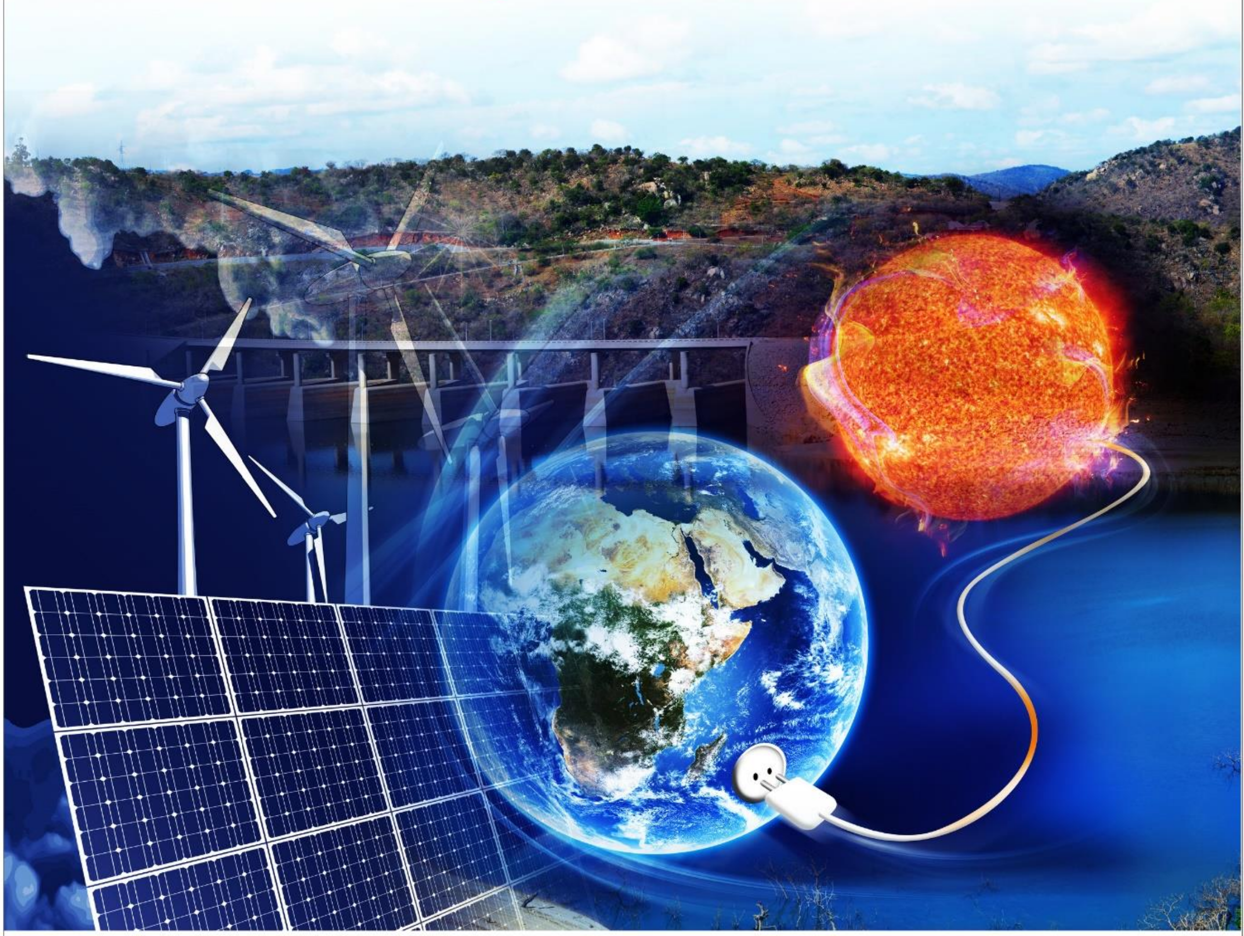
PROCEEDINGS OF THE 4TH INTERNATIONAL CONFERENCE ON INFRASTRUCTURE DEVELOPMENT AND INVESTMENT STRATEGIES FOR AFRICA

DII - 2017

30 August – 1 September 2017
Livingstone, Zambia



INFRASTRUCTURE AND SUSTAINABLE DEVELOPMENT - IMPACT OF REGULATORY AND INSTITUTIONAL FRAMEWORK

Editors Dr EM Mwanaumo, Dr I Musonda & Dr F Muleya
Co-editors Dr BP Mwiya, Mrs CS Okoro, & Dr A Lungu

DII – 2017

4th International Conference on Development and Investment in Infrastructure - Strategies for Africa

