warning. This also allows for more rational maintenance or replacement scheduling resulting in the optimization of maintenance cost and increase the reliability of high way bridges.

From 1964 to date Zambia has had no effective bridge monitoring technology apart from adhoc, subjective visual inspections which are not so reliable and pose serious limitations in determining extent of damage and structural integrity and associated planning and maintenance. This puts users at high risk of catastrophic events. Despite continued use of old bridges since Zambia got its independence, no Structural Health Monitoring system has been put in place. However, in 2010 Road Development Agency (RDA) conducted a bridge inventory which indicated 454 major bridges and 3321 culverts. Out of these major bridges, 28 on feeder roads were beyond repair, 49 were too expensive to repair (eg. the Kafue Hook Bridge of Lusaka-Mongu Road), 126 were in a marginal condition while the conditions of the rest ranged from satisfactory to good. According to National Bridge Inventory (NBIS-USA), bridges must be inspected every 2years but it took Zambia more than 45years to conduct the first more detailed inspection and condition rating. According to National Highway Institute for the Federal Highway Administration (FHWA), condition rating of 1995, 0.00 to 9.45% of the Zambian major bridges did not meet structural integrity requirements and were a risk to users. Collapse and failure of bridges in Zambia could be attributed to lack of SHM tools to aid decision making.

Zambia embarked on major upgrading and expansion of the road network (2012), which is now experiencing increased imposed loads on bridges, hence the urgent need for special monitoring techniques beyond visual inspections. Inadequate planning for bridge maintenance, repair and/or replacement schedules is proving to be costly as it has no basis for structured decisions.

Major advancements have been recorded in SHM research and technology in past years. Bridge SHM may be categorised in to two phases; periodic and continuous monitoring (V.zanjani, 2014a, Yin et al. 2010b, Birsby 2006a). This paper discusses periodic bridge SHM which was conducted on Nansenga Bridge in Lusaka province of Zambia. The methodology was into four parts; (a) acquisition of real time data as per built details of the bridge by using GPR system and Ultrasonic Pulse velocity detector, (b) redesign of the bridge to BS 5400 Part 2 & 4 of 1978 aimed at verifying field data, (c) development of a Finite Element analytical model of the bridge with an HB moving truck load. The FEM was validated by use of SHM field data, and, (d) use of integrated wireless micro crack detectors, GPR system and Ultrasonic pulse velocity tester to measure and quantify bridge conditions of highly distressed areas indicated by linear and dynamic FE analysis.

2. Structural Characteristics and Geometry of the Nansenga Bridge

The Bridge is a three span reinforced concrete balanced cantilever type, as shown in Figures 1 and 2. Table 1 summarises details of the bridge.

Figure 1: Side view of Nansenga Bridge

Figure 2: Beam-Slab Deck for Nansenga Bridge

Table 1: Bridge parameters

Length of deck	**Spans**	**Carriage width**	**Deck Thickness**	**Foot cycle path**
33.1m	7.0m,18.3m,7.0m	6.8m	200mm	1.2m
Parapets	Girder Type	No# Notional lane	Piers	Abutments
Open	Hunched Beam (1350x850)mm	2No. (3.4m)	2No.	Non- Integral
Foundations	Material Type	Bearings	Bearing location	
Reinforced Concrete	Reinforced concrete	Elastomeric	Pier	

2.1 Nondestructive testing and evaluation-ultrasonic pulse velocity and ground penetration radar

Nondestructive testing and evaluation equipment was employed to determine the real time conditions of materials on bridge structural elements and to collect as built bridge structural details. Ground penetration radar technology was used to establish rebar diameter and cover to reinforcement. Ultrasonic pulse velocity was used to determine strength of concrete beams, piers and the deck slab.

2.2 Bridge control design

A bridge control design of the Nansenga Bridge was conducted to BS5400, in order to compare results with structural parameters obtained by NDT/E equipment. The control design employed both serviceability and ultimate limit states. Load combinations C1 (Permanent Plus HB loads) and C3 were considered. Table 2 summarizes design consideration as per the 5400 code of practice whilst Table 3 compares scanned to the control design results.

Table 2: Design load considerations in accordance with BS 5400 part 2 (1978)

Load	**Type**	**SLS**		**ULS**	
Load combinations		C1	C3	C1	C3
		Partial Safety factors			
Dead load	Concrete	1.0	1.0	1.15	1.15
Super imposed dead load	Surfacing	1.2	1.2	1.75	1.75
Live Load	HA	1.0	1.0	1.5	1.25
	HB	1.1	1.0	1.3	1.1
Temperature Difference			0.8		1.3

Table 3: GPR Scanned results VS Design Review (BS 5400 part 2)

GPR Scanned		**Design review BS 5400 part 1&2 1978**
Average Cover	72mm	50mm
Rebar(compression & tension)	8Y32 top of cantilever, 8 Y25 bottom,Y12 stirrups	8Y32 top of cantilever ,8 Y25 bottom,r12 stirrups
Rebar spacing average	Stirrups 100mm, 200mm	Stirrups (100mm,200m)
Compressive Strength	37 MPa	30-40 MPa
Shear Reinforcement	Present (Y20,Y16)	Present(Y20,Y16)
Flexural Reinforcement	Present	Present

2.3 Finite element modeling

A full 3D finite element model was developed using a finite element software FEM Design 17. A 2/3/4 finite element analysis was used and the model consisted of 49419 nodes, 12594 surface shell elements and 13016 line connection elements. The model comprised of the bridge deck, girders and piers. Elastomeric bearings were modeled as hinged connections between girders and piers. Fixed line connections were used to model interaction between the deck and the girders. A crack analysis based linear dynamic analysis and linear static analysis was performed. A damping ratio of 5% was set within finite element software. Figure 3 presents the FE model whilst Figure 4 indicates moving load maximum shell stresses.

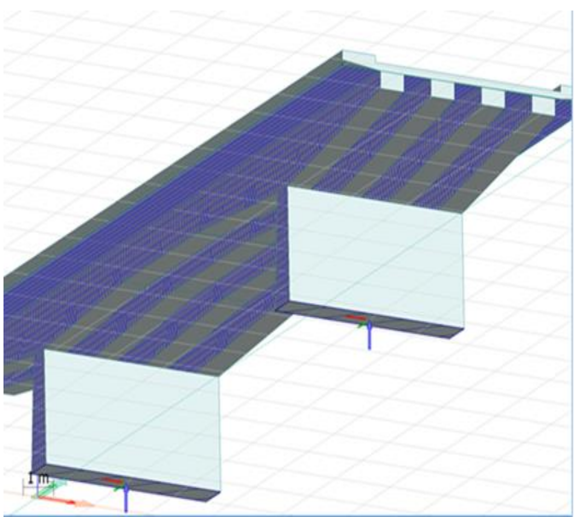

Figure 3 FE Model of the Bridge

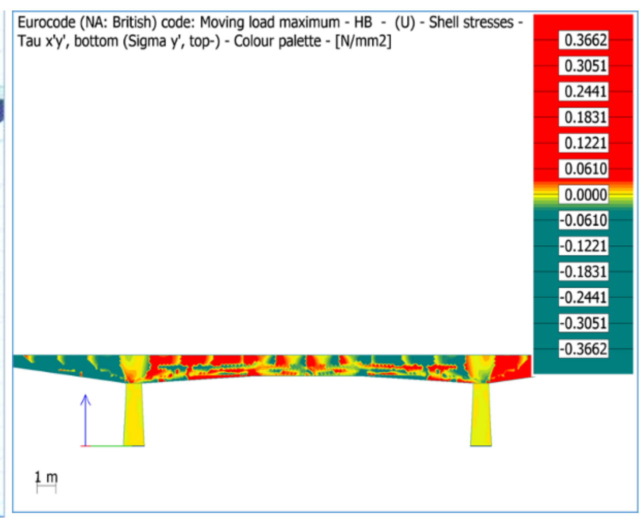

Figure 4 Moving load maximum shell stresses

As crack analysis is a non-linear approach, the principle of superposition is not valid. Therefore, crack analysis is not applicable for load groups and the computations have to be executed for every single combination. (Ferenc Nemeth 2015).

2.4 Moving load (dynamic) analysis

30 Units of HB in one notional Lane was introduced as moving load on the bridge at a constant speed of 30km/hr, in order to investigate the dynamic behavior of the bridge.. Figures 5 and 6 give an indication of the maximum shell stresses and influence lines due to moving load, respectively. Table 4 summarises the moving load models.

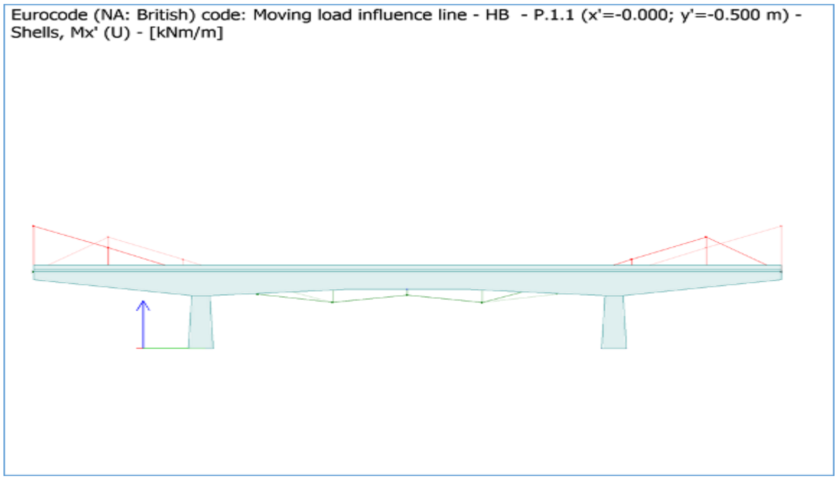

Figure 5: Maximum shell stress under moving load

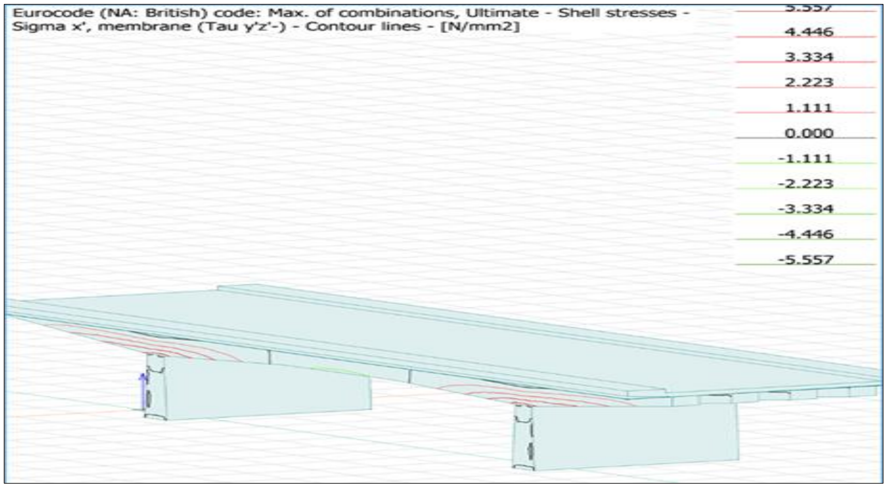

Figure 6: Influence line for moving load

Table 4: Moving loads

No.	Name	Vehicle	Return	Lock direction	Cut loads to path extent
1	HB	EC LM1 Lane 1. (Truck) [Distributed]	Yes	Yes	No
2	Moving Load	EC LM1 Lane 2. (Truck) [Concentrated]	Yes	Yes	No

2.5 Periodic monitoring and experimental tests

Periodic monitoring was conducted monthly over a period of four months, from 3rd July 2017 to 3rd October 2017. An integrated microscopic crack width detector was used to identify cracks upon scanning and it provided self-automated crack width measurements within its band width. Microwaves where projected at distressed member locations with a high resolution Probe Cam that sends measured cracks to a screen/Tablet via Bluetooth and Wi-Fi. This is a remote sensing technique which can be conducted within a radius of $30m^2$.

Figures 7 and 8 show field SHM in progress. An ultrasonic detector was used to determine depths of cracks. Testing was conducted on highly distressed areas, as predicted from the FE model. These nondestructive tests were conducted at intervals of 30 days. Figures 9 to 11 show results on the four Girders at support ends.

Figure 7: Field SHM in progress (2017)

Figure 8: Field SHM in progress (2017)

3. Results and Discussion

The NDT/E technique was employed to determine the strength of concrete, rebar diameter, spacing and cover to reinforcement, as-built drawings/details for the study bridge (Nansenga Bridge) could not be located. The design review results were consistent with most of the collected field data.

The 3 span bridge was loaded with 30 kN/m HA UDL + KEL on all spans in one notional lane and 45 units of HB on another notional lane on the most severe point as indicated by influence line. Grillage analysis was used to design the bridge using PROKON 3.0, considering the girders as T beams. Scanned tensile and compressive reinforcement on longitudinal beams corresponded with calculated values using PROKON. Shear reinforcement was detected at beam-pier supports and cover to reinforcement averaged 72mm, more than the 50mm allowed for in the design code BS 5400. Figures 9 and 10 present bending moment distribution diagram and long term elastic deflections from the analysis.

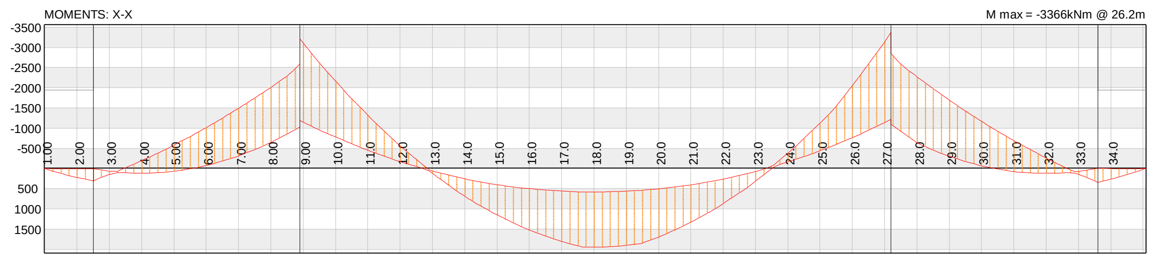

Figure 9 Moment distribution diagram

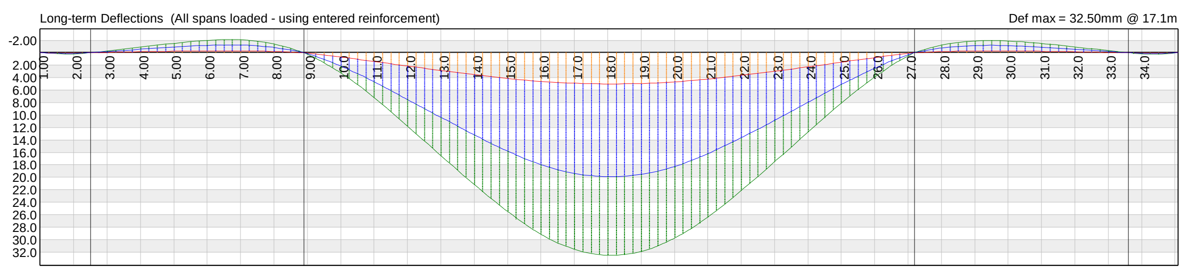

Figure 10 Long term deflections

3.1 Finite element modeling

As specific objective of the study, a finite element model was developed to correctly represent global bridge behavior and accurately predict strains, stresses, and displacements in the deck. Dynamic, fatigue, and thermal analyses were conducted.

The finite element model was validated with the field data which was verified by the design review. The reinforced-concrete bridge was modeled using triangular and quadrilateral shell elements with 4/3/2 nodes. Stresses at various points through the thickness of the elements were determined due to moving load and static uniformly distributed load, as Euro Code EC1 part 3. Concrete plane plates were used to simulate typical reinforced-concrete bridge s piers, beams and deck. The FEM design 17 employs a plasticity-based constitutive model that simulates cracking, tension stiffening and shear capacity of cracked concrete.

Second-order analysis of structures based on the linear theory means that the equilibrium conditions are determined according to the shape of the structure before loading. In this research, however, deformations during the loading were only taken into consideration in the relationship of membrane forces and bending moments. In reinforced concrete, normal forces influence the bending moments because of the deflections perpendicular to the rebar and modify the deflections.

The model revealed that flexural shear cracking was first observed as the moving load under load combination ULS (LM1) distributed (938 kN/m^2) was introduced. Cracking propagated laterally in the X and Y directions as the applied load increased, with wider cracks occurring parallel to the X direction. The FE model indicated initial cracking with the moving load. Table 5 presents the analytical predictions of cracks due to high stresses at the top and bottom**.**

Table 5: Analytical crack prediction

ID	**Elem**	**Face**	**Width 1 mm**	**Direction 1 rad**	**Width 2 mm**	**Direction 2 rad**	**Load Combination**
P.1.1	1	bottom	0.000	0.548	0.000	2.119	Dead load + super imposed + HB live load
		top	0.000	0.724	0.000	2.295	Dead load + super imposed + HB live load
	11	bottom	03	2.384	0.000	3.955	Dead load + super imposed + HB live load
		top	0.213	2.418	0.111	3.988	Dead load + super imposed + HB live load
	12	bottom	0.34	0.491	0.412	2.061	Dead load + super imposed + HB live load
		top	0.311	0.477	0.288	2.048	Dead load + super imposed + HB live load
	13	bottom	0.294	1.095	0.237	2.666	Dead load + super imposed + HB live load
		top	0.311	1.074	0.241	2.645	Dead load + super imposed + HB live load
	14	bottom	0.000	0.859	0.000	2.430	Dead load + super imposed + HB live load
		top	0.000	0.822	0.000	2.393	Dead load + super imposed + HB live load
	15	bottom	0.000	2.283	0.000	3.854	Dead load + super imposed + HB live load

3.2 Experimental Tests and Periodic Monitoring

With the use nondestructive wireless equipment, attention was paid to predicated areas of high distresses and cracking regions. The measured cracks corresponded with the FE analysis. At the supports, flexural shear cracks were detected, with increasing crack widths from top to bottom on both cantilevered beams of the bridge. The cracks, monitored over a period of 3months, exhibited a maximum progressive growth of 0.185mm/month on Beam 01 whilst Beam 02 had a growth of 0.102mm/month. Crack width ranged from 0.397 to 0.513mm on beam 02 (Figure 11a,b,c), 1.391 to 1.748mm on Beam 01 (Figure 12a,b&c) . These values exceeded the safe allowable maximum crack widths of the design codes of 0.25mm Euro Code and 0.3mm British code.

The depth of cracks was investigated with an Ultrasonic pulse velocity detector. Crack depths were measured at each crack. A maximum crack depth of 212.63mm was detected on Beam 01 while on Beam 02 it was 94.4mm. Figures 11 to 13 show the crack widths detected.

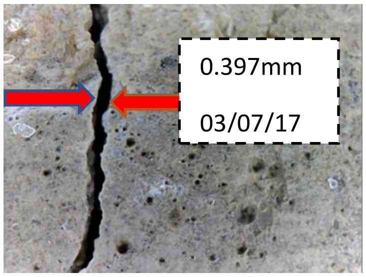

Figure 41a beam 02

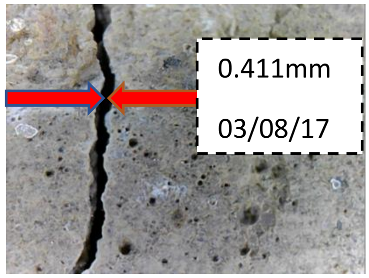

figure11b beam02

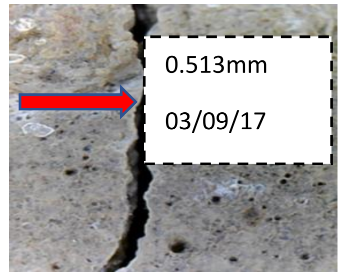

Figure 11c beam02

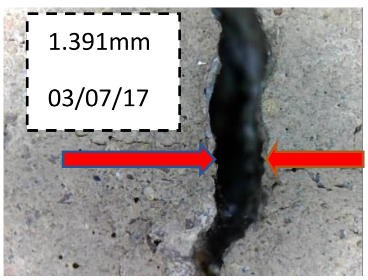

Figure 12a beam 01

Figure 12b beam 01

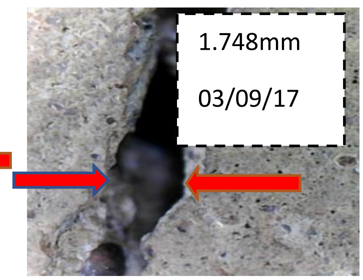

Figure 12c beam01

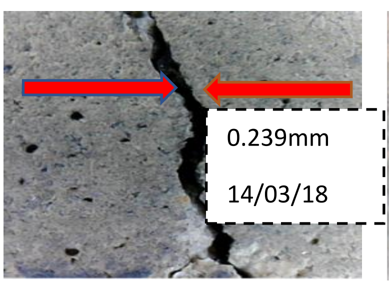

Figure 13a

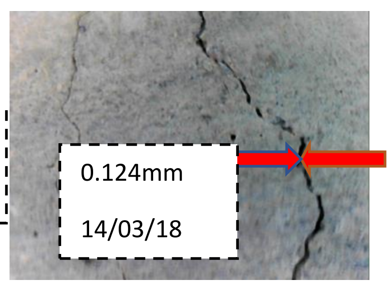

Figure 13b

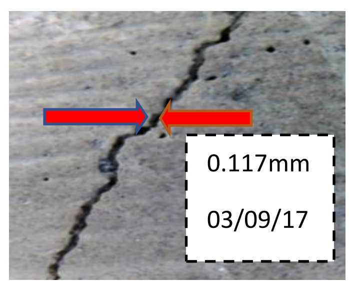

Figure 13c

4. Conclusion

Use of NDT/E combined with Finite Flement modelling produced accurate results for structural health monitoring of a bridge, in the absence of as-built structural drawings. The use of NDT/E equipment (GPR,UPV) to collect data provided adequate guidance during a design review. On the other hand, the design review guided and verified data collected by NDT equipments. This enhanced correct data input in the finite element modelling.

The finite element analysis predicted a true behaviour of bridge elements (piers, beams and deck), when subjeted to various loading conditions. Distressed and cracked regions were well predicted. This was confirmed by measurements of flexural shear cracking of beams at points of maximum moments.

The width of cracks detected on girders exceeded allowable crack widths in the British and Euro codes, which limit the maximum crack widths to 0.3mm and 0.25mm, respectively. Crack widths of more than 6 times the maximum limits were observed on the cantilivered beam. Similarly, the excessive crack depths of 94 to 212mm have excessively reduced flexural and shear capacity of the bridge, which could lead to structural failure, if not attanded to urgently. This rapid detorioration of the bridge must have resulted from increased traffic and high impact loads at the bridge deck-abutment interface. Further, due to poor maintenance, the potholed bridge surface leads to further impact loading.

5. Recommendations

Based on the findings, the following remedial measures must be considered on the Nansenga Bridge:

- Repair of the bridge deck by strengthening the members, through application of carbon fibre reinforcement polymers;
- Repair of the rough surface of the bridge to reduce on impact of traffic loads;
- Introduction of elastomeric bearings between abutments and the bridge deck, to reduce on impact loads at the cantilever end and Abutment; and,
- Introduction of controlled traffic flow, i.e. allowing only one vehicle on the 2 notional lanes, at a time.

In view of the extensive damage, demolition and and contruction of a new bridge is an option worth considering.

Further, the Road Authorities should urgently consider adopting NDT/E and FE modelling to rollout a continuous SHM of bridges in Zambia. Continuous SHM will ensure that Road Agencies make informed and timely decisions on Bridge Maintenance, Management and Replacement.

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Electronic Integration of Urban Public Transport through Automated Payment Systems

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Abstract

Urban public transport services in South Africa are dominant. However, they are not reliable, which leads to customer dissatisfaction. Government at all spheres has introduced innovative formal urban public transport mode as a solution to this challenge. Gauteng province has introduced the speed train (Gautrain) and the Bus Rapid Transit (*A Re Yeng* bus) to develop a reliable and attractive system for commuters. With these innovative systems developed, there is a challenge faced by commuters to connect from one mode to another. Therefore, there is a need to integrate the speed train and the BRT system. Technological innovations such as electronic smart cards are making traveling to be easier. Smart cards are not only means of payment but process huge amount of information which offer a large range of possibilities such as managing, controlling and assisting to increase the capacity of buses and trains on certain location to improve efficiency. Consequently, the use of smart cards to pay fares assists to reduce the stress of carrying hard cash, increase security for travelers and improve safety. The current work therefore investigated the possibilities of how payment systems can promote electronic integration to create short-term travel times forecast in the City of Tshwane. Accordingly, introducing one electronic smart card for Gautrain/Gaubus and *A Re Yeng* to offer efficiency, reliability and integrated urban public transport system is important. The study adopted a qualitative approach to extract, analyse and present data. Content and documented analysis were used to collect information from several sources. Preliminary results reveal that commuters have separate smart cards to board the Gautrain and *A Re Yeng* systems. Further, commuters do not switch smoothly from *A Re Yeng* to Gautrain, which causes delays. The study concludes by acknowledging the important role of smart cards in urban public transport as it serves both the authorities and the commuters. The study recommends that integrated smart card system be deployed. This could attain high accuracy in data collection to assist authorities, reduce delays and produce sufficient information-efficient urban public transport to connect people to different land uses.

Keywords: automated fare collection, integration, payment systems, smart card, urban public transport

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1. Introduction

Globally, the reliability of urban public transport systems is constantly under review. In recent years, the widespread dominance of privately owned cars and people's quickening pace of life has increased the importance of public transport service reliability and on-time performance. Reliability is one of the most important operational attribute of urban public transport services. Dorbritz et al. (2009) discussed the importance of punctuality in timed-transfer type systems; small delays in arriving at timed-transfer points can lead to a missed connection for commuters. In the centre of attention are the commuters who require simple, fast and reliable urban public transport. Integrated smart card collection of fare system and transparent integrated urban public transport system is a solution. The questions are whether the modern fare collection systems meet the requirements of commuters and also whether commuters switch smoothly from one mode of public transport to the next. For these reasons, the aim of this article was to examine the current fare collection system in the City of Tshwane of both *A Re Yeng* (BRT) and Gautrain/Gaubus and investigate the possibilities of integrating the two modes of urban public transport through the use of one integrated smart card payment systems.

2. Literature Review

According to Yap et al. (2018) in many developed counties, urban public transport authorities has introduced Automated Fare Collection (AFC) systems to collect public transport fare. AFC systems, require commuters to have a smart card to board in urban public transport. Commuters are required to tap in and out when using this payment system for travelling. The data collected from the smart card systems is used for many purposes by scientists and practitioners on a strategic, tactical and operational level (Pelletier et al., 2011). The objective of AFC systems is to create a new method of revenue collection, and large amounts of data are collected which assist public transport operators with the travel behaviour of the commuters. Data from AFC systems can also be used for destination interpretation especially when switch in-between are done by commuters (e.g. Tr_epanier et al., 2007; Nunes et al., 2016), transferal reading (e.g. Hofmann and O'Mahony, 2005; Jang, 2010) and journey reading to assess the origin-destination (OD) conditions (e.g. Seaborn et al., 2009; Wang et al., 2011; Munizaga and Palma, 2012; Zhao et al., 2007; Gordon et al., 2013). AFC systems also allow integration of smart card of different urban public transport operators (e.g. Nij€enstein and Bussink, 2015), and grouping different urban public transport stops in order to identify locations that need more attention in regard to capacitate those areas with activity centres based on smart card data (Cats et al., 2015). The availability of smart card data from public transport travelling the last decades allows analysing current and predicting future public transport usage.

2.1 Technology of fare collection in integrated transport system

According to Olivkova (2017) Check-in system is a key interface between the carrier and the passenger. This term is associated with tariff and conditions of transport, used in the sense of realization fare collection, points to the organization of getting in and out of the public transport vehicle, and the definition of paid transport space within the stations. It also defines a method of selling tickets and their validation, produce a valid travel document to authorized ticket inspection personnel. The check-in system must be primarily supported by appropriate distribution of tickets, by their suitably wide range, by clearing system, by information system, by the benefits of fare collection system for individual transport operators etc. (Křivda et al., 2009). Check-in system directly affects how the passengers perceive transport system and its services. It is reflected in the final quality of the service, which can be detected in a survey of passenger satisfaction or other suitable methods (Olivková 2016). Optimal setting of these factors can bring improvement of urban public transport services and thereby positively contribute to the increase of new passengers at the expense of private car traffic. This is one of the fundamental goals of integration in public transport. A Common global approach in the development of integrated multimodal transport systems has been fare and ticketing system integration (Luk and Olszewski, 2003; Garcia and Azan, 2005; Hidalgo, 2009). Fare system integration has been shown to facilitate "seamless" transfers and thus encouraging the use of transfer routes (Sharaby and Shiftan, 2012). Integrated ticketing systems must satisfy two main requirements to become integrated (a) no additional cost for transfers, and (b) all modes and services to use the same ticketing system (Sharaby and Shiftan, 2012). Smart cards have been widely used to enable fare and ticketing integration, as they allow users to efficiently board and egress any type of service (Luk and Olszewski, 2003; Grotenhuis et al., 2007). Numerous European countries use integrated payment systems. In Belgium, Brussels's STIB offers integrated pricing and ticketing, Bilbao's Creditrans is an integrated ticket, Helsinki public transport pricing is an integrated fare system (Meghazi, 2008).

2.2 Integrated urban public transport

People are encouraged to use urban public transport instead of their private motor vehicle (Rabl and deNazelle, 2012). Globally, policy makers have included integrated urban public transport in their policies. Government authorities are investing in new infrastructure to improve the quality of urban public transport services (Vassallo et al., 2012). Many Cities around the world already implemented urban public transport but it is not integrated, and to integrate urban public transport in these cities it would be difficult. Factor such as spatial integration should be considered. Development of such system, certain steps need to be followed. Further, it is significant to understand what the commuters need for the system to be attractive.

It is crucial that urban public transport is properly planned as it advance and provide better access to all individuals. It allows access for every individual to travel to their place of interest without any limits (Chowdhury 2018). In developed countries, government and transport agencies are integrating formal urban public transport for efficiency and to reach all individuals. Nevertheless, regardless of some improvements in these spaces, the knowledge acquired in regards to commuters and how this supports the policy makers' views of an integrated system is inadequate. This understanding is critical to attract more commuters to use public transport.

Importance of integrated urban public transport system is to deliver to commuters a system that has alternative that does not limit they are desired travel routes and also with an appropriate, accessible, efficient, safe, effective and reliable system (Ibrahim, 2003; Luk and Olszewski, 2003; Ulengin et al., 2007). Numerous researches have revealed that integrated urban public transport systems can draw more users. Ibrahim (2003) stated that in Singapore, where urban public transport use is considerably high at 60% of mode share, the government aimed to increase the mode share to 75% through integration. Matas (2004) examined the important rise of urban public transport use (>40%) in Madrid, Spain from 1986 to 2004 and got the reason to be the changes made for integration. The research showed that integrated urban public transport fare system and network integration had high influence on the use of public transport. Buehler (2011) piloted an assessment study between USA and Germany and indicated the use of urban public transport in Germany to be greater; 40% of German travellers used sustainable modes (8% for public transport) while only 11% of American travellers used sustainable modes (2% for public transport). One of the reasons given was better integration of urban public transport services in Germany. Abrate et al. (2009) assessed the impact of fare integration on the ridership of services from 69 Italian operators. The effects of integrated fare systems on patronage were 2% in the short-run and 12% in the long–run.

3. Research Approach

The objective of this paper was to examine the current fare collection system in the City of Tshwane of *A Re Yeng*, Gautarin/Gau bus and investigate the possibilities of integrating the two modes of urban public transport through the use of payment systems. A Qualitative case study research design was employed. Research instruments used are interviews which are crucial as they allow views of key stakeholders (Commuters and Authorities of both Gautrain and *A Re Yeng*) and participant observations as it is critical for authors to analyse the conditions through own views. Sources of data are Gautrain/ Gaubus, *A Re Yeng* commuters, officials and the journal articles as they critical to review previous studies related to the one conducted. Content analysis highlight the current payment systems and future improvements on payment system to develop a well-functioning public transport system, and correlation analysis highlighting the relationship of payments methods between Gautrain and *A Re Yeng*.

A random sampling was used to interview commuters to get different views that are not biased and a purposive sampling was used to interview Officials (Gautrain/Gaubus and *A Re Yeng*) in order to acquire professional and most relevant data. Thirty interviews conducted with current users of Gautrain/Gaubus and *A Re Yeng* in the City of Tshwane. Main questions asked were about the payment systems in regards to Gautrain/Gaubus and *A Re Yeng*. How easy/convenient commuters load money into their smartcards, with the current mode of payment system if they get delayed and when travelling to areas that need them to switch public transport, do they switch smoothly from one mode of transport to the other immediately, what do they use to board public transport, what kind of payment system do they use and is it convenient. Details asked on the possibilities of developing and adopting composite and integrated smart card allowing them to use on both these modes. Such data was analysed to provide guidelines and policy recommendations on rail and road integration purposes. Fifteen interviews were conducted with authorities from Gautrain/Gaubus and *A Re Yeng*. Data collected from these officials was mainly the policies that currently guide their developments, integration strategies and how best they attend to commuter challenges. This assist to provide at the end of the study relevant and up-to-date information that help officials to adjust their policies, plans, targets in line with realities, needs, expectations and preferences of current and potential users of urban public transport.

4. Research Findings and Analysis

The South African community is encouraged, by the government, public transport authorities to use urban public transport especially for regular trips such as the daily commute. However, most of the City of Tshwane private vehicle owners are refusing to use urban public transport, reducing the total number of commuters using urban public transport due to unreliability and lack of efficiency. Lack of reliability for urban public transport services is an important concern for the commuters. Public transport officials suggests that commuters entering and stopping at the designated stations, busses being caught in traffic congestion, are crucial factors to on-time performance of buses at the stop level . Delays and missed connections are a main source of anxiety related to routes involving transfers. The City of Tshwane formal urban public transport Gautrain/ Gaubus and *A Re Yeng* are two different operators. Both these urban public transport modes have the same objectives. These objectives are to move customers from one location to the next efficiently, reliable system and trustworthy. Gautrain/Gaubus and *A Re Yeng* commuters expect these objectives to be fulfilled by both operators. However, users tend to struggle on several occasions to get to desired destinations on time. One of the reasons, Gautrain/Gaubus does not go to certain locations and *A Re Yeng* go to those areas. These UPT modes do not work with one another in any form. Some commuters only have access to *A Re Yeng* only and want to use Gautrain/ Gauteng in a case of emergency but they cannot, as some individual has no money to purchase another smart card at that particular moment and as most daily UPT users load cash monthly on a specific mode that they use to get to work.

Gautrain/ Gaubus officials specified that payment system is done electronically. Automated fare collection is used and customers seem not to have a problem with the system. 90% of Gautrain/ Gaubus commuters interviewed are satisfy with the payment services as there are alternatives for loading money (see figure 1).

Figure 1: Gautrain/ Gaubus payment systems (Authors, 2018)

Further, commuters do switch smoothly from Gautrain to Gaubus. However, 10 % of the commuters that use Gautrain/Gaubus and *A Re Yeng* indicate that they are challenged when switching between the two systems as they have to load money on *A Re Yeng* smart card while they have funds on the Gautrain smart card and on some occasions they get delayed by long queues. 50% of the Gautrain commuters are interested in the integrated smart card as they highlighted that it will be convenient for them when they switch in between and further mention that this can make some of them to start using *A Re Yeng* too as an alternative. The other 50% of commuters were disinterested as they mention that they have never been on *A Re Yeng* and do not use it.

A Re Yeng officials highlighted that the payment system is done electronically which is more efficient and commuters enjoy this method which was developed last year. 70% of the *A Re Yeng* commuters gave a negative feedback, as they indicated that the payment system is on and off meaning that when commuters want to load money on the smart cards, the system is offline which causes them to take an alternative mode forcing them to use informal urban public transport such as taxis and on some occasions queues are long which make them to miss busses that they intended to take. 30% of the commuters highlighted that some of them they load monthly fare and therefore payment system is not a challenge to them. All commuters interviewed agree with the use of integrated smart card as it will allow them to have alternatives of loading money into their cards and when they want to switch in between the systems, it will be easy to do so.

4.1 Gautrain fare collection system

The development of electronic fare collection technologies in urban public transport contributes to customer satisfaction, smoother movement of passengers and increases the efficiency of collection of fare (Olivkova 2017).

Commuters use a Gautrain Gold card to board on both Gautrain and Gaubus. Hard cash is not allowed, commuters enter inside the platform when they use the smart card to tap in and can only leave the platform when they tap out. The Gold card should be loaded with money so it can allow the customer to tap-in. There are counters provided to load money. To avoid long queues for loading money in the smart card, there is an alternative ticket machine provided as shown in figure 1. This ticket machine is a self-service that are only found at the Gautrain stations.

4.2 *A Re Yeng* fare collection

Electronic payment systems are a very efficient way of collecting urban public transport fare. *A Re Yeng* bus also uses the electronic payment method (figure 2) to collect fares; however, it is different from Gautrain/Gaubus. *A Re Yeng* bus also use smart cards to collect the transport fare and there are four types of these smart cards. The first type is Silver card which is used by normal adult class were by rates are charged normally. The second type is for people living with disabilities and students who use a green card and a flat fee of only R7.00 is applicable for all trips on *A Re Yeng*. The third type is purple card for pensioners over 65 years old, the pensioners have discounts when using the bus outside peak hours and also travel free during eligible periods. The last type is a blue card which is used by pensioners between 60- 65 years old, this card qualify for a 25% discount during eligible periods. With this smart card, there are numerous benefits when an individual load more than R60 on the card, they receive more points and those points are converted to a free journey. However, with these modes of urban public transport (Gautrain/ Gaubus and *A Re Yeng*) using smart cards, there is no integrated payment method or card to connect both systems.