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2017

Published by
The Development and Investment in Infrastructure (DII) Conference Series
P. O. Box 17011
Doornfontein
Johannesburg, South Africa, 2028

ISBN: 978-0-620-74121-7

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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-2017). The DII-2017 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 2017 conference, themed *"INFRASTRUCTURE AND SUSTAINABLE DEVELOPMENT – IMPACT OF REGULATORY AND INSTITUTIONAL FRAMEWORK",* 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:

- Infrastructure development strategies for developing countries
- Renewable energy for sustainable growth and development
- Human factors in infrastructure development
- Legal and ethical issues in infrastructure development
- Infrastructure finance, procurement and value engineering
- Sustainable development and growth infrastructure
- Appropriate technology and innovation
- Integrative infrastructure development planning
- ICT in infrastructure development
- Social infrastructure development in developing countries
- Infrastructure, climate change and pandemics in developing countries

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-2017

ACKNOWLEDGEMENT

The Organising Committee of the DII-2017 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, A+urban technics, Wah Kong Construction, the Universal Mining and Chemical Industries Limited, Zambia Environmental Management Agency, China Civil Engineering Construction Corporation Zambia Limited, Kalijee Construction Zambia Limited, AVIC International Corporation, 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 Dr Innocent Musonda, Dr Erastus Mwanaumo, Dr Franco Muleya, Dr Trynos Gumbo, Dr Justus Agumba, Prof Didibhuku Thwala, Prof Clinton Aigbavboa, Dr Balimu Mwiya, Dr Alice Lungu, Dr Chabota Kaliba, Dr Nelly Chunda-Mwango, Prof Mundia Muya, Mrs Chioma Okoro, Ms Changwe Kafukula, Ms Chama Mwansa and Mr Brian Mutale are recognised. The support of Mr Ansary Nazeem and Prof Steve Ekolu is laudable.

DISCLAIMER

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

Dr Innocent Musonda (Chairman: Scientific Programme)
Prof Didibhuku Thwala
Prof Clinton Aigbavboa
Dr 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 I Musonda, University of Johannesburg, RSA
Dr B Mwiya, University of Zambia
Prof CO Aigbavboa, University of Johannesburg, RSA
Prof D Thwala, University of Johannesburg, RSA
Prof M Muya, University of Zambia

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.

Dr C Trinkl, Technische Hochschule Ingolstadt (THI), Institute of new Energy Systems (InES), Germany
Dr D Mzyece, Oxford Brookes University, UK
Dr E Munshifwa, Copperbelt University, Zambia
Dr JN Agumba, University of Johannesburg, RSA
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Prof Mbaiwa, Okavango Research Institute/ University of Botswana
Prof N Gil, MBS, University of Manchester, UK
Prof PD Rwelamila, University of South Africa, RSA
Prof W Zörner, Technische Hochschule Ingolstadt (THI), Institute of new Energy Systems (InES), Germany

THE PEER REVIEW PROCESS

Overview

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 66 submissions, 41 papers were finally accepted and included in the DII-2017 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: Academic Programme
University of Johannesburg

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 centers.

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 organisations 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 in excess of 490 undergraduate, 300 Master of Engineering students and 15 Doctoral Candidates across all the departments. There are currently 60 academic members of staff in its five departments. The school is realigning itself to become a trainer of trainers by increasing its capacity in training at postgraduate level. 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. This programme is hosted by the School of Engineering. From this experience, the School identified many gaps in engineering management fields, the ICT sector, and project management area and developed a number of other programs in electronics, construction and engineering management. The aim was to elevate the caliber 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 Engineering

2. Master of Engineering in Engineering Management
3. Master of Engineering in Construction Management
4. Master of Engineering in Structural Engineering
5. Master of Engineering in Water Resources Engineering
6. Master of Engineering in Environmental Engineering
7. Master of Engineering in Project Management
8. Master of Engineering in Electrical Power Engineering
9. Master of Engineering in Telecommunications Systems
10. Master of Engineering in Information and Communication Technology Security
11. Master of Engineering in Information and Communication Technology
12. Master of Engineering in Computer Communications
13. Master of Engineering in Information and Communication Technology Policy, Regulation and Management
14. Master of Engineering in Wireless Communications
15. Master of Engineering in Geo-Informatics and Geodesy
16. Master of Engineering in Renewable Energy Engineering
17. Master of Engineering in Production Engineering and Management
18. Master of Engineering in Thermo-fluids Engineering
19. MEng in High Voltage Engineering and Power Management *(New Programme)*
20. MEng in Electromagnetic Compatibility and Electrical Safety *(New Programme)*