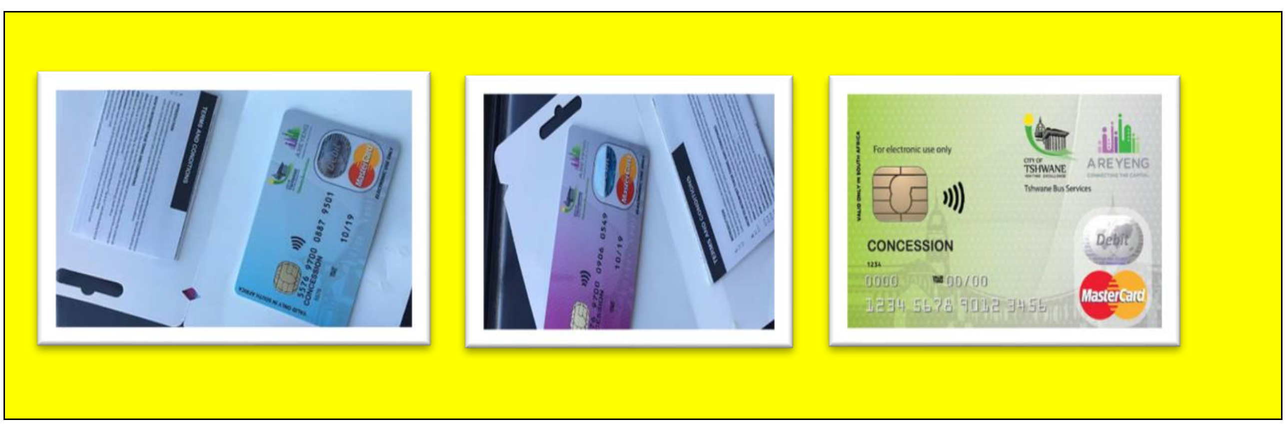

Figure 2: A Re Yeng payment systems (Authors, 2018)

5. Discussion

Gauteng province, department of roads and transport (2013) indicates that urban public transport has an important role in the entire Republic's economy, contributing to poverty decrease by allowing the useful activities that produce active economic growth, and by providing less fortunate people with access to economic opportunities and social services, and a means of participating fully in society. A Gauteng ITS Plan assist with the planning, funding and deployment of ITS technology which will facilitate the integration of urban transportation systems and promote best possible utilization of existing and future transportation networks.

The use of smart cards for payment in urban public transport is a globally system that is mostly found in the developed countries. The introduction of electronic payment systems in urban public transport system has assisted with the availability of great amounts of smart card data, which can be used to analyse current travel patterns and to predict the effect of structural network changes on future public transport usage. The City of Tshwane urban public transport has adopted the same system to manage and operate the payments which is also convenient for customers. Gautrain/ Gaubus use a smart card called Gautrain Gold card for payment system as shown on figure 1 which is separate from *A Re Yeng* smart card. Both operators, Gautrain/ Gaubus and *A Re Yeng* have different benefits for smart card holders. To load the money on the Gautrain/ Gaubus smart card there are counters at all stations and there is an alternative in order to manage long queues as there are machines used by individuals to load money on their cards, securities are found at all station for assistance.

On the other hand, *A Re Yeng* smart card can only be loaded with money on the counter that is found at the station. *A Re Yeng* system use one counter for loading money and this cause delays if there are many customers who want to load money. Since both systems are using smart cards for payment, advancing to an integrated smart card will not need lot of changes or take long process but could assist both operators services to improve. Further, *A Re Yeng* bus system can be strengthen as it has one counter per station. If a commuter want to switch in-between the two modes, it will be less stress for reloading. Fare integration is the possibility presented to commuters to make journeys from origin to destination by using the same amount of money for any mode or the operator used and with all allocated rights amongst the modes and operators. The City of Tshwane urban public transport payment system is not integrated but can be made an integrated fare system. Integration of smart card is the possibility as developed countries urban public transport has demonstrated. To use one integrated smart card to travel from origin to any place of interest by Gautrain/ Gaubus, and *A Re Yeng* is possible. This technique does not stop to apply different fares according to modes or operators. It is important to note that integrated (multi-mode, multi-operator) fare schemes are initiatives taken or at least endorsed by transport authorities to make travel by formal urban public transport convenient. E-ticketing makes ticketing integration easier to implement because it can manage a more complex fare system without necessarily harmonising amongst fares of different operators or modes. Each operator or mode keeps its own single fares and the smartcard acts as a unique means of payment. In addition, the system can include rules for transfer rights in order to be more attractive. Fares integration is no longer a pre-requisite to achieving seamless travel.

6. Conclusion and Recommendations

The aim of this paper was to examine the current fare collection system in the City of Tshwane of *A Re Yeng* and investigate the possibilities of integrating the two modes of urban public transport through the use of payment systems. The findings have showed that both Gautrain and *A Re Yeng* systems use electronic fare collection and the payment systems are separate. Therefore, development of integrated system through smart card payment could bring the element of efficiency on commuter's movement, reduce unnecessary delays and allow an alternative for customers to load money on either platform of the user's choice. If the integrated electronic payment system is developed, this can contribute to strategies and policy recommendations that will promote the development and running of effective, efficient, reliable and well integrated public transport systems (road and rail) that foster socio-economic benefits and spatial transformations, thus providing a conduit to best practices that can be replicated to other provinces and countries within the African continent.

Pricing of journeys should be cheap and remain constant/ fixed fare. Short or long distance travelled by a passenger must not determine the pricing even the switch in between of urban public transport. With this, formal urban public transport will dominate and draw new users. During the day and peak-hour, pricing discounts could be made available. Smartcard users if allowed a one-time ride in case the balance of their smartcard is not sufficient for a ride, the difference will be repaid when they recharge the smartcard. Further, the more use of smart card the user can be credited with more trips. The integrated smartcard user is rewarded with a discount for adding value to their smartcard via the most cost effective channels (e.g. direct debit, internet) as opposed to third party sales outlets and on board. All users of *A re Yeng* smart card holders receive discount on their travel compared to non-permanent users who buy single trips paper tickets. All mentioned alternatives are probably to interest new users and grow their trustworthiness.

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Critical Planning Considerations for PPP Road Project Sustainability: A Case Study Approach

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Abstract

Road transport projects are complex and laden with risks and uncertainties which influence their success or otherwise; even more so, with projects involving the private sector. Private investors decide to proceed with projects based on projections of costs and benefits potentially accruing to a proposed project, which ultimately reflect the success or failure of the project. However, the risks associated with roads delivered through public-private-partnerships (PPP) are grave and if strategies are not put in place to reduce or mitigate the chances of their occurrence, the expected performance of the projects may not be realised. The current paper aims to identify critical feasibility considerations to ensure sustainability of PPP road projects. A thematic content analysis of extant literature and case study illustrations was undertaken. Journal and conference articles were sourced from databases including Academic Search Complete, ASCE Library, Google Scholar, Scopus, Taylor and Francis, Google and Science Direct. Findings revealed that joint decision-making and concessionaire selection procedure and considerations were the most important feasibility factors for PPP road projects sustainability. These factors should be taken cognisance of at the feasibility stage to ensure that mechanisms are put in place in order to realise expected project performance.

Keywords: public-private partnerships, road infrastructure, sustainability

1. Introduction

Road projects, like any other infrastructure developments, go through certain development stages including pre-planning, implementation, and operation and maintenance stages and each of the stages has specific purpose and objectives (Khmel and Zhao, 2016). Road project life cycles are unique in the sense that they do not have a definite end in time and are not disposed of easily; instead they undergo a continuous process of change as their individual components wear out and are replaced with new materials in the maintenance phase (Liljenström, 2013). This unique feature

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underlies the importance of sustainability of procurement and financing structures for maintenance and operational activities. Moreover, procurement and financing structures and considerations defined at the planning stage allow for successful partnership and eventual continued operational success of the projects (Rebeiz, 2012; Gupta *et al.*, 2013). Consequently, public-private partnerships (PPPs) have been advocated as a panacea to ensuring sustainability of road infrastructure developments through their long life cycles.

Public private partnerships (PPPs) have been used for over four decades predating the contracting out initiatives of the 1970s in the USA (Buertey and Asare, 2014). It has since been widely adopted to accelerate the delivery of a wide range of key infrastructure projects, including road projects (toll ways), for instance, the Gauteng Freeway Improvement Project in South Africa and the Maputo Development Corridor's N4 toll road project (Farlam, 2005; Brits, 2010). Increased traffic demand as a result of economic growth and wider acceptance of the user pays principle are reasons that ginger PPP adoption in the transport sector (Pantelias and Roumboutsos, 2015).

However, despite the din advocating the adoption of PPPs, the private and public sector partners have a bleak record of delivering on large infrastructure costs and performance promises, including road infrastructure (Flyvberg et al., 2009). For instance, in Germany, a new tolling system in 2003 that was meant to showcase efficient PPP road management failed, resulting in an estimated loss of €6.5 billion in toll revenues (Flyvberg et al., 2009). Another example is the M1/M15 toll motorway in Hungary, cited earlier whose traffic volume was 40% lower than forecasted (Cuttaree, 2008). Consequently, the concessionaire was unable to service its debt and the government had to take over the concession at a high cost. In addition, the South African N4, Maputo corridor toll concession's lack of information and openness resulted in the tolling process impacting negatively on local perceptions of PPPs and many residents were outraged that placing tolls on the N4 will hinder access to opportunities and schools, jobs and the main shopping centres in Nelspruit (Brits, 2010).

Nevertheless, a recurring theme is that for PPPs to be successful, governments need to undertake thorough feasibility studies to identify, assess and address the risks and develop strategies to manage them such as risk transfer (Farlam, 2005). This tends to suggest that the risks inherent in PPP arrangements are surmountable given adequate attention to the factors that underlie the sustainability of the structures. More especially, given the long duration of concession periods, emphasis should be on the arrangements proposed (at the planning stage) for the operational phase. Procurement and financing structures are critical because if defined at the initial stages of a project, the continued viability of the projects in terms of financial returns and operational sustainability will be affected.

Most previous studies on PPP and sustainable road delivery have focused on incentives to promote public participation and investment. For instance, Feng et al. (2015) focused on the role of government guarantees in toll road delivery (toll charge, road quality and capacity) as a means of incentivizing private investors, irrespective of actual demand. Tan and Yang (2012) explored the usefulness of flexibility in PPP contracts under demand uncertainty. However, demand is not the only risk that threatens the sustainability of road projects and thus Tan and Yang's focus is somewhat inadequate. Glaister et al. (2010) revealed that a performance contract that incentivizes effective delivery and good operations will ultimately contribute to the reduction of risks associated with private sector participation in infrastructure development. However, this study did not include projects in Africa and cannot really be generalized since environments and stakeholders' interests differ in geographical locations (Pârvu and Voicu-Olteanu, 2009; Glaister et al., 2010). More recently, Nnaji and Okoro (2016) focused on success factors for PPP in transport delivery. However, few studies have related the feasibility analysis of these optimal procurement and financing strategies to the sustainability of road projects funded through PPPs. It can be argued that the sustainability of road infrastructure projects cannot be realized if plausible trajectories and enabling conditions to sustain cash flow and revenue source are not adequately addressed at the feasibility stage. Moreover, the financial burden of maintenance and operational activities lies on the cash flow from the road investment while in operation.

The objective of the current study is to identify critical factors that should be considered at the project feasibility stage in order to sustain road infrastructure delivery using PPPs. Furthermore, a study in Africa is necessary to ascertain whether the factors are relevant and applicable to the region given that PPPs differ according to the location or country. The methods adopted to conduct the study, as well as the findings are presented hereafter.

2. Methods

The current study was conducted through a detailed review of extant literature and a thematic analysis. The search for literature for the current study started by listing the relevant key words and phrases, namely, on PPPs and sustainable road delivery and using them in conjunction with feasibility studies, procurement and consideration. The approach adopted for the study was a desk study. Databases used included Academic Search Complete, ASCE Library, Google Scholar, Scopus, Taylor and Francis, Google and Science Direct. A simple matrix was conducted to determine which keywords and phrases led to relevant literature. Materials were selected only if they met the following criteria: possession of any of the keywords; articles published in the last 12 years (since 2005). Each piece of literature was reviewed and synthesized to determine the focus, context and key findings. Thematic analysis was thereafter used to identify emerging themes from eighteen articles specifically focused on PPP sustainability factors for road infrastructure delivery. Thematic content analysis identifies, analyzes and interprets patterns of words (themes) used in textual data (Vaismoradi et al., 2013). The relationships between the works and views of authors are highlighted to reveal the consensus in the literature (Avni et al. 2015). The PPP sustainability considerations, from the thirteen articles, are tabulated and the frequency of occurrence in the sampled literature is evinced and this reflects the level of consensus among the sampled authors regarding the factors.

Following the thematic content analysis, two projects that exemplify the successful application and sustainability of PPP in road transport infrastructure in Africa were identified and discussed in order to extract critical sustainability factors.

3. Overview of PPPs

Public–private partnerships (PPPs) are arrangements whereby private parties participate in, or provide support for, the provision of infrastructure, using their skills, expertise and assets, and thus resulting in a contract for a private entity to deliver public infrastructure-based services (Pârvu and Voicu-Olteanu, 2009; Hueskes, 2017). The World Bank (2014) defines PPP as:

> *"…a long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility, and remuneration is linked to performance".*

The preceding definition encompasses new and existing assets. The concept of PPPs is suggestive of the existence of voluntary agreements, outsourcing or contracting out, public interest in the provision of service, service level agreements (Suđić et al., 2013). These arrangements in road transport infrastructure projects thus involve parties who have a binding agreement and obligation to provide road infrastructure assets and manage the services thereof for the welfare and to the satisfaction of the users, throughout the infrastructure life cycle.

Public–private partnerships can differ widely in different countries depending on cultural, economic and social context and therefore any model adopted should be applicable to the situation and particular environment (political, financial and otherwise) (Pârvu and Voicu-Olteanu, 2009; Glaister et al., 2010). According to Burger and Hawkesworth (2011), Buertey and Asare (2014) and Shen et al. (2016), PPPs are of a wide variety, depending on the ownership of capital assets, extent of involvement and responsibilities of the private partner or the investment distribution, the amount of risks undertaken, duration of contract and the conceptualization of the project. For instance, the private partner may undertake to be responsible for the design, financing and/or ownership. This suggests that with some procurement models, ownership reverts to the public sector, a view supported in Buertey and Asare (2014). Thus, different variations exist depending on the level of involvement of the private partner and the nature of the contract (reversal of ownership at the end of tenure). Such forms include the *Design-Build-Operate (DBO), Design, build, finance, operate and manage/maintain (DBFO, DBFOM),* B*uy/lease, build and operate (BBO), Design, build and operate and transfer (BOT)* (Burger and Hawkesworth, 2011; Buertey and Asare, 2014).

However, although PPP models are varied, they have unique characteristics. In their studies on the adoption and sustainability of PPPs in infrastructure investments in Romania, China and Belgium, Pârvu and Voicu-Olteanu (2009), Feng et al. (2015) and Hueskes et al. (2017), respectively, used document analysis and case studies to identify various attributes of PPPs, stating that they:

- are contractual agreements between a public agency (or government – federal, state, or local) and one or more private sector entity;
- are long-term in nature (typically about 20-40 years);
- transfer general responsibility of service delivery to a private company;
- transfer certain risks to the private sector;
- focus on the specification of project outputs rather than project inputs; and
- integrate or “bundle” different functions into a single contract such as design, construction, financing, maintenance and/or operation.

These unique characteristics of PPPs exist in infrastructure projects and taking cognizance of the associated risks during planning contributes to ensuring sustainability of the subject projects.

3.1 Assuring sustainability of road transportation infrastructure through sustainable PPPs

Risks that can occur in the life cycle of road infrastructure project include common and PPP-specific risks. The common risks that arise, regardless of the structure of ownership, financing and operation are technical, engineering design, construction risk, cost escalation, revenue (demand and price volatility), force majeure, political, environmental and operating risks (Farlam, 2005; Pantelias and Roumboutsos, 2015). The PPP-specific risks are related to the type of PPP implemented, the scope of and country of development (Glaister et al., 2010; Pantelias and Roumboutsos, 2015). PPP road projects have to contend with pre-investment risks; however, operation phase risks are equally a concern if not more, because the projects have to be sustained to be able to perform as expected and desired. Such operation phase risks include cost overrun (high operating costs), quality performance, revenue, competition and network risks. These have to be assessed at the planning stage in order to make provisions and decipher strategies to manage the risks at the operation stage, especially since some of these risks are difficult to assign a priori (Pantelias and Roumboutsos, 2015). This underlies the importance of feasibility studies that include evaluation of possible configurations of procurement and financing structures and especially considerations to ensure that they are sustained throughout the project.

Having PPP models that bundle infrastructure design, construction, finance and operation into a single long-term contract with a private concessionaire encouraged as a way to transfer risk from the public to the private, increasing accountability and ultimately, assuring performance (Siemiatycki, 2010). In addition, the bundling of various functions into one long-term contract could make it in the interest of private partners to take life-cycle costs into account, since it provides an incentive to think, “beyond the design stage and build in operational and maintenance costs which may cost more initially but result later in lower operating and running costs, and so deliver cost effectiveness over time (Hueskes et al., 2017). Incentives for low cost construction are thus aligned, thereby minimising lifetime costs of operations. In this sense, sustainability goals can be achieved.

3.2 PPP sustainability factors for road infrastructure delivery

As earlier stated, PPP-specific risks relate to the type of arrangement, country (political) and size of project. Therefore, PPPs can succeed given certain conditions and appropriate circumstances with regard to governance strategies and the objectives of the partnership (Liyanage et al., 2015; Hueskes et al., 2017). Hence, PPP governance and partnership factors which can influence the sustainability of road infrastructure, including risk sharing, bidding, decision-making, and so on, are identified and discussed hereunder.

3.2.1 Private partner selection considerations

Considerations here have to do with the bidders and negotiations and legal adherences during the tendering process as well as specification of penalties for non-compliance at any stage of the road infrastructure development process (Liyanage et al., 2015). The procurement process to short-list and select concession companies, termed special purpose vehicles (SPV), to construct, manage and operate the road projects should be open, competitive and involve state-owned development institutions (Carter, 2015; Liyanage et al., 2015). This will ensure that the public sector has enough control to supervise the services, safeguard public interests and justify investments in a particular project over other priority areas (Levitt and Eriksson, 2016). In addition, the SPV concession must be owned and governed by its initial investors for an extended time period, including design, construction and a ramp-up period of several years of operation and maintenance (Levitt and Eriksson, 2016). Moreover, selection of experienced and committed concessionaire is vital in ensuring performance of road networks (Carter, 2015). This is because committed concessionaires will likely be concerned about the welfare of the users in addition to recouping their capital.

3.2.2 Appropriate risk and benefit allocation

Consideration of how much risks have been transferred to the private sector or borne by the public sector, for instance, lower traffic demand or non-repayment of debt or cost recovery is important (Feng et al., 2015; Liyanage et al., 2015). Benefits achievable by or accruable to the partners, on the other hand, also need to specified early on in the contract depending on measurable, achievable, realistic and time-bound objectives (Liyanage et al., 2015). Concurring with these views, in a case study analysis of a PPP mechanism adopted in the provision of an expressway in China, Shen et al. (2016) stated that a risk-based concession time period should be used in developing a PPP contract so that the benefits will be commensurate with the risks to various parties in the project.

3.2.3 Clearly defined or unilaterally specified responsibilities, control, rules and procedures

The concerned parties need to be clear on specification of deliverables, reference design or rigid tender specifications, minimum standards for condition of infrastructure, roles and responsibilities of different parties involved, performance targets, penalties for non-compliance, and procedures for amendments, dispute resolution or termination, renegotiations (if any) (Liyanage et al., 2015). For sustainability of road quality and thus asset value, specification of the standards for infrastructure maintenance is paramount. The division of responsibilities of the private and public partners should be governed in an elaborate and precise performance contract stipulating the responsibilities of the parties in operation and maintenance of the road infrastructure assets (Levitt and Eriksson, 2016). This will also assist in establishing boundaries of control by both parties and providing monitoring and efficient road transport infrastructure management while in operation.

3.2.4 Choice of source of finance considering cost

The sources of finance as well as the cost of obtaining such finance for road projects need to be considered in road project developments. The funding of road infrastructure projects implemented under PPP conditions can be done on the basis of project financing. Project financing simply refers to the financing of projects depending on project cash flows for repayment, as defined by the contractual relationships within a subject project (Khmel and Zhao, 2016). It entails lending against future cash flows of a project that is legally and economically self-contained and lends itself to governance by a SPV (Pantelias and Roumboutsos, 2015). Project finance is usually used to raise money from banks on a limited or non-recourse basis to fund capital-intensive projects while providing a lower risk-adjusted cost of capital than other forms of corporate financing (Finnerty, 2013; OECD, 2014).

Toll roads are usually financed through these non-recourse loans that are secured against future toll revenue only and with no other collateral and so the repayment of loans depends on precise traffic estimates and revenue obtainable from the users (Welde and Odeck, 2011). Financing new infrastructure through user fees is increasing worldwide and cost recovery for a private investor is only possible through toll roads or user fees. Traffic forecasting is complex and adding tolls increases the uncertainties in cost recovery (Welde and Odeck, ibid.). Moreover, the financial burden or responsibility of maintenance lies on the cash flow from the road investment while in operation, as evinced in Figure 1.

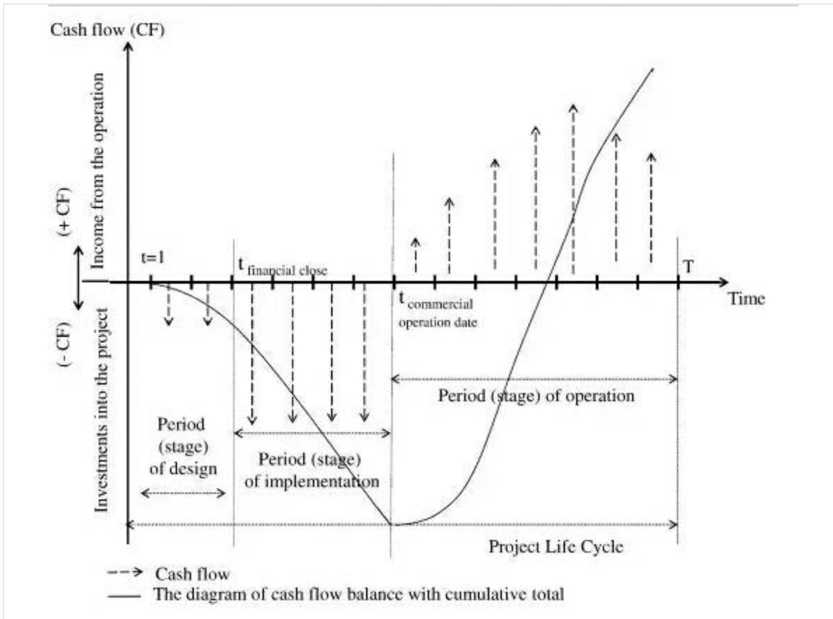

Figure 1: Cash flow projections in the life cycle of a typical PPP project (Source: Khmel and Zhao, 2015)

During the design and implementation stages of the project, the sponsor's own funds invested as capital (corporate financing, that is, from the investor's own balance-sheet resources), as well as debt and/or budget financing are sufficient for activities at these stages; whereas, the constant cash flows generated in the operation phase are used to pay off debts and generate revenue (Khmel and Zhao, 2016). In addition, discounts and medium term notes and letters of credit may also be used for payment during the operation period, but for capital investments along the line such as capacity expansion, capital market instruments including bonds and shares may be used. It is also important to define the cost of a particular source of finance, especially in cases where debt represents the entire capital of the project, but borrowers require capital (necessary (Khmel and Zhao, 2016). In other words, the financial resources available to an investor are defined by their nature (credit and/or equity), with the distinction drawn from whether priority claims in corporate finance or residual claims in project cash flows are received (OECD, 2015).

3.2.5 Incentivising private consortia

Planned managerial actions in the planning stage should be put in place to mitigate occurrence of risks. The private sector can be incentivised via risk transfer and guarantees based on expected functional output specifications (Liyanage et al., 2015). Risk transfer by means of non-financial contract is widely used as a means of managing risks in project finance in the event of poor cash flows from the investment (OECD, 2014). Transferring risks means "to shift risks from some participants in the project to others, assuming they will manage the risks better and that the risk level will be lower (Suđić et al., 2013). In addition, if risks occur for instance, benefit shortfall from underestimated demand for the road network services (that cannot be controlled), some form of indemnification or guarantee can be paid to the SPV or private sector partner (OECD, 2014). These contingencies should be worked into the contracts at the onset. For instance, government guarantees have been used to attract private investors' participation into build-operate-transfer (BOT) road projects (Feng et al., 2015). According to Feng et al. (ibid.), different types of guarantees influence the quality, charge and capacity (demand) of road projects. For instance, a minimum guarantee increases toll charge while decreasing road quality and a price guarantee decreases toll charge and increases road quality and capacity. In addition, a contract with flexibility, whereby the parties agree on ex post optimal adjustments according to the observed demand curve, could be used to assure an investor of a secure investment (Tan and Yang, 2012).

Concurring with these views, Zhang and Chen (2013) opined that concessions should be maneuvered to provide the concessionaire with necessary recourses against decisions of the financial regulator and incentives to continuously improve efficiency, cost-effectiveness and quality of service, attract private funding, technology, knowledge and expertise and good performing concessionaires can be reconsidered during periodic rebidding based on record of good operations.

3.2.6 Loyalty and trust

According to Christina et al. (2016: 905), trust is a social and psychological construct which is used to define the nature and quality of relationships between actors in a system and reflects the extent to which one party is willing to accept another's vulnerability in a relationship based on beliefs about honesty, fairness and altruism of another. It is a psychological state which includes the intention to accept vulnerability, based on positive expectations of each other's intentions or behaviour (Lousberg and Noorderhaven, 2014). Trust between partners in a PPP relationship is regarded as one of the most critical factors for the success or sustainability of road projects especially in the event of a more hands-off approach by the government (Lousberg and Noorderhaven, 2014; Hueskes et al., 2017). However, it is linked to interests and the level of transparency. Transparency necessitates an open approach to decision-making, which allows for the establishment of a mutual trust between partners in a PPP (Zhang and Chen, 2013).

Trust is fostered by personal contacts, the sharing of meanings and perceptions and jointly defining and tackling problems in relation to varied interests and can be deliberately increased by enhancing transparency (Lousberg and Noorderhaven, 2014). Lousberg and Noorderhaven (ibid.) demonstrated the stochastic nature of trust in the course of a project (life cycle). The authors opined that as a project progresses, partners tend to develop opportunistic behaviours that seek to fulfil their personal interest or it could be compromised due to conflicts over risks, revenues and costs. Greater openness and transparency or clarity of interests is necessary to improve trust. Both sectors must have mutual trust and act responsibly to achieve common goals without putting self-interest above all (Botlhale, 2016). These views were echoed in Christina et al. (2016) in which it was reported that trust is especially important in PPPs given the high levels of uncertainty and complexity which characterize them and the power differentials which exists among government, SPVs and the community/members of the public.

3.2.7 Joint decision making

Involving private sector in contract structuring and encouraging participation of members of the public for which the infrastructure is being provided is essential in ensuring performance of road projects (Carter, 2015; Hueskes et al., 2017). The public needs to be consulted because they are the ones who would eventually pay for the services and they should understand what a proposed development is all about and what needs of theirs would be fulfilled, both in the short run and long term. Thus, sharing system-related information with the public, consultation regarding fees and increments, involving locally-based project companies/contractors, involving private sector in operations/reality checking of outcomes, involving the public in planning for discounted user charges, getting the local community to understand why the project is being done, and so on, influence road project performance (Devkar et al. 2009; Glaister et al., 2010; Carter, 2015; Mišic and Radujković, 2015; Osei-Kyei and Chan, 2016).

From the thematic content analysis of literature from eighteen articles focused on road transport delivery using PPPs, the top four factors identified were joint decision-making, private partner selection considerations (including open and competitive bidding, selection of experienced and committed concessionaire, etc), incentivising private sector investors, and choice of financing considering cost. These findings are summarised in Table 1.

4. Case Study

Following the identification of the seven factors from the thematic analysis, the case studies were conducted to verify if the most frequently occurring factors were relevant within the African context.

4.1 Case 1 – N4 toll road, Maputo corridor

The N4 toll road was one of the Maputo Development Corridor projects running from Witbank in South Africa to Maputo in Mozambique. The Mozambique did not have money to improve and maintain its portion of the highway, which had been neglected and damaged in the country's long civil war. The South African government also faced an accrued backlog for road infrastructure in 1997 of R37 billion. The governments of South Africa and Mozambique signed a 30-year concession for a private consortium (made up of three construction companies) to build and operate the road for R3 billion (1996 estimates). The project was financed from 20% equity and 80% debt. Both governments jointly guaranteed the debt and equity because there was considerable user payment and demand risks, given the high toll fees.

Thus, considering the costs and demand risks associated with the projects, both governments jointly decided to finance the projects (joint decision-making). In so doing, responsibilities were clearly spelt out. Although the project faced challenges and opposition from the users (public) regarding the toll charges, all stakeholders (both governments and the companies) had understood the implications, and commercial risks were shared among partners (Farlam, 2005; Brits, 2010).

With their joint efforts, the parties are able to keep the performance of the N4 toll road on par with world-class standards, with sufficient funding for regular upgrading, rehabilitation and maintenance, as well as traffic and safety management services (Trans African Concessions, 2017).

Table 1: PPP sustainability factors identified from thematic content analysis

Literature source	**Year**	**Joint decision making**	**Private partner selection considera-tions**	**Incentivi-sing private consortia**	**Choice of finance considering cost**	**Loyalty & trust**	**Appro-priate risk & benefit allocation**	**Clearly defined responsibility, rules & procedure**
Devkar et al.	2009	X						
Glaister et al.	2010	X	X					
Welde & Odeck	2011				X			
Tan & Yang	2012			X				
Finnerty	2013				X			
Sudic et al.	2013			X				
Zhang & Chen	2013							
Lousberg & Noorderhaven	2014			X	X	X		
Carter	2015	X	X					
Feng et al.	2015			X			X	
Liyanage et al.	2015		X	X			X	X
Misic & Rajukovic	2015	X						
Pantelias & Roumboutsos	2015				X			
Botlhale	2016					X		
Christina et al.	2016					X		
Levitt & Eriksson	2016		X					X
Osei-Kyei & Chan	2016	X	X					
Hueskes et al.	2017	X				X		
Frequency		6	5	5	4	4	2	2
Percentage frequency		33	28	28	22	17	11	11

4.2 Case 2 – Senegal's Dakar-Diamniadio road

With concerns regarding acute congestion in Senegal's capital city of Dakar, a group of government agencies, companies and international development groups partnered to successfully deliver the first toll road in Dakar-Diamniadio (Gainer and Chan, 2016). A private company contributed a portion of the project cost and then was responsible for maintenance of the highway (in exchange for toll revenues), while the rest of the upfront cost was borne by the government.

The 32-kilometer highway, which opened in August 2013, was successful during implementation because at the planning stage, there were clear and visible benefits, consensus-building and stakeholder engagement, political commitment and proactive implementation by government agencies, strong involvement of development institutions and experienced and committed concessionaire (Carter, 2015). Although risk was a major consideration, the partnership structure, which was a build-operate-transfer, was attractive to private investors. The concessionaire was selected based on experience and sufficient liquidity.

In this case, there was also clear agreement on the risks and responsibilities to be borne by both parties. For instance, the concessionaire bore the traffic risks and was responsible for safety and quality management). In addition, there was communication and understanding between parties and the community as regards the expected impacts of the development (Gainer and Chan, 2016).

Even during the feasibility studies, it was evident that the project was going to be sustainable. Toll sensitivity studies showed that even with a 20 to 30% decline in traffic, the financial rate of return was still guaranteed (African development Bank (AfDB Project Appraisal Report, 2009). Reports indicate that currently, travel time is reduced significantly from 90 to 30 minutes on journeys between the Dakar city and its great suburbs. In addition, there is increase in property values, improvement in accessibility, as well as quality of lives (AfDB, 2018). Further, the project is financially profitable with a financial rate of return of 20.16%, and its sustainability of the investments will be ensured by the PPP formula, whereby the concession was made responsible for the maintenance of the highway and toll equipment (AfDB Project Appraisal Report, 2009).

4.3 Case 3 – The Lekki-Epe toll road concession project

The Lekki Toll Road Infrastructure Project, along 49.4KM of the Eti-Osa Lekki-Epe axis of Lagos consisted of the construction of new highway, culvert structures, provision of street lightings, and construction of two new toll plazas (Olele, 2016). A concession company was obliged to design, rehabilitate, construct, operate, maintain and toll the existing expressway planned for expansion, under a 30-year Concession mandate from the Lagos State Government. The project was successfully undertaken due to an experienced and committed concessionaire, due diligence, and involvement of local lending institutions. The state government's commitment and support in the loan of N5billion to the concessionaire assisted in the overall financing of the project (Trinity, 2009).

However, the project initially faced challenges as a result of high upfront cost including procurement costs, lack of strong support and commitment from the federal government, change in state government and managing stakeholders (Trinity, 2009; Olele, 2016). Nevertheless, these challenges were overcome partly by the PPP framework that took cognizance of the risks (financial and economic, mostly) of the project (Olele, ibid.).

From the three cases studies discussed above, it can be seen that the top two factors established in the literature review were relevant to the success of all the three PPP road projects examined in the case study illustration (Table 2). The table highlights the factors identified from the studies considered. This tends to suggest that joint decision making and private partner selection considerations are the most important factors to consider at the planning phase of road infrastructure projects in order to ensure sustainability of such projects.

Table 2: PPP sustainability factors identified from case studies

Case study	**Joint decision making**	**Private partner selection considera-tions**	**Incentivi-sing private consortia**	**Choice of finance considering cost**	**Loyalty & trust**	**Appropriate risk & benefit allocation**	**Clearly defined responsibility, rules & procedure**
Case 1	X	X	X	X		X	X
Case 2	X	X			X	X	X
Case 3	X	X	X	X			

5. Conclusion

The study sought to determine PPP factors which should be considered at the planning stage of road projects in order to ensure sustainability during operations. The objective has been met. The most critical factors were joint decision-making and concessionaire selection procedure and considerations. These considerations include the nature of bidding, the level of commitment and experience of the concessionaire and so on. These factors were first identified from a review and thematic content analysis of extant literature. Subsequently, case studies were used to assess the relevance of the factors on successful PPP road infrastructure projects in Africa, in order to establish applicability within the African context. Analysis of the case studies evinced that the factors contributed to success of the projects studies and were therefore applicable to the African context.

The current study provides evidence of the most critical factors that should be considered in PPP road infrastructure delivery in order to ensure sustainability. The findings provide information to guide road transport planners, policy makers and investors in planning for future infrastructure developments. Future research could adopt other research techniques to conduct a similar study and refute or further validate the findings of the current study. Further studies could also focus on other geographical areas as results may differ and the current case study findings may not be generalizable to other regions.

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Critical Success Factors for an Effective Performance of the Procurement Department Function: The Case of Local Government Offices in Ghana

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Abstract

Procurement in the public sector has immense impact on the country's economic expenditure. This has led to increased attention from governments and state institutions towards how resources are expended. The procurement departments within the public organizations is the crucial function that manages procurement expenditures of the organization. Notwithstanding its important role in public procurement in the organizations, the critical success factors have not gained much attention to ensure efficient performance and success of the procurement departments. The purpose of this paper was to investigate the critical success factors for effective performance of procurement functions in the local government offices. Review from pertinent literature identified 15 success factors for effective performance of the procurement departments. Empirical investigation was carried out using questionnaire survey to gather primary data from local government district offices in Ghana concerning their perception about these success factors on the performance of procurement departments. Data analysis involving one sample t-test was used to analyse the data. The findings show that concepts of value should be adopted in addition to the traditional success factors for the procurement department. This findings are important in ensuring effective performance of procurement departments in Ghana.

Keywords: public procurement, procurement department, procurement success, procurement performance

1. Introduction

Public procurement consist of the purchase of goods, works and services by governments and public organizations to meet their needs and fulfil obligational duties and responsibilities (OECD, 2016). A study by World Bank (2015), showed that over 50% of total government spending goes into public procurement and between 60 - 70% of government expenditure in developing

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economies is procurement related. This magnitude of procurement on the economy of country has aroused many challenges to policy, management and procurement managers (Thai, 2004).
Though public procurement has relatively improved within the Ghanaian context, not much attention is given to requirements for an effective functioning of these procurement departments. Meanwhile these procurement departments are the basic block of public procurement which is a crucial function of government and impacts directly on the achievement of governments policies and could also be used to stimulate private sector growth (Edler et al., 2006; UNPCDC, 2014).

The formation of a procurement department is a good management strategy (Carter and Narasimhan, 1996) hence its adoption by many governments. Research studies have shown that the procurement department is major spender of organization's revenue therefore it becomes a threat for financial losses for companies when it is inefficient and ineffective (Segev et al, 1998; Leung et al, 2003). Baily et al. (2008) made the assertion that certain resources are needed for efficient functioning of the procurement department. Procurement department has gained ascending importance over the past decades due to its activities being a determinant for the organizations success (Kioko and Were, 2014) and this emphasises that its strategic importance cannot be denied (Brandmeier and Rupp, 2010). Despite procurement's importance of delivering high quality of goods, works and services, organising a procurement department in the public institution has scarcely been analysed in the past (Glock and Broens, 2013). To achieve optimization of procurement expenditure and operations, effective and efficient procurement departments are required (Victor, 2012). To improve the inefficiencies and effectiveness associated with public procurement, efficiencies at the basic levels of procurement should be implemented (Chebet and Kwasira, 2016; Marimo, 2010; Kabaj, 2003). This paper is part of a larger research to find out factors needed to set up an efficient procurement department in Ghana. The purpose of this study is to identify critical success factors for efficient and effective functioning of procurement departments within the local government district assemblies in Ghana.