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

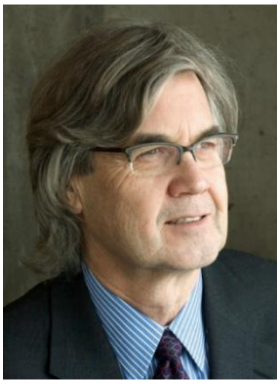
The Infrastructure Investment and Development (DII) conference is an international conference which provides a forum for discourse on the status quo regarding Africa's massive shortfall in infrastructure development and investment that limits its productive capacity and global competitive advantage. Inaugurated in 2014 in Livingstone, Zambia, the conference has been jointly hosted by the University of Johannesburg, the University of Zambia, Copperbelt University, National Council for Construction of Zambia, the Construction Industry Development Board of South Africa, and the Chartered Institute of Building of United Kingdom the Africa Region, and was recently (in 2016) supported by the Network of Energy Excellence for Development (NEED), a project funded by the European Union (EU) and implemented by the African, Caribbean and Pacific Group of States (ACP). The conference is a great platform for international delegates including Built Environment professionals, researchers, academics and post-graduate students who are passionate about eliciting solutions to the challenges faced in infrastructure provision and sustainability. The conference further offers platform for brainstorming and probing into strategies to realise Africa's vision in securing the future and attaining full potentials in infrastructure development and investment.

Themed, *"INFRASTRUCTURE AND SUSTAINABLE DEVELOPMENT – IMPACT OF REGULATORY AND INSTITUTIONAL FRAMEWORK",* the 2017 conference will focus on regulations, and general infrastructure development and investment in Africa, addressing a broad range of topics around infrastructure investment, development and sustainability. The confirmed keynote speakers include:

Prof Luke MUMBA

LUKE MUMBA has a wealth of knowledge and experience gained over his illustrious academic and professional career that spans over 25 years. Born and raised in Zambia, Prof Mumba holds a doctorate degree in genetics from University of Cambridge (1994); a Master's Degree in Molecular Genetics from the University of Wales, UK, (1987); and a Bachelor's Degree in Biology & Chemistry from UNZA (1985). He received recognition as an Extraordinary Associate Professor in the Department of Botany & Zoology of the University of Stellenbosch, South Africa between 2012 and 2014. He is a recipient of four international research fellowships and awards (British ODA Fellowship; Beit Trust Fellowship; UNESCO Fellowship; and the Rodger Gilbert Memorial Prize Award).

Luke is the Founding Director of the Biotechnology Outreach Society of Zambia, a professional association spearheading biotech outreach in Zambia. He is also one of the founding trustees of the Zambian Academy of Sciences. He has received many awards, fellowships and visiting scholarships including from the Hawaii State Foundation (Honolulu), Austrian (Innsbruck) and the British ODA Fellowships. He has served in many national boards including as Chairman of the National Aids Council Biosafety Committee, member of the Board Directors of the Zambia Wildlife Authority (ZAWA), Member of the National Plant Genetic Resources Committee, member of the University of Zambia Council and Senate, and as member of the National Biosafety Committee. Luke has also presented, researched and written widely on genetics, biotechnology and on science, technology and innovation (STI) in general. Prof Mumba has contributed to the development of STI strategies and policies at national, regional and continental levels in Africa. He is currently a member of the African Union Commission (AUC) Monitoring and Evaluation (M&E) Committee on the "Science, Technology and Innovation Strategy for Africa" (STISA-2024).



Prof. Murray METCALFE

MURRAY METCALFE is Professor, Globalization in the Faculty of Applied Science and Engineering at the University of Toronto (UofT), and is also a Senior Fellow at UofT's Global Cities Institute. He holds a B.A.Sc. in Industrial Engineering from the University of Toronto and a M.S. and Ph.D. in Engineering-Economic Systems from Stanford University. He began his professional career at McKinsey & Company, the management consulting firm, and then spent over 20 years in the venture capital industry in the U.S., until returning to academia in 2008. In the spring of 2008 and again in the fall of 2016, he was a Visiting Scholar at the Tokyo Institute of Technology.