2. Review of Critical Success Factors (CSFs) for the Procurement Department Function

Success factors are inputs in a project that requires careful management since they have influential impacts on the success of the project (Cooke-Davies, 2002). The attainment of these success factors provides the management and implementers with better understanding on how to enhance outcomes (Tsiga et al., 2017). These success factors help small and new entrants to improve performance ensuring efficient resource allocation (Bullen and Rockart, 1981). CSFs has been adopted by various sectors to align the success of projects for the past decades (Berssaneti and Carvalho, 2015). Previous studies has identified various factors which are sometimes separated or interwoven that need to be reinforced in order to gain overall procurement department success. Although the procurement function is required to be perfect in all its task operation it is essential to identify the critical factors needed for its success (Brandmeier and Rupp, 2010). Table 1.0 shows the success factors and their various categories to promote procurement department to greater performance.

Table 1: Summary of success factors for the procurement department

Category	Factors	Sources
Management strategy	Defined and communicated strategy, senior management, early involvement of procurement, suppliers and stakeholders in projects, key performance indices, cost cutting methods/levers, risk management, corporate thinking and cross-functional responsibility, global sourcing for total cost of ownership and lifecycle cost.	Aberdeen Group (2006), Kearney (2004), Yu et al. (2005), Hughes (1986), Chua et al. (1999), Nguyen et al. (2004), Chua et al. (1999) and Nicolini (2002), Pinto and Slevin (1988).
Procurement coordination	Central coordination and local execution	Brandmeier and Rupp, (2010), Nicolini (2002), Nguyen et al. (2004), Cooke-Davies (2002), Belout and Gauvreau (2004)
Procurement processes	Standardized procurement processes	Nguyen et al. (2004), Phua (2004)
Methods and tools	Procurement handbook Intranet as procurement knowledge base, continuous establishment of data transparency, E-procurement and e-platform and methods for forecasting, inventory and pooling of needs	Aberdeen Group (2006), Fortune and White (2006), Belout and Gauvreau (2004)
Human resource	Highly qualified procurement personnel, personnel interaction and specialized procurement roles	Fortune and White (2006), Belout and Gauvreau (2004)
Supplier management	Structured supplier portfolio, supplier evaluation, cost reduction by supplier development, supplier value integration, negotiation concepts and management of sub-suppliers	Kearney (2004), Nguyen et al. (2004), Phua (2004), Fortune and White (2006)

3. Methodology

From Literature, 15 factors were identified as critical success factors for procurement departments upon consultations with public procurement experts. The study adopted structured survey questionnaire to solicit primary data from public procurement practitioners. The questionnaire survey was engaged since it is an effective technique to acquire a large sample size for quantitative data analysis (Saunders et al., 2012). Additionally, similar studies in success factors has adopted questionnaire survey for their research (see Chan et al., 2010; Zhang, 2005). The population for the study is procurement departments within the district assembly with the sample frame involving one procurement practitioner from each of the procurement departments within the district assembly in Ghana is 216. Hence 216 procurement departments were contacted to participate in the study. 12 procurement departments did not want to participate in the study hence the 204 procurement departments were sampled for the study.

The study conducted an initial semi-structured interview with eight public procurement experts concerning the various factors identified in literature and their relevance with procurement department success within the Ghanaian context. These persons were selected purposively using the criteria of high performing procurement departments based on the performance maturity assessment by the procurement regulatory authority in Ghana. This interview subsequently guided the design of the questionnaire for the survey. The interviews exposed 15 factors as critical success factors for the effective and efficient functioning of procurement departments. The interview ensured that the outcome was of relevance with respect to the Ghanaian public procurement setting.

The study adopted the stratified sampling technique to all categories of district assemblies in Ghana. This method was chosen in view of the fact that metropolitan, municipal and district assemblies would be proportionally represented to avoid bias in the data. The sample was drawn from procurement departments within metropolitan, municipal and district assemblies from all the 10 regions in Ghana. Each region had a proportional representation of metropolitan, municipal and district assemblies in the data collected with respect to their respective proportional representation within the region. Also this method was appropriate for the study since it provides the opportunity for the different classifications to be represented in their proportions respectively which in turn eliminate sample bias (Saunders et al., 2012).

The structured questionnaires were distributed to 204 procurement departments within the district assemblies across Ghana to solicit for relevant information on these critical success factors identified. A response rate of 55% was achieved which was considered relatively high considering the Ghanaian context (see Antwi, 2000; Hammond, 2006).

4. Data Analysis

The statistical tool used to analyse the data was one sample t-test. The one sample t-test was used to establish the relative importance of these 15 factors with respect to the procurement department. The significance level was set at 95% with respect to conventional risks levels. Thus using a five point Likert rating scale, a success factor was ascribed as important or critical when their mean is >3.5. In cases where two variables have the same mean value, the variable with a lower standard deviation will be given the priority (Field, 2005). According to Field (2005), when the standard error is large it means there are lots of variability between means of different samples and when the standard error is small it suggests that most sample means is similar to population mean. From Table 2, the standard error variable is relatively close to zero which suggests that the sample is an accurate reflection of the population. In order to achieve a one-tailored test results of significance for these factors, a two-tailored test was initially conducted. The values of these two-tailored test were subsequently divided into two to achieve the one-tailored results needed for the hypothesis test *(i.e. U > Uo)*.

4.1 One sample t-test for ranking critical success factors

The one sample t-test was used to establish the relative importance of these critical success factors on making the procurement departments effective. The one sample t-test was used to determine whether respondent considered any of the factors as important success factors for the procurement departments. The mean for various factors were computed to help understand and discuss agreement among respondents. Table 2 and 3 shows a summary of the test results. Table 2 reports the total number of respondents, mean, standard deviation and standard error for each variable factor. For each factor the null hypothesis was that the factor was unimportant as a success factor for procurement department success *(Ho: U=Uo)* and the alternative hypothesis was that the factor was important as a success factor *(Ha: U>Uo)*, where Uo represents the population mean (Uo was fixed at 3.5, see Ling, 2002).

Table 2: Results of one sample test showing test significance

Success Factors	**N**	**Mean**	**Std. Dev.**	**Std. Error Mean**
Precisely defined and communicated standardized procurement processes	113	4.0885	.97795	.09200
Support of senior management for procurement	113	3.9823	1.06051	.09976
Early involvement of procurement and key stakeholders in the development of projects	113	3.9292	1.06668	.10034
Right key performance indices for projects	113	4.0354	1.05161	.09893
Risk management of future evolution possibilities of suppliers	113	3.6903	1.11867	.10524
Some level of central coordination and local execution	113	3.7345	1.06919	.10058
Procurement knowledge base intranet and handbook	113	3.6903	1.11867	.10524
Continuous establishment of data transparency	113	4.0796	.89783	.08446
E-procurement engagement and IT solutions	113	3.8319	.99913	.09399
Methods of needs assessment and aggregation of needs	113	3.8230	1.12781	.10610
Good interaction of procurement staff with other units	113	3.5221	1.26842	.11932
Use of specialized procurement roles	113	3.9469	1.00748	.09478
Supplier/contractor evaluation and management	113	3.9912	1.04792	.09858
Negotiation concepts	113	3.6637	1.07413	.10105
Life cycle cost of project and value analyses	113	4.0265	1.14533	.10774

The summary from Table 3 shows that *precisely defined and communicated standardized procurement processes* was ranked the highest factor whiles *good interaction of procurement staff with other units* was ranked the lowest from the total of 15 variables.

With *precisely defined and communicated standardised procurement process* (p=0.0000) being ranked highest from Table 3, it supports the proposition of relying on standardized procurement process which is demand characteristic of public procurement (Murray, 1999; Telgen et al., 2007). This demand is heavily required by governments and regulatory authorities by providing procurement rules and regulations for executing procurement activities. Any contrary practice to the procurement rules and regulations is considered as unproductive and perceived as corrupt.

Table 3: Summary of mean rankings and 1-tailored results

Item	**Success Factors**	**Mean**	**Sig 1-tailored**	**Std Dev.**	**Rank**
CSF1	Precisely defined and communicated standardized procurement processes	4.0885	0.000	0.97795	1
CSF2	Continuous establishment of data transparency	4.0796	0.000	0.89783	2
CSF3	Right key performance indices for projects	4.0354	0.000	1.05161	3
CSF4	Life cycle cost of project and value analyses	4.0265	0.000	1.14533	4
CSF5	Supplier/contractor evaluation and management	3.9912	0.000	1.04792	5
CSF6	Support of senior management for procurement	3.9823	0.000	1.06051	6
CSF7	Use of specialized procurement roles	3.9469	0.000	1.00748	7
CSF8	Early involvement of procurement and key stakeholders in the development of projects	3.9292	0.000	1.06668	8
CSF9	E-procurement engagement and IT solutions	3.8319	0.0005	0.99913	9
CSF10	Methods of needs assessment and aggregation of needs	3.823	0.0015	1.12781	10
CSF11	Some level of central coordination and local execution	3.7345	0.011	1.06919	11
CSF12	Risk management of future evolution possibilities of suppliers	3.6903	0.0365	1.11867	12
CSF13	Procurement knowledge base intranet and handbook	3.6903	0.0365	1.11867	13
CSF14	Negotiation concepts	3.6637	0.054	1.07413	14
CSF15	Good interaction of procurement staff with internal and external stakeholders	3.5221	0.4265	1.26842	15

This could be the explanation for the respondents ascribing high importance to this factor. Subsequently the second factor which is *continuous establishment of data transparency* (p=0.0000) shows that transparency of procurement activities as required by public procurement principles is another factor respondents consider highly as a success factor for the procurement department. Developing countries like Ghana has seen procurement malpractices and corruption of different kinds in public procurement hence one tool used to monitor malpractice and corruption is transparency of procurement activities.

This could be the reason for respondents rating data transparency high although it is a conventional success factor in public procurement. Along with this conventional demands from public procurement is *Methods of needs assessment and aggregation of needs* (p=0.0015) and *some level of central coordination and local execution* (0.011) which were considered as significant factors for success. Apart from the so-called conventional factors used in public procurement to factor success, respondents acknowledged emerging factors such as *right key performance indices for projects* (p=0.0000), *Life cycle cost of project and value analyses* (p=0.0000), *Supplier/contractor evaluation and management* (p=0.0000) and *Risk management of future evolution possibilities of suppliers* (0.0365) as significant for indicators of procurement department success.

This indicates that respondents perceive organizational performance, risk and value management concepts important for public procurement to ensure efficiency and effectiveness despite risk management ranking 12th from Table 3. Note that although *negotiation concepts* (p=0.054) are also considered as important with a mean value above the hypothetical mean and a contributor to organizational success in other jurisdictions, respondents did not recognize its significance strong enough to be success factor for the procurement department success. This could be as a result of discouraging negotiations within the public procurement circles hence procurement practitioners have acknowledged its benefits but are hesitant in adopting it.

However *Support of senior management for procurement* (p=0.0000) was considered as critical for procurement department success because the procurement departments have to go through a chain of procurement approvals to execute procurement activities hence senior management employees both internally and externally are involved in the procurement process. Likewise *Use of specialized procurement roles* (p=0.0000) was considered significant for procurement department success.

The public procurement regulatory authority in Ghana encourages the use of specialization among employees for tasks which could explain the reason respondents considered it important. Despite *E-procurement engagement and IT solutions* (p=0.0005) ranking 9th from Table 3, it was considered significant for the success of procurement departments. E-procurement and information technology is yet to be operationalized in public procurement in Ghana although Ghana has advanced in the adoption and implementation of e-procurement. This provides informative evidence that procurement practitioners in Ghana are willing to adopt this emerging technology in public procurement to attain its benefits as achieved by other developed countries and economies. Another factor procurement practitioners considered as significant is *Procurement knowledge base intranet and handbook* (p=0.0365).

As indicated by other researchers knowledge is crucial for organizational development and this could be the explanation for procurement practitioners embracing this emerging tool as a success factor for the procurement unit. Subsequently *Good interaction of procurement staff with internal and external stakeholders* (p=0.4265) was considered as a good factor of success for the procurement department success since its mean is above the hypothetical mean but its significance as a factor that will drive the procurement was seen as not influential. This is contrary to the demands of public procurement hence procurement practitioners should reconsider the relevance of this factor as a success factor.

Generally the findings suggest that public procurement is developing towards modern concepts and technologies for procurement so procurement departments would have to incorporate these factors into their operations to be effective and efficient to meeting future paradigms.

5. Conclusion

The procurement department plays a focal and vital role in the organizations procurement which has huge financial implications on the organization and its achievement of goals. A review of literature identified 15 success factors which were subsequently ranked using mean scores. The findings reveals that the mean score values of all factors identified were high. This implies that the 15 CSFs identified are important factors for the success of procurement unit performance in Ghana. The five top ranking factors thus precisely defined and communicated standardized procurement processes, continuous establishment of data transparency, right key performance indices for projects, life cycle cost of project and value analyses and supplier/contractor evaluation and management implies that aside the conventional factors for success in the public procurement sector, emerging concepts and approaches e.g. life cycle cost of project and value analyses should also be regarded in ensuring the success of procurement departments. A look at the middle ranked factors supports the fact that emerging concepts and approaches such as e-procurement engagement and IT solutions and risk management of future evolution possibilities of suppliers should be incorporated into the procurement department to enhance its success. Although negotiation concepts and good interaction of procurement staff with external and internal stakeholders were ranked relatively low, steps should be taken to promote this factors due to its benefits it brings to the procurement department.

This paper provides good understanding of the success factors one has to consider in ensuring that the procurement department is effective and successful within Ghana. The findings from this study is expected to enhance the performance of procurements departments in Ghana. This findings inform managers and decision makers within the public organizations how to strategize their procurement departments to be successful. Future research need to be conducted on the impact of this findings on the procurement department practices and the organization as a whole.

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Multifaceted Financing Constraints in Public Infrastructure Investment and Development

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Abstract

The study examines the multifaceted financing constraints in public infrastructure investment and their implications for development thereof especially in developing countries. The recent global economic meltdown creates an uncertain economic climate and risky financing in public infrastructure investment and development. The study used literature review followed up by a case study approach and expert interviews to collect empirical data. The study offers a synopsis of financing constraints in public infrastructure investment and development and the alternative. Findings reveal that the predominant constraints are economic, social and fiscal management related and interact with each other. Financing constraints in public infrastructure investment and development require a sustainable financing approach over the long-term. The study identifies Public-Private Partnership as an alternative financing instrument which may be suitable in public infrastructure investment and development provided it is well structured with reasonable incentives put in place. The paper concludes that while public infrastructure investment is an instrument that drives economic growth, it is severely limited by many constraints and although public-private partnerships have many benefits, these are rarely realised in practice due to reasons such as inadequate knowledge and frameworks for successful implementation. This paper improves knowledge on financing constraints and the need for exploration of alternative financing approaches in public infrastructure investment and development to improve delivery in this area.

Keywords: development, finance, PPP, public infrastructure

1. Introduction

The role of the public sector in the provision of public infrastructure investment and development is vital to realize the country's economic development objectives. According to Gurara, Klyuev, Mwase, Presblero, Xu and Bannister (2017), public infrastructure investment and development is widely conceived as an economic development driver despite the deficiency in public infrastructure investment and development which affects growth. There is increasing need to develop public infrastructure investment and development especially in countries with less economic outputs. Public infrastructure investment should become the national development

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strategic pillar of economic development (Acosta-Ormaechea and Morozumi, 2017). The financing of public infrastructure investment is central to the country's broad economic and social development policies which aims to accelerate economic growth, narrow economic and social fragmentation and achieve economic and social development objectives (Wentworth, 2012). The country's macroeconomic development policies seek to increase economic growth, employment and to narrow structural gaps (Wentworth, 2012). Public infrastructure investment is a vehicle used to realize the country's macroeconomic development objectives such as to increase growth, employment creation, and narrow structural gaps to lessen inequality and poverty (Gurara et al, 2017). The purpose of this paper is to examine the multifaceted financing constraints which stifle the sustainable financing of public infrastructure investment and to also augment PPPs knowledge in the financing of public infrastructure investment and development.

2. Multifaceted Financing Constraints in Public Infrastructure Investment

Literature on public infrastructure investment acknowledges that the public sector plays an important role in the provision of public infrastructure investment in developing countries (Mutandwa, 2015). The public-sector share in public infrastructure investment and development constitute a large share to date (Acosta-Ormaechea and Morozumi, 2017). However, it is difficult to analyze public infrastructure investment due to lack of comparable systematic data (Gurara et al, 2017). It is noticeable that there are more holdups in public infrastructure investment in developing countries than in developed countries and this trend affect the quality, quantity and accessibility of economic infrastructure in developing countries (World Bank, 2015). Infrastructure lag and rising public infrastructure investment demand, costs increases construction and maintenance costs and it also stifles the financing of public infrastructure investment in developing countries (Estache and Fay, 2007). Wentworth (2012) opines that public infrastructure investment is a strategic developmental agenda which champions National Development Plan (NDP). However, there are financing constraints resulting from the uncertainty of global economic climate whereby global economies reflect slow recovery from the 2009 global financial crisis (Estache, Serebrisky and Wren-Lewis, 2015). According to Gurara et al. (2017), numerous financial and economic experiences in developing countries exacerbates the financing trajectory in public infrastructure investment because the financing requirements in public infrastructure investments are scaling up. IMF (2015) postulates that negative public saving investment balances, increasing government debt to GDP ratios, increasing fiscal vulnerabilities, rising budget deficits and interest rates, depreciation of local currencies and external debts are major concerns which stifle the financing of public infrastructure investment and development.

2.1 Financing issues in public infrastructure investment and development

According to Reungsri (2010), public infrastructure investment expenditure dominates public sector investment requirements while the financing of public infrastructure is constrained by numerous factors. Chong and Poole (2013) assert that public infrastructure investment is fundamental to economic growth and societal development as developed infrastructure structures and facilities support economic and social services. Public infrastructure comprises distinguishing features which makes it special and stimulates governments' to invest more in infrastructure (Chong and Poole, 2013). Chand (2008) argues that heavy borrowings used to finance public infrastructure investment adversely increases insolvency. Chong and Poole (2013) highlight that public infrastructure is monopolistic in nature and is characterized by large scale of economies. Optimistic infrastructure investment externalities stimulate government interest and increase development of infrastructure networks (Chong and Poole, 2013). Positive infrastructure externalities influence government investment in public infrastructure development because of expected positive net benefits (Chong and Poole, 2013). Airoldi et al. (2013) indicate that public infrastructure investment drive is activated by increasing population growth, urbanization, clean water, sanitation and by growth of per-capita income. Cawood (2014) asserts that governments are stimulated to lessen public infrastructure investment backlog because of increasing mobility patterns to improve the standard of living, employment opportunities and skills development. Airoldi et al. (2013) state that the dilapidating roads, power stations and increasing travelling stimulates public infrastructure investment and development. However, public infrastructure investment and development drive in both developed and developing countries is constrained by rising fiscal deficits (Airoldi et al, 2013). Cawood (2014) argues that the increase in public infrastructure investment is a catalytic mechanism to ensure the realization of sustainable economic growth. According to Cawood (2014), the financing of public infrastructure investment within the middle-income countries reflects the importance of economic and financial sustainability and contributes to improved annual growth targets.

In addition, Airoldi et al. (2013) indicate that historically, over a period of forty-years public infrastructure investment expenditure rates declined in developed countries. Global public infrastructure deficits averaged $2.7 trillion dollars in 2008 and 2010 (Airoldi et al, 2013). Valila et al. (2005) highlight that historic spending regimes in public infrastructure investment in Europe averaged 2.5% of GDP in 2000 and in 1970, investment rate averaged 5% of GDP reflecting a steady decline. According to Cawood (2014), African countries have public infrastructure investment holdup of 30% while in other countries public infrastructure is so dilapidated and spikes the demand surge due to backlogs on every infrastructure type. Adam and Bevan (2014) articulate that historically, public infrastructure investment demand has always been viewed in context with long-term sustenance of economic growth. According to Bianchi and Drew (2013), global fiscal deficits are impede the financing of public infrastructure investment projects in both developed and developing countries. Bianchi and Drew (2013) postulate that the lessening capital infrastructure investments budgets in numerous projects is attributed to unpredictability of economic growth and fiscal instability. Airoldi et al. (2013) posit that the annual increasing financing gaps in public infrastructure investment average $1.1 and $1.5 trillion dollars. Adam and Bevan (2014) highlight that rising public infrastructure demand weakens public finance sustainability and affect future financing of public infrastructure.

Pessoa (2008) posits that constrained public finance adversely affect the financing of public infrastructure as well as the quality and efficiency of public infrastructure investment. Page, Ankner and Jones (2008) theorize that public finance constraints impedes public infrastructure investment. According to Page et al. (2008), it is impotant to engage private sector in public infrastructure investment. Garvin (2003) notes that public finance constraints increases the importance of considering public-private partnership as an alternative approach to finance public infrastructure investment. Cawood (2014) asserts that multifaceted financing constraints in public infrastructure investment and development intensify public institution's financing fragmentation and inadequate infrastructure planning at a macro-level.

According to Cawood (2014), public infrastructure investment is constrained by inadequate financing, technical capacity to identify viable and feasible infrastructure projects. Esty and Sesia (2010) highlight that noticeable declining financing trends in public infrastructure investment stimulates public-private partnerships in public infrastructure. According to Bianchi and Drew (2013), use of sovereign bonds in public infrastructure investment is no longer the case due to sensitivity of country's fiscal positions. The financing of public infrastructure investment is further stifled by continuous scrutiny of credit rating agencies, which makes it challenging to finance public infrastructure through sovereign bonds (Bianchi and Drew, 2013). Cawood (2014) indicates that inadequate integrated coordination and insufficient regulatory clarity increases substantial financing constraints in public infrastructure investment. According to Cawood (2014), inadequate public-sector skills to prepare feasibility studies, project management and procurement exacerbate the financing constraints in public infrastructure investment and development. Airoldi et al. (2013) indicates that global economic crisis depletes government vaults and widens the financing gaps in public infrastructure. Azaino (2012) argues that fiscal instability in numerous countries constrains public finance and adversely affect capital infrastructure investment projects. According to Emirullah and Azam (2014), high inflation and unstable exchange rates result in unaffordable sovereign debt while fiscal stability favours flexible financing conditions and lending terms. Pessoa (2008) highlights that constrained public finance in public infrastructure investment stifles decision-making processes and bureaucratic processes in the financing of public infrastructure investment.

2.2 Public debt and fiscal deficit issues

IMF (2011) highlights that large structural deficits and public debt build-up is a concern which affect progressive fiscal policy implementation. Ferrarini et al. (2012) assert that sovereign downgrades in USA and Europe contribute to global financial market turmoil. IMF (2013) reports that public debt increases retard potential economic prospects and constrains prospective fiscal policy and expose the economy to external shocks. IMF (2013) suggests that increasing public debt risks economic growth prospects. Ardagna, Caselli and Lane (2007) assert that emerging market economies view public debt as a challenge because expansion of public debt adversely affect economic development over the long-term. According to Ardagna et al. (2007), public debt increase escalates this view that advanced economies will falter to service liabilities and increase credit risk. According to Pasquali (2015), global financial crisis increases sovereign debt and plausible risks of indebtedness over the long-term. IMF (2012) highlights that currently, several countries face the prospects of heavy debts over the next coming years.

Melecky and Melecky (2014) claim that effective debt management practices buffer public sector expenditure, guarantees effective debt servicing during aggregate shocks and safeguards public finance from imperceptible debt crisis. Public debt oriented economic output targets, maintenance of economic growth through fiscal policy constrains public finance and the financing of public infrastructure investment due to increasing budget deficits and public debt (Matalik and Slavik, 2005). According to Mesik (2010), politicians turn a blind eye to fiscal responsibility and accountability principles and risk the sustainability of public finance in public infrastructure investment. In light of public debt and fiscal deficit burden, there is a need to restructure public debt due to fiscal macroeconomic risks (Sikulova and Frank, 2013). However, Das, Papaioannou and Trebesh (2012) elucidate that public debt restructuring ensures containment of public debt. According to Reinhart and Rogoff (2008), debt-restructuring approaches improve revenue, lessens inflation and current account balance and is not sufficient to finance public infrastructure investment and development through debt and deficits.

2.3 PPPs feasibility in public infrastructure investment

According to Azaino (2012), increasing financing gaps in public infrastructure investment and development requires a financing approach that is suitable over the long term and PPPs are considered appropriate. PPPs are generally acknowledged by numerous governments as means to collaborate in public infrastructure investment (Estache et al, 2015). Eldrup and Schutze (2013) assert that public-private partnerships have been previously used to expedite public infrastructure investment as a result of public finance constraints. OECD (2014) reports PPPs as alternative financing approaches which are viewed as suitable financing instrument and enhances private sector participation. According to Emirullah and Azam (2014), PPPs are a viable mechanism because the current fiscal capacity is constantly constrained due to public finance challenges. Ishmael and Ajija (2013) argue that PPPs' successful implementation requires good governance, public and private sector commitment, policy and regulatory framework that remain conducive to PPPs functioning. Della-Croce and Gatti (2014) assert that global policy makers continuously debate the decline of public finance in public infrastructure investment. Kripa and Xhafa (2013) note that PPPs significant consideration requires good partnerships to realize public infrastructure investment. According to Kahwajian, Baba, Amudi and Wanos (2014), the PPPs implementation rationale in public infrastructure investment is steered to bridge the financing gaps in order to complement fiscal stability in various countries and renews public infrastructure investment hope as a public choice. Emirullah and Azam (2014) argue that countries with constrained public finance perceive private sector as an option through public-private partnerships.

According to Della-Croce and Yermo (2013), the private sector is significant to global development of public infrastructure investment. World Bank Development Committee Report (2015) indicates that the global availability of private sector finance in public infrastructure investment projects but there are challenges in achieving fruitful public private sector engagements (WBDCR, 2015). Della-Croce and Yermo (2013) indicate that increasing collaboration is required to fulfill the long-term financing requirements in public infrastructure investment and development. According to Della-Croce and Gatti (2014), the public sector's inability to finance public infrastructure investment stimulates financing shifts in public infrastructure investment and development. According to Feremo (2015), it is important to balance the financing approaches and techniques in order to leverage private sector financing capability in public infrastructure investment through realisitc collaborations. Della-Crose and Yermo (2013) suggest the need to complement new financing mechanisms and models which enhance efficiency and advance PPPs in public infrastructure investment. According to Della-Croce and Gatti (2014), global economic climate reshapes financing approaches in public infrastructure investment and development. Gardner (2012), Della-Croce and Gatti (2014) indicate that recent global financial and economic turmoil stimulates short and long-term financing approaches which prolongs the sustenance of public finance in the financing of public infrastructure investment. For Sorge (2004), increasing prioritised public infrastructure investment projects demand substantial financial capital injection to finance power plants, toll roads, ports, rail terminals, dams, and green energy among others. Grimsely and Lewis (2004) argue that although PPPs are considered an alternative financing instrument numerous challenges affect the successful implementation. PPPs success implementation require comprehensive knowledge when PPPs are considered in public infrastructure investment and development (Grimsely and Lewis, 2004).

3. Methodology

The study uses a case study approach and expert qualitative semi structured interviews as the method for data collection. The study was exploratory in nature and thus the data collection process was primarily qualitative involving the collection of indepth accounts of the participants and analysis of case study documents about the phenomenon. The study used an interview guide with focused interview questions on public private partnerships implementation. The study purposefully selected two case studies with seven experts who had extensive knowledge of implementation of public and private infrustracture investment projects in South Africa and Czech Republic, ranging from 10-24 years. The study requested participants to particpate in this study where a letter of permission was sent requesting their voluntary participation explaining the purpose of the study. Participants‘ consent was obtained and flexible interview schedules obtained. Annonymity and confidentiality of participants were assured. Each interview took just over an hour to complete and collected data was analysed qualitatively. Atlas.ti software package was used to manage, store and retrieve data. The emergeing themes were coded and analysed.

4. Findings

The findings reported in this paper form part of a broader project study. For purposes of this paper, only some the interview findings are reported and discussed as indicated in this section. The key findings on the constraining financing factors are depicted in figure 1 below.

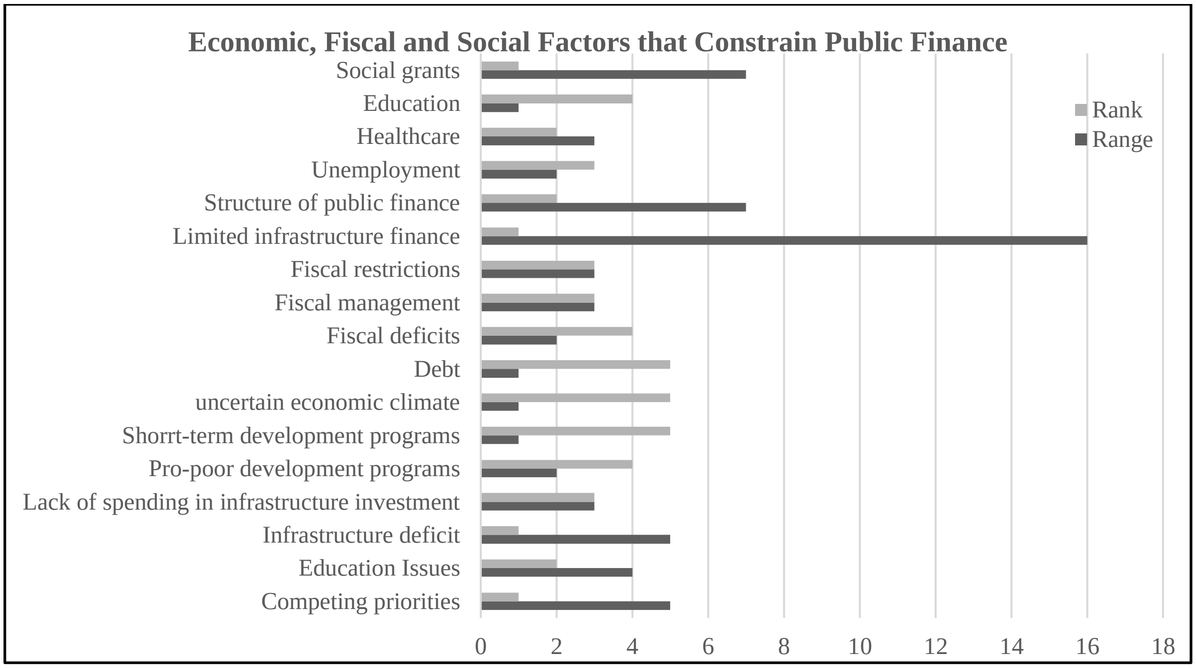

Figure 1: Constraining factors limiting public finance in public infrastructure investment

Figure 1 presents a number of generic factors which were found to be the main constraints of public finance in public infrastructure investment. According to the findings, these multifaceted constraints signalled a need to explore alternative financing instruments which could be sustainable over the long-term. The nature of factors identified that constrain public finance imply that over the long-term public finance will be facing some challenges. The constraining factors were classified and ranked according to economic, social and fiscal related constraints.

From an economic point of view, limited infrastructure finance was ranked the highest followed by the structure of public finance across all three clusters. The study found that economic constraints give rise to lessening financing capital expenditure, fiscal restrictions, infrastructure deficits, limited budgets, and strict fiscal restrictions. The findings also revealed that economic constraints compound expenditure on competing priority spending programs, increasing educational requirements, infrastructure deficits, lack of spending in public infrastructure, pro-poor development programs resulting in unclear economic climate, most of these being social oriented. Other social constraints included factors such as social grants, healthcare, unemployment and short term development programs. Regarding the fiscal aspects, constraining factors included fiscal restrictions, fiscal deficits and fiscal management. According to the findings, the constraints are interlinked and cannot be looked at in isolation. The respondents also indicated that although PPPs have a potential to deliver economic, social and environmental benefits, this is not always achieved in practice primarily due to inadequate knowledge and lack of regulatory frameworks for successful implementation. The respondents further agreed that PPPs that are well structured with reasonable incentives in place, could offer alternative financing options to mitigate public sector financing shortcomings.

5. Discussion

Fiscal related constraints comprised lack of infrastructure finance, structure of public finance, fiscal restrictions and debt. This is in line with institutional theorists who advocated for adequate management of public finance in a sustainable manner. Lack of infrastructure finance means that there is no or limited finance allocated in public infrastructure investment and development. The lack of infrastructure finance in public infrastructure investment implies that public infrastructure investment lead to holdups and have a negative impact on economic growth and development as indicated in the literature (Gurara et al., 2017; World Bank, 2015). This also means it would be difficult to realize the country's social and economic development goals. Fiscal restrictions are a major constraint in any public-sector agenda because this means that spending need to be prioritized only essential short-term spending programs. The results support the theory that cutting on spending in other programs such as public infrastructure means that long-term program spending is minimized or cut. As Baldaci and Kumar (2010) indicate that public debt and fiscal deficit expansion are a cause of concern in numerous countries because of fiscal long-term effects. The current spending on short term competing spending programs through debt means that there is no public finance available in public infrastructure investment because debt limits the country's opportunity to borrow for infrastructure investment.

The results of the study showed that social constraints comprised unemployment, social benefits, health care, environment and education. It was found that these social constraints in public finance aggravate expenditure on employment, social benefits, health care and on education. The findings imply that the public sector is mandated to compensate farmers due to environmental factors and this widens the spending environmental issues limiting capital in public infrastructure investment. The finding further mean that with the fast-changing population with a number of children and youth eligible for enrolment, the public sector is required to spend on the increasing educational demands with limited resources which constrain public finance in public infrastructure investment. The study found that social benefits are predominant factors that widen public sector spending due to changing population dynamics and puts pressure on public finance and constrain public infrastructure investment. Findings revealed that unemployment issues are a major constraining factor which require adequate public-sector response to provide employment opportunities as a consequence of declining economic growth. This suggests that if the amount which is spent every month on social benefits and child care grants could possibly be used to develop public infrastructure to provide employment opportunities for the economically active population for wealth creation. This strategy could also lessen the pressure on public finance and improve sustainability of public finance over the long-term in line with IMF (2015) which argues for the lessening of social constraints in public finance in order to reduce expenditure and alienation of public infrastructure investment.

This study infers that the multitude of factors constraining public finance in public infrastructure requires a re-examination of financing approaches and PPPs are viewed as a sustainable financing approach due to mitigate the numerous constraints which limit public infrastructure investment and development and widen the infrastructural financing gap. However, the study also found that while PPPs hold numerous benefits, these are not always realisable in practice.

6. Conclusion

This study set out to identify the multifaceted financing constraints in public infrastructure investment and development. The findings of this study confirm that there are numerous intertwined economic, social and fiscal managed related factors which constrain public finance in public infrastructure investment. The implications of these constraints point to the need for examining alternative financing instruments particularly PPPs because of their long-term contractual nature and good leverage of private sector finance and collaboration in public infrastructure investment. The study recommends that there is need to consider various contexts, knowledge levels of stakeholders and the structural or regulatory frameworks for successful implementation of PPs as an alternative to the traditional financing route for public infrastructure.

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Sustainability in Road Infrastructure Development: Financing Strategies

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Abstract

Sustainable road infrastructure development is the key to unlocking a nation's massive economic potential that lies untapped in remote and almost inaccessible places, as well as in maintaining functional trade routes for trans-frontier trade among nations. It provides an opportunity to optimally apply the nation's road maintenance resources in a manner that directly responds to the exact needs of the existing road asset as well as the need for strategically developing new road links. Maintenance of a coherent and intelligible balance between road maintenance budgets and capital expenditure for road development should be observed at all times in a deliberate and sustained manner in order to yield the maximum benefits from road sector investments. At no point should the existing road asset be allowed to waste away at the expense of road development. In that regard, the diversified economic activities across the country can thus be deemed to be truly linked through the sustainable regional and national trade corridors. Further, it is incumbent upon a nation's road asset managers to ensure that sufficient resources for road maintenance are made available. This calls for application of innovative and alternative sources of financing that are drawn away from traditional sources of income. In this paper, therefore, the authors discuss sustainability challenges and solutions in road infrastructure maintenance and development with special focus on alternative funding strategies. Desk study, interviews with purposively selected engineers and managers involved in road maintenance, construction and financing in Zambia as well as field visits were conducted. Findings revealed that sustainability of road infrastructure is achievable through government financing strategies such as parliamentary appropriation, use of fuel levy, use of road tax, road tolling, Private Finance Initiative (PFI), Public-Private Partnership (PPP), loans and grants.

Keywords: construction, financing, maintenance, road, sustainable

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1. Introduction

This paper is about educational and engineering practice development that aims at assisting road asset managers in Sub-Saharan Africa in evolving and adapting to innovative asset management systems and alternative funding strategies for road maintenance.

Zambia's road transport infrastructure, for example, largely analogous with most Sub-Saharan African Countries, predominates with freight and passenger transport estimated at about 90% (Ecoroad Africa, 2011). Roads, therefore, in spite of their heavy capital requirement in terms of construction and maintenance costs, play a critical role in intra – Africa trade linkages. Billions of dollars are required annually to maintain the existing road asset, often with a huge maintenance backlog, carried over from year to year. As such, funding for road maintenance cannot be over-emphasized as our nations attempt to go beyond just traditional sources of finance.

Experiences across the sub-region show varied proportions of paved road network sizes against the total road network. While Zambia has no more than 20% of its total network paved to bituminous standard, the continental average largely hangs around similar estimates (Atlassian Confluence, 2017). However, the demand for all-weather roads necessary for improving accessibility and mobility remains extremely huge. Disinvestments in road infrastructure development and maintenance tend to worsen road network conditions. Rising commodity prices for vital road inputs on the international market further tends to inhibit the number of kilometres that could be built or maintained in a given year.

With marginal income as measured in terms of Gross Domestic Product (GDP), Zambia, therefore, remains heavily dependent on external support for road construction and maintenance. Coming to terms with rising budget deficits and road maintenance funding gaps has largely been traumatising to road asset managers. The stalling of road projects raises additional project costs in interest claims, standing time costs, and suspension or termination entitlements. There is earnest need, therefore, for sustainable road financing and maintenance in the minds of our road asset managers. They need to see the interaction between effective and efficient road asset management and sustainable infrastructure financing.

1.1 Objective

Sustainability in road infrastructure development requires continuous research and development and promotion of the industry best practices taking into account resilient and durable designs, as well as efficient and effective maintenance regimes. But above all, sustainability demands adequate project financing. This paper, therefore, aims to achieve the following objectives:

1) Identifying alternative road financing strategies, and
2) Recommending best practices within the context of Zambia.

1.2 Rationale

It is generally acknowledged that Sub-Saharan African (SSA) Countries remain among the poorest in the world, whilst remaining over-dependent on foreign aid (World Bank, 2015). The cost of borrowing road maintenance funds is considerably high, and resources must be applied prudently. Efficient and effective application of road maintenance funds ultimately leads to sustainable road asset management. As such, alternative more affordable forms of financing sources for road maintenance and construction should be adopted if our roads are to be sustainably maintained.

Expansion of existing road networks should not be undertaken at the expense of preserving road asset, and without considering the life-cycle costs for subsequent maintenance of new road links. Inherently, the critical aspect of sustainable road maintenance requires striking a favourable balance between road construction and maintenance. Adequate maintenance budgets entails the achievement of full benefits over the service life of a road due to timely maintenance, with scheduled maintenance being deferred as far as possible. In that respect, this averts premature failure of roads, which would otherwise draw resources away from new candidate roads and impede sustainable maintenance. Mobilising resources away from traditional sources appears to be the way ahead for any country looking to sustainably maintain the road infrastructure.

2. Literature Review

The authors have conducted extensive literature review over the past decade, resulting in publications which document the evolution of road asset management systems, road financing models and sustainable road infrastructure development (Kaluba, 2014; Tembo, 2015a; 2015b). Buttressed by the desire for continuous improvement in the road transport sector, the key driver has been the belief in change management as a means of evolving and adapting to often scary, but indispensable, strategies for sustainable road financing.

Across to Asia, the Indonesian Road Sector Policy Note stresses the need for setting up a sustainable financing mechanism to preserve road assets, adding that when debating budget allocations under fiscal constraints, roads become less visible than other competing social needs such as Health and Education. Suffice it mention that the identified key strength in sustainable funding for road maintenance was based on the “user pays” principle which was secured through the levying of a Road User Charge (fuel levy, vehicle license fee, etc.) and the establishment of a Road Fund was considered as part and parcel of a comprehensive approach to road sector reform under which roads were to be managed like a business and where users would play a much stronger role than hitherto in the management of road maintenance.

In several developing countries, financing road infrastructure poses a huge challenge due to the fact that the available resources are insufficient to meet existing and new investments, while the return on investments (RoI) is below par. In Zambia, this situation is akin to the situation where the annual road maintenance backlog is estimated at US $352 million on one hand, but with new road upgrading projects such as the Link Zambia 8000 added to the same national budget (Ntsimane, 2017). This has further exacerbated the high financing gap in Zambia's road sector, prompting the Zambian Government to introduce alternative ways of mobilizing revenue.

There has been recent growth and interest in scholarly work focussing on non-traditional ways of raising resources to meet the exponential growth of road sector needs such as Kaluba (2014) in which a comprehensive analysis on road financing in Zambia was conducted on the national road-tolling program (NRTP) which was introduced in 2013. The research attempted to answer the central research question: 'In quest to introduce road tolling as an innovative and self-financing mechanism for routine road maintenance programmes in Zambia, how feasible is it for the Government of the Republic of Zambia to collect tolls on its own rather than outsourcing a private sector under a public-private partnership (PPP)?'

The study revealed that while Willingness to Pay (WTP) measured through social acceptance, is quite high, the system was not effective enough and many road users seemed not to be benefitting from paying their tolls. The research, further showed that Zambian roads were characterised by low traffic volumes and therefore would not generate sufficient revenue through road tolling while public sector direct tolling was prone to a number of risks. In particular, the study showed that road tolling through the public sector would have lesser cost implications given that the roads were already in existence, despite a heavy backlog of maintenance.

Kaluba (2014) drew conclusions that suggested public sector direct operation of toll roads in Zambia was feasible. However, this was dependent on the revenues being reinvested back into the road sector to improve the road condition. Further, in order to increase efficiency and effectiveness, Government should consider involving the private sector in the collection and management of toll fees in arrangements such as a Special Purpose Vehicle (SPV).

2.1 Methods of financing road infrastructure

The above discussion shows that road infrastructure financing through general government tax revenue was a challenge in most countries around the world. Consequently, Heggie (1999) observes that road financing is usually off-budget, and commercial ventures which are designed to generate a secure and stable source of finance should not create fiscal inflexibility. Several methods and concepts on how governments could raise additional revenue for investment and maintenance of road infrastructures are available. However, Queiroz (2003) argues that the most prominent ones are: vehicle licences, vehicle-distance travelled charges, road tolls, vignettes, charges for non-standard or overweight vehicles, and earmarked taxes on fuel. Implementation of road user charges is usually acceptable to road users but Yenny (2002) provides key underlying principles of taxing road users. He accentuates that charges should be economically efficient, equitable, cost little to collect, and not easily evaded.

Kaluba (2014) explored detailed descriptions of these methods and underlying concepts which are reproduced here.

2.1.1 Vehicle licences and renewal fees

Vehicle licences and renewal fees are the most common forms of road user charges in most countries and are easy to collect because it just requires a vehicle owner to present his/her car for examination and payment of the stipulated fees. Queiroz (2003) explains that licence fees are differentiated between different types and weights of the car to reflect the costs that each type of vehicle causes to the road. However, Yenny (2002) questions vehicle licenses as not use- related and do not fully meet the principle of sound economic policy which requires that charges are related to user behaviour i.e. anticipated damage and use of road space. Queiroz, (2003) illustrates this with an example, of two trucks of the same weight where one truck using 20,000 km per year is paying the same as one traveling 100,000 km.

2.1.2 Charges for non-standard or overweight vehicles

It has earlier been alluded that the most appropriate forms of road charges have to address use of the road space, and charges for the disproportionate damage caused by heavy vehicles. Henceforth, Queiroz (2003) laments the purpose of making charges for non-standard and overweight vehicles are based on the principle of making the road user compensate for the extra damage caused to the roads by over-sized or overloaded vehicles. However, it is difficult to come up with the ‘optimal charge’ or damage and this means that the charges rarely reflect the real costs imposed on the roads by heavy or non-standard. Further, apart from exorbitant capital cost of equipment to measure vehicle size and weight, this mode of revenue mobilization is not likely to receive high social acceptability, as generally, road user behaviour tends to alienate with policy which is perceived to infringe on freedoms of choice (Jakobsson et al. 2000; Schade and Schlag, 2003; Schade and Baum, 2007).

2.1.3 Earmarked taxes on fuel

Parry and Strand (2012) suggest another method of generating revenue for roads whereby a levy or tax is imposed on fuel. Taxes on vehicle fuel satisfy most of the basic principles of good road charges such as those highlighted by Queiroz (2003) as relatively inexpensive to collect, easy to administer, reasonably equitable, and proportionate to road use. However, Parry and Strand (2012) argue that the main disadvantage of taxes on fuel is that motor vehicle use is associated with an unusually diverse variety of externalities, including local and global pollution, traffic congestion, traffic accidents, and road damage which are not usually reflected in the fuel tax. Queiroz (2003) also points to the problem of equity in which a truck may consume more fuel per kilometre than small cars and would therefore pay more fuel taxes per kilometre travelled, but damage to the roads is not factored in.

Parry and Strand (2012) argue this inequity renders taxes on fuel to be economically not viable. On the other hand, Queiroz (2003) observes taxes on fuel are also used by Governments to promote health (such as controlling air pollution) and may not be necessarily for generating additional resources for road financing. However, what is important is how revenues generated from fuel levies are used. Kaluba (2014) notes inequity of fuel levies as not all fuel purchased is used on roads; some is consumed by locomotives on railroads and heavy mining and agricultural equipment.

2.1.4 Road tolls

Literature is replete with proponents of road tolling in enhancing revenues for sustainable road maintenance and construction. Ferrari (2002) argues that generally, tolls are imposed to objectively serve either of the two distinct purposes i.e. reducing traffic congestion or as a means to raise revenue to recuperate part of the costs planned for road maintenance and rehabilitation programmes. Yang and Bell (1997) defines tolls imposed to reduce traffic congestion as 'congestion tolls' while tolls implemented to raise revenue are called 'road tolls'. However, any type of toll road ultimately influences decisions on the chargeable toll rates as well as which toll system to be employed. For instance, Ababutain (2002) and Swan and Belzer (2010) separately argue that a toll road which aims to restrain traffic demand is likely to administer higher than average toll fees in order to discourage road users while one which primarily aims to raise revenues for road improvements would enact a socially affordable toll rate. Therefore, leverage on economies of scale would capture as many road users as possible, and promote compliance while discouraging default, which would translate into more revenues, earned (Ababutain, 2002; Swan and Belzer, 2010).

Considering that road tolls are charged directly for the use of particular facilities and are therefore equitable, road tolling is one of the most popular sources of road financing in both developed and developing countries. As observed by Munroe et al. (2006), States in the United States of America (USA) which face budget problems, embrace road tolling as an external source for financing construction and maintenance of new roads. In Europe, Broadus and Gertz (2009) observe that Germany has since 1995 led more than 20 other European countries in tolling Heavy Goods Vehicles (HGV) for using the roadway which has benefited these counties in expanding sources of revenue beyond the gas tax, managing demand for road space, encouraging efficient operations, levelling the tax burden on haulers registered in different countries, and reducing carbon dioxide emissions. Elsewhere, Muller (2001) writes that toll roads have also been introduced for purpose of revenue mobilization in South America and Asia, with Japan embracing a fair share of road pricing on bridges and tunnels.

In Africa, limited financing and maintenance of roads has also prompted several countries to introduce road tolls as an alternative means of financing the road sector (Heggie, 1999, p. 87). South Africa is the pioneer going by SANRAL (2009) reports that "tolls were first collected as far back as 1700, and currently with around 51 conventional toll plaza points across South African road network, all of which are being operated indirectly through various private concessionaires". In other African countries such as Namibia, Botswana and Tanzania, Munroe et al. (2006) observe that road authorities collect entry and exit tolls from foreign registered vehicles at their geographical boundaries or borders with other countries.

Perhaps the most compelling argument against road tolls is provided by Queiroz (2003) who postulates that road tolls is an expensive method of raising revenue. He observes that significant capital costs (construction of toll plazas and tollbooth, controlled access) and operating costs (toll collection) have to be incurred for revenue collection from tolls to be efficient. Wachs (2006) also indicates that toll road financing is often a complex system divided among many organizations and jurisdictions. Heggie (1999) supports views above and adds that tolling may reduce road-financing gaps but is only economic on a small part of the road network.

Despite the concerns, this is one of the road financing methods that has been approved for implementation on some selected roads in Zambia. This method has never been implemented before in Zambia despite numerous intentions over the past two decades as documented by Aurecon (2010). The understanding is that road tolling is a new concept which depends on mode of implementation, for it to contribute effectively as a means for additional financing for roads in Zambia. Subsequent sections will explore Zambia's road sector plans, and road tolling plans.

2.2 Financing models in the road sector

Tanaka et al. (2005) observe that Governments have traditionally been the sole financiers, implementers, and regulators of road infrastructure. This can be attributed to the wider public interest whereby roads are mainly funded using public funds due to the vital role they play in facilitating socio- economic development for which many view them as a "socially beneficial activity" (Munroe et al. 2006, p.3). This observation stems from the fact that roads, like most transportation systems, are often highly political and subject to wider debate with diverse range of stakeholders such as motorists, truckers, and the general public and many others (Ng and Loosemore, 2007; Tanaka et al. 2005).

However, Grimsey and Lewis (2002) observe that limitations on public funds available for financing infrastructure projects such as roads has led to many a government to invite the private sector to enter into long-term contractual agreements for financing.

2.3 Types of private financing schemes

Kwak et al. (2009) broadly define a PPP as "a cooperative arrangement between the public and private sectors that involves the sharing of resources, risks, responsibilities, and rewards with others for the achievement of joint objectives". Siemiatycki (2013) argues that Public-private partnerships (PPPs) are guided by the belief that governments and firms working in meaningful collaboration will deliver projects that have better outcomes than any one party could deliver on their own, further arguing that PPPs are a cost-efficient and effective mechanism for the implementation of public policy across a range of policy agendas. This assumption is reinforced by Tsamboulas et al. (2007) who provide a summary of plausible justifications for using the private sector in infrastructure projects as follows:

i. "Minimisation of required public funds for project financing, levied from additional taxation and contributing to state budget deficits;
ii. Benefits resulting from private sector management and control efficiency during construction and operational phases of the project; and
iii. Freeing of public funds through the national budget for use in other projects".

PPP models range from greater public sector responsibility (such as Design-Bid-Build or Design-Build) to greater private sector responsibility (such as BOT, BTO, DBOM, DBF and DBFO, etc) and full privatisation (such as BOO, BOOT) (Zambia PPP Act of 2009).

2.4 Pitfalls of PPP models

2.4.1 Overview of risks associated with PPP models

Critical views on PPPs are largely provided by Meaney and Hope (2012) who demonstrate that some PPPs are not able to drive technical efficiency, a key motive behind PPPs. They further argue that private sector financing costs are higher than the government's cost of debt, and hence PPPs are more expensive to finance than traditional public procurement. Thus, as the argument goes, PPPs can only make cost benefits where the private sector is able to generate substantial efficiencies in operations. Meaney and Hope (2012) observed that governments are suffering immensely poor VFM through reduced negotiation power as the private sector demands more and more incentives from government, with the net effect being that government were now bearing more risks than the private partner.

3. Methodology

The methodology used involved interviews, study tours, and desk study. However, this paper is largely premised on desk study.

(i) **Interviews:** Targeted expert interviews were conducted with selected engineers and managers involved in road maintenance, construction and financing in Zambia.
(ii) **Field Visits**: In course of their duty, the authors have collected data on road financing strategies. This experience was key in successfully completing this treaties.
(iii) **Desk Study**: extensive literature review through desk studies was conducted.

4. Findings

Key findings are presented below:

4.1 Interviews

The lack of appropriate financing strategy for Zambia's ambitious project of building 8000km of bituminous roads in order to transform the country from a landlocked into a land linked country, could not guarantee programme sustainability. This was evidenced by the huge number of stalled projects across the country. It was established that that mounting national debt could further scupper the options for accessing cheaper capital for project implementation. This would make it hard for the country to recover the project losses and return to sustainable means of maintaining and constructing roads. There was general consensus among the experts that an optimal balance should be maintained between maintenance and capital road projects in order to ensure sustainability.

4.2 Field Visit

Traffic assessments during field visits negated the prospects of successfully tolling peripheral road links due to lower traffic volumes. This further suggested that relatively higher operational cost would reduce available resources for road maintenance if toll collections were ring-fenced on roads where they are collected. It was established that roads deprived of maintenance contributed to public dissent and had a high probability of reducing the willingness-to-pay.

4.3 Desk studies

Results from literature review clearly demonstrated that resources for road maintenance and construction would never be enough, and that it was difficult to determine with absolute precision the financial requirements for clearing backlog maintenance. Raising of additional resources for road maintenance and construction entailed looking beyond traditional sources of income. User-pays-principle through road tolls, road tax and fuel levy and engagement of strategic partnerships through private finance initiatives and public-private partnerships would thus play a pivotal road in sustainable road maintenance.

Whilst leveraging on the power of PPPs, recent experience with PPPs has not always been positive. Most PPPs tend to be unsuccessful due to "wide gaps between public and private sector expectations; lack of clear government objectives and commitment; complex decision making; poorly defined sector policies; inadequate legal/regulatory frameworks; poor risk management; low credibility of government policies; inadequate domestic capital markets; lack of mechanisms to attract long-term finance from private sources at affordable rates; poor transparency; and lack of competition" (Kwak et al. 2009, p.51).

5. Discussion

Sustainability in road infrastructure projects should be at the core of decision making prior to launching any project. A well structured financing strategy should be in place clearly defining the roadmap to long-term project financing, carefully selecting from among the available models those that meet the economic, social, political and technical set up of our country. Management of stakeholder expectations should constitute a well-structured strategy that emboldens the policy, legal and institutional set-up of the nation's road sector vehicles.

From the work of Potts (2002) and Tanaka et al. (2005), we identify that evaluation of the financial viability of private financing projects requires the development of an investment model in which financial indicators such as payback, internal rate of return (IRR) and net present value (NPV) are used for measuring the value of the investment. Project analysis criteria which may be used in Cost Benefit Analysis (CBA) and NPV calculation to appraise the desirability of a toll road project requires further discussion. For developing countries like Zambia, Tanaka et al. (2005) propose undertaking a transparent VFM risk assessment rather than just relying on qualitative techniques.

The significance of social and political feasibility in infrastructure projects cannot be over-emphasized. Despite correlation between a country's infrastructures to its economic growth, it is critical to note that social and political feasibility of policy measures, are among the major issues in contemporary transport policy debates. Much of the growing debate among stakeholders, which precede any consideration for implementation, has been on whether policy surrounding infrastructure projects can either be socially or politically feasible or both as argued by Rienstral et al. (1999).

They further argued that although various types of analyses had been applied to measure social feasibility in road infrastructure projects, many have been inconclusive because they were largely subjective rather than objective due to their individualistic perceptions which were not collective.

From reviews of studies on social feasibility of policies surrounding infrastructure development, it is evident that the level of acceptance depends on:

a) The value of rewards or social benefits expected to be derived from the implementation of the policy, and not on how severe punitive measures for non-compliance or default may be
b) The level of appreciation of the accruable benefits resulting in a positive approval or support of the proposed infrastructure policy.

This was also illustrated by Zhou and Chilunjika (2013) who, perhaps, provided the most compelling evidence of a low social acceptance to PPP arising from poor understanding of social benefits through the case of Gauteng Freeway Improvement Project (GFIP) in which the Government of the Republic of South Africa borrowed debt to improve the Gauteng road network pre 2010 football World Cup. An attempt to introduce Open Road Tolling (ORT) through E-Tolling years later after the World Cup had been held and roads had already been worked on was met with widespread public disapproval and the expensively assembled Electronic Tolling Collection (ETC) gantry system lies in the balance as political acceptance looks set to disown the project earlier approved.

6. Conclusion

This paper had set out to achieve the following objectives: 1) Identifying alternative road financing strategies, and 2) Recommending best practices within the context of Zambia.

It can therefore be concluded that the paper adequately identified road financing strategies. These were:

1) Government financing through parliamentary appropriation
2) Use of fuel levy
3) Use of road tax
4) Road tolling
5) Private Finance Initiative
6) Public-Private Partnership
7) Loans and grants

Each of these strategies was found to have their own strengths and weaknesses, which could be explored further in future studies.

7. Recommendations

In making recommendations of best practice for use in Zambia, several considerations must be made. These include aspects of social, political and institutional arrangements and their supporting economics. Therefore, the following recommendations were made.

1) Deployment of institutional and legislative framework that enables the road fund to directly collect and manage the road user charges for efficient and effective use in road maintenance. This cuts out the longer cycles in retrieving revenues from consolidated government coffers. Further, this enables Road User Charges to be securitized for bridging finance,
2) Deploy cheaper revenue collection methods by using existing structures, rather than creating expanded cost centres, such as the case may be in wide-scale tolling. The use of Zambia Revenue Authority to collect Fuel Levy as well as the use of Road Transport and Safety Agency to collect Road Taxes/Vehicle License Fees seems more efficient in that respect,
3) The macro-economic environment of a country is an important factor to consider when deciding on the financing and implementation arrangements. Parity in pricing road user charges, demands consistency with people's earnings. This improves the willingness-to-pay,
4) Exercise caution when deploying PPPs: undertake complete project appraisal along with associated proposed financing strategy while ensuring that a political environment and legislative framework is in place to support the ventures,
5) Efficient budget controls and effective project management. This helps in lowering construction unit costs as well as incremental project related costs and claims,
6) Overload control programme to limit damage to the road asset. Further, realistic pricing for road use demands getting closer to the real charge and most countries including Zambia have in place axle load limitations for each road, and strict penalties/fines are applied on overloaded and/or contravening vehicles. However, this method of revenue generation has been there for some time, and may not contribute significantly to creating additional financing for roads in Zambia if there is no increase in the user charges and/or if efficiency gains are not made.
7) Utilise all user charges for road maintenance in order to reduce the backlog created by deficits in government appropriated funds.

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Challenges of Student Housing Provision through Public Private Partnership

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Abstract

The conditions of suitable accommodation congruent to students' academic pursuits are at their worst decline. Inadequate hostels for students in Nigerian Universities have been of great concern to Government and the University authorities. In the absence of public funds for infrastructure projects, the government's attempt to attract the private sector in the provision of student housing has not recorded significant achievement. This study reports on the challenges faced by developers in adopting the Build Operate Transfer (BOT) model of project delivery with focus on public private partnerships (PPP) in Nigeria. The study found that developers perceive investment in student housing under BOT as worthy of investment. The study used a mixed method of data collection. One hundred and twenty questionnaires were administered to members of the Real Estate Developers Association of Nigeria, and interviews were conducted with the Nigerian Infrastructure Regulator commission (ICRC). The study found that Developers are willing to adopt BOT for Student Housing. The study concludes that lack of long term loans, time and cost intensiveness of a BOT project, high interest rate on loans, disinterest on the part of lending institution, and preference for traditional procurement route are the challenges faced by developers in adopting Build-Operate-Transfer for the provision of student housing.

Keywords: build-operate-transfer, Nigeria, public private partnership, student housing

1. Introduction

Housing is one of the basic needs for everyone closely related to human life cycle (Nurdini and Harun, 2012). Nowadays, proper housing is considered to be the very basic requirement of modern day living. Aigbavboa (2015) asserts that student housing has long been regarded as an essential component of the facilities provided by higher learning institutions in assisting students to expand their intellectual capabilities.

Hostel accommodation is regarded as one of the essential facilities required in any academic environment to facilitate learning (Muhammad, Dodo & Adamu, 2014). Students cannot survive

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without housing facilities. Accommodating students on campus is second only to the dissemination of specialist knowledge (Aigbavboa & Thwala, 2012). Therefore providing student housing is important to any tertiary institution. Najib, Yusof & Osman (2011) defined student housing as a supervised living and learning hostel consisting of shared housing facilities and amenities for the community of residents who use it, is built on-campus, owned by the university, provided for inexpensive chargeable rooms, and administered to accommodate the undergraduate or postgraduate students.

Nigerian Universities have traditionally accommodated students almost exclusively on campuses and hostel buildings because student housing has been an integral component of Nigerian universities. Financial constraints and population explosion of students have made this impossible and difficult for universities to provide on campus accommodation for students which has resulted in overcrowded buildings, continuous deterioration and the decay of these facilities (Onyike & Uche, 2012)

The conditions of most hostels in Nigerian universities is not congruent to students' academic pursuits and is at its worst decline. According to (Muhammad, Dodo & Adamu (2014) overcrowding is the major problem in hostels. The report by the presidential committee on critical needs of Nigerian Universities stated that only 111,509 (8.9%) of the total student population of 1,252,913 students across 61 public universities are accommodated on campus (Edet, 2012). According to AbdulAzeez, AbdulHafeez and Kado (2015) only few universities in Nigeria can accommodate up to 50% of their student population and there is as much as 90% deficit in some Universities. Alaka, Pat-Mbano, and Ewulum (2012) lament on the overcrowding in hostels in Nigerian universities and this has mounted pressure on the facilities.

In 2004 the estimated cost of meeting the shortfall in student accommodation alone in Federal Universities was estimated at ₦63.19 Billion (USD175Million) (Sulaiman, 2004). It is obvious that government will find it difficult to do it alone. In the absence of sufficient public funds for infrastructure projects, it makes sense to explore innovative financing models such as Build Operate Transfer (BOT). The government has in this regard encouraged private developers to go into hostel development and management, and relieving federal universities of these duties as directed by the Federal of Ministry of Education in 2004.

The government's attempt to attract the private sector in the provision of student accommodation, has however not recorded significant achievements (Muhammad, Dodo and Adamu, 2014). Ibrahim (2014) found the level of private sector participation in providing hostel accommodation in Nigeria tertiary institutions using BOT to be low. Zaki (2011) concludes from his research that university hostel development schemes under the Build-Operate –Transfer scheme is economically viable and promise to be profitable to developers who engage under the scheme. However investors and developers haven't been able to participate in the scheme. According to Dahiru (2011) most BOT infrastructure projects fail at procurement stage in Nigeria. Therefore this paper looks into the challenges faced by developers in the provision of student housing through Build Operate Transfer.

2. Literature Review

2.1 Student housing

Universities are not only responsible for providing facilities to cater for academic (teaching and research) activities, but they are also saddled with the responsibility for ensuring that adequate facilities for living while studying, are provided for the students to stimulate their learning abilities (Alaka, Pat-Mbano & Ewulum, 2012). Bella-Omunagbe (2015) defined student housing as accommodation specially constructed to create an environment that supports the living and learning experience of students while pursuing their education. South African Government Gazette (2013) defines on-campus accommodation as “units for accommodation within the university premises, which can differ from big blocks of rooms which are similar to residence halls, to multiple bedrooms that accommodate students”.

Student Housing are either located on campus or off campus. They may be owned and managed by the institution; by a private entity; or by partnership between the institution and a private entity. Student hostels can be institutionally or privately managed; self-catering or with catering services; and a variety of shared amenities like bathrooms, kitchens, laundry, lounge and recreational facilities. In other cases, basic amenities can be en suite. Student Housing must be well managed to promote and sustain a safe and comfortable environment that promotes the living and learning experience of occupying students (Penven, Stephens, Shushok and Keith, 2013).

Various studies have shown the importance of On-campus hostels. Kobuea, Oke, Aigbavboa (2017) observed that being accommodated in a harmless, safe, well managed residence is both socially and academically advantageous for students. Equally, Thomsen (2007) opined that student housing or accommodation contributes critically to the attainment of the overall objectives of universities. On campus student housing enhance the integration of students, promote diversity and foster unity. According to the authors, student accommodation provides security and privacy, as well as promote good friendships among the residents.

Student accommodation also provides an environment that stimulates intellectual development, allows for easy interaction with fellow peers; fosters team and communal spirit among students; make students see studying as their main occupation and also provide a community setting (Onyike and Uche, 2010; Banning and Kuk, 2011; Najib and Osman, 2011). Therefore providing student housing should be a priority for universities.

2.2 Public private partnership (PPP)

There is a huge demand for public infrastructure and services worldwide and government's budgets are restricted. As the gap between the growing demands for public services and infrastructure, on one hand, and financial and budgetary constraints, on the other hand, is constantly widening, the governments around the world especially in developing countries are interested in implementing PPP projects as a way of delivery the much needed infrastructure including student accommodation (Khmel and Zhao, 2016). According to Zhang and Chen (2013) Public–Private Partnerships (PPPs) play an important role in bringing the private sector competition to public monopolies in infrastructure development and service provision. The PPP model also assists in merging resources of both public and private sectors to better serve the public.

PPPs are a long-term contract between a private and a public party for the provision of public services or goods. Sources of funds or Sponsors of the project can include banks, pools of banks, international financial institutions, any counterparty of the project company. Capital for the project can be provided from different sources and use one or several financial instruments (Khmel and Zhao, 2016).

One important type of PPP arrangement that is mostly practiced is the Build- Operate-Transfer. In this system, a private sponsor finances the design, construction, maintenance, and operation of a public project for a specified concession period, at the end of which it transfers ownership to the government agency, hopefully after recouping its costs and achieving profits (Algarni, Arditi, and Polat, 2007).

The main idea behind using BOT is to alleviate the spending on governments' side by seeking capital from external financiers especially on large-scale projects. Project participants include the granting authority, usually a government agency; the project sponsor; and usually one or more financial institutions. The granting authority identifies project requirements, establishes the concession period, solicits tenders, and awards the contract. The project sponsor typically is a consortium or a joint venture of engineering, construction, and venture capital firms.

2.3 Build operate transfer in providing student housing

Private sector participation is the involvement of formal and informal private enterprise in the provision and management of accommodation in tertiary institutions (Asare- Kyire *et al.*, 2012). One of the reasons for private sector participation is that governments are facing deep budget and public finance difficulties. University authorities have also complained that there has been no finance to adequately provide student accommodation. The Federal Government of Nigeria has been responsible for providing the capital and recurrent expenditure of the Federal owned universities in Nigeria. Over the years the capital allocations to universities have been declining. Consequently, the Nigerian government is no longer able to provide adequate funding to enable universities meet their management needs. The Federal Government of Nigeria in 2004 directed Heads of Tertiary Educational Institutions in the country to hand over hostels in campuses to private managers and also encourage private investors to build hostels for students. However the policy was not fully implemented. In 2006 the Federal Government issued a policy statement directing that new hostels can only be constructed through Public-Private Partnership (PPP) based on Build Operate and Transfer (BOT) basis.

According to Okebukola, Abdullahi, Balogun and Bankole (2004) the objective of the policy is to encourage private sector participation in the provision of hostel facilities in universities and to encourage private sector to plough back some of their profit into very critical areas of national need. By involving the private sector, universities are able to channel their resources more to teaching and research activities rather than to municipal functions.

3. Methodology

The approach used to collect, asses and analyze the data is both quantitative and qualitative (mixed method) because the study sought to understand the perception of stakeholders (developers and Infrastructure Concession Regulatory Commission) on the challenges in providing student housing through BOT. The sample was purposively selected based on their knowledge and experience on Public Private Partnership and student housing.

Questionnaires were administered to Real Estate Developers and interviews were conducted with the Director General and the Public Private Partnership resource centre of the Infrastructure Concession Regulatory Commission. The respondents were requested to rank and indicate their level of agreement on statements to challenges that they face. Descriptive statistics were used in analyzing and rating the responses obtained from the respondents through questionnaires. One hundred and twenty questionnaires were administered to developers Registered with the Real Estate Developers Association of Nigeria. Eighty Two were received back translating to sixty eight percent was response rate.

4. Findings, Analysis and Discussion

In table 1, perceptions of developers on the viability and feasibility of investing in student housing in tertiary institutions is presented. As shown 76% of developers perceived investment in student housing under BOT to be a worthy investment. On the other hand, 24% of the respondents did not think that it was worth it investing in student accommodation. These feedings suggest that largely, private developers are interested in investing in student housing given that the marjority saw the investment to be worthwhile. This finding seem to confirm Zaki’s finding (2011) on viability of BOT in student housing in which they found that they were profitable and viable as a business venture.

Table 1: Private Developers' perception on viability of investing in student housing under BOT

Type of response	Frequency (Fr)	Percentage (%)
Viable	61	74
Not Viable	21	24
Total	82	100

Developers where asked if they were willing to participate in the university BOT scheme. Table 2 shows the willingness of developers to go into Build Operate Transfer for Hostel Provision. About 85% of the respondents indicated willingness to go into BOT for Student Housing and 15% were unwilling to invest in student hostel under BOT.

Table 2: Willingness to participate in build operate transfer in student housing provision

Type of response	Frequency (Fr)	Percentage (%)
Willing	70	85
Not willing	12	15
Total	82	100

The study looked into developers' major sources of finance. As can be seen from Table 3 most of the developers indicated that they utilised internal funds, 81% of the respondents indicated thus, and while 68% of the respondents used bank loans as the major sources of finance for project development. Other sources of finance include loans from thrift and credit society as well as foreign direct investment. BOT projects need long term loans. Most banks only give short term loans. Medium and long term loans are usually obtained from access to insurance and pension funds. There is need for developers to have access to long term loans.

Table 3: Sources of Finance used for funding project

S/N	Sources of finance	Frequency (Fr)	Percentage (%)
1	Internal funds	67	81
2	Thrift and credit society	12	15
3	Banks loans	56	68
4	Insurance and pension funds	-	-
5	Bonds	-	-
6	Foreign Direct Investment (FDI)	4	5

Table 4 shows the level of participation in provision of student housing. Findings show that 59% of the developers adjudged their level of participation to be low (below 45 %), 32% percent of private developers perceived their level of participation as average. Nine percent of developers ranked their participation in BOT for student accommodation to be high. None of the respondents ranked their participation as very high. The finding on BOT participation by the private sector conforms to findings by Muhammad *et al*. (2014) who from their studies found that most developers have not been able to participate in the BOT scheme for student housing.

BOT is a more expensive method of funding capital projects because of the requirement to finance the profits of the private firms (financial parties) and the additional borrowing costs (interest rate). Developers have difficulty in accessing long term credit. Some financial institutions especially commercial banks have not been willing to grant long term loans. The interest rate in Nigeria is double digit and banks are not willing to give long term loans. This is in agreement with Shonibare (2010), who argues that local banks provide inadequate access to long term capital and the interest rate is high.

Table 4: Developer's level of participation in student housing provision under BOT

Level of participation	Frequency	Percentage (%)
Very high (≥70%)	-	-
High (60-69%)	7	9
Average (45-59%)	26	32
Low (30-44%)	34	41
Very low (<30%)	15	18
Total	82	100

4.1 Challenges of student housing provision through build operate transfer

The long term nature of BOT investment has also posed challenges to investors and developers alike. As most Nigerian investors prefer short term investment while BOT hostel project are long term. Developers also decry the lack of commitment by tertiary institutions to attract private sector investment in the provision of hostel.

Table 5 presents the findings on the challenges of student housing through BOT. The time and cost intensiveness of a BOT project has scared away investors. Nigerian investors seem to opt for projects which are short time in nature whereby they are able to invest and recoup their investment after a short period rather that tie down their capital for a long term. Zaki (2011) reached a similar conclusion and assert that private investors in Nigeria may not be willing to tie down their capital in investment that will start yielding profit in 15 years.

The finding of this study is also in line with Ayeyemi (2012) who opined that long term nature of BOT has been a challenge to its adoption and implementation. In addition, findings show that governance problems in Nigeria with its government ever changing policies tends to scare away private sector investment. Inconsistent Government policy has also affected the adoption. According to Akuta (2013) Policy continuation is something that is lacking in Nigeria and therefore not conducive to investment.

Table 5: Challenges of student housing provision through public private partnership

Challenges	1	2	3	4	5	Sum	Mean
Time and cost intensiveness of a BOT project	1	3	5	15	59	375	4.57
Lack of long term loans	1	7	3	19	52	360	4.39
High interest rate on loans	4	6	3	19	50	360	4.39
Disinterest on the part of lending institution	4	7	9	16	46	339	4.10
Preference for traditional procurement route	4	10	6	22	40	330	4.02
Inconsistent government policy	12	19	15	16	20	323	3.94
Lack of transparency in the procurement process	7	7	9	22	37	321	3.91
Hostel provision still seen as the role of the government	4	16	10	18	34	312	3.80
Challenge of structuring a BOT package	9	10	7	20	36	310	3.78
Resistance to change	5	12	14	22	29	304	3.71
Lack of commitment by higher institution to explore BOT	10	23	7	15	27	269	3.28
Inexperience and lack of understanding of BOT	14	19	10	17	22	260	3.17
Poor regulation of BOT concession agreement	27	22	13	15	4	234	2.84
Fear of vandalism (During student protest)	20	23	10	17	12	224	2.73
Lack of skill and expertise in implementing BOT projects	27	16	22	10	7	200	2.44
Low level of confidence in BOT procurement method	30	20	19	7	6	185	2.20

4.2 Response from the Infrastructure Concession Regulatory Commission

According to the Infrastructure Concession Regulatory Commission there was no record of any Build Operate Transfer Hostel in Nigeria. The ICRC being the custodian of all concession agreement and all PPP project don't have any record of BOT project while there a number of BOT hostel projects in the country. This may be due to the fact that universities were autonomous entities and so they were free to enter in to a contract with any organization or entity they chose to. The university councils ratify which contracts they would like to sign and not the ICRC.

According to the respondents, Build Operate Transfer (BOT) PPP models have been used in several jurisdictions where new infrastructure is required. BOTs by nature require significant investment from the private sector in the areas of technical and financial expertise. As a result, private companies are typically concerned about ensuring due returns to investors and shareholders. In other words, managing risks such as revenue risks, financing risks and construction risks are of optimum importance to private companies.

5. Conclusion

There is a huge demand for public infrastructure and services worldwide whereas government's budgets of most countries are always limited. One of the major problems facing higher institutions in Nigeria is shortage of housing for student accommodation. Private sector has been brought into this space to contribute towards providing hostels through BOT. This study has examined the challenges of BOT procurement in providing student housing in universities in Nigeria. The study also looked into the procurement procedure for PPP in Nigeria. The study found that developers perceive investment in student housing under BOT as worthy of investment. Developers are willing to go into BOT for Student Housing. The study concludes that lack of long term loans, time and cost intensiveness of a BOT project, high interest rate on loans, disinterest on the part of lending institutions, and preference for traditional procurement route hinder the adoption of BOT in Nigeria to develop student accommodation. Future research should investigate how the issue of finance can be tackled.

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