Murray is a member of a team from multiple faculties - management, global affairs, and engineering - conducting research on the scaling of innovation in cities in the developing world. As part of that effort he was a contributor to the edited volume *Innovating for the Global South* (University of Toronto Press, 2014). Among his teaching responsibilities Prof. Metcalfe has developed and taught the courses "Technology, Engineering and Global Development" and "Innovative Technologies and Organisations in Global Energy Systems." He also led a combined team of UofT and IIT professors, who taught a course at the Indian Institute of Technology Bombay (IIT Bombay) in Mumbai, India. He also serves as a senior advisor in the private equity area at LMCG Investments, an investment management firm in Boston that is a subsidiary of the Royal Bank of Canada. He is also involved in several not-for-profits working in the areas of global development, social entrepreneurship and sustainable large cities.

Prof. Amira Omer Siddig OSMAN

AMIRA OMER SIDDIG OSMAN is currently an Associate Professor in Architecture at the University of Johannesburg. Amira obtained both her B.Sc. and M.Sc. Architectural degrees from the University of Khartoum in Sudan. She also holds a post-graduate diploma from the Institute for Housing Studies in Rotterdam (IHS) and a PhD in Architecture from the University of Pretoria. She has worked as an architect in Sudan and South Africa. Amira has also worked as a United Nations Volunteer (UNV) in Maseru, Lesotho and as a Senior Researcher at the Council for Scientific and Industrial Research (CSIR) in Pretoria. She is a registered Professional Architect with the South African Council for the Architectural Profession.

Amira has conducted research and taught at a number of institutions for almost 30 years. She established the Housing and Urban Environments (HUE_UP) research unit at the University of Pretoria and the DESIGN | MAKE | TRANSFORM" design Unit 2 at the University of Johannesburg. Amira was a convener for the World Congress on Housing, 2005 held at the University of Pretoria and of the Sustainable Human(e) Settlements: the urban challenge, 2012, hosted by FADA, University of Johannesburg and its partners. She also served as UIA 2014 Durban General Reporter for the International Union of Architects (UIA) and the South African Institute of Architects (SAIA). She is also a consultant and researcher at the

Centre of Applied Research and Innovation in the Built Environment (CARINBE) at the University of Johannesburg.

Prof. Imasiku NYAMBE

IMASIKU ANAYAWA NYAMBE is a Professor of Geology and Coordinator of the University of Zambia (UNZA) Integrated Water Resources Management (IWRM) Centre, a Centre that he established. He is a Fellow of the Zambian Academy of Sciences. Formerly, Director of the Directorate of Research and Graduate Studies (DRGS), responsible for research and postgraduate studies at the University of Zambia (UNZA), 2009-2017. He has a PhD in earth sciences (sedimentology) 1993, an MSc in geology (hydrogeology /sedimentology) 1989 from Canada and B. Min. Sciences (geology) 1982 from the University of Zambia. He is a recipient of the Canadian Commonwealth Scholarship and the American Fulbright Fellowship.

Prof. Nyambe worked in the copper mining industry in Zambia (1982-1986) before joining the University of Zambia (UNZA), where he has over 25 years' experience as a geo-scientist undertaking research in the areas of geology, sedimentology, hydrogeology, environment and mining, Integrated Water Resources Management (IWRM), and basic Remote Sensing and GIS. Prof. Nyambe has published over 170 articles as book chapters, in journals, technical reports, presentation papers, posters and abstracts presented at many conferences, fora, symposia, workshops and meetings all over the world, and has travelled extensively. He championed geoscience as career in Zambian schools encouraging girl-child to enter the School of Mines and founded the Corporate Graduate Link and Incubator Programmes at DRGS. His involvement in research on mining and the environment earned him an award from Zambia Environmental Management Agency in 2012 and awarded a National Science and Technology Council's ***Certificate of Achievement*** for the exceptional contribution to research and innovations.

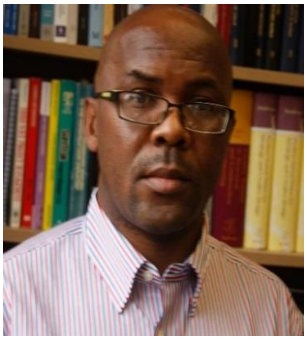
On Public Service, Prof. Nyambe has served in many national committees including University of Zambia Senate; Man and Biosphere; Petroleum Technical; National Remote Sensing; and Water Sector Advisory Group (WSAG). He has been President of the Geological Society of Zambia (GSZ) (2000-2010) and President of the Association of Geoscientists for International Development (AGID), Zambia (1996-2000). He has been a Commissioner (board) member of the National Heritage and Conservation Commission (2014-2017) and at regional level as a Board member of the Global Water Partnership-Southern Africa (2017 to date) and a founding member.

He is currently, the Acting Chairperson and founding member of Zambia Water Partnership – the Zambian Chapter of the Global Water Partnership and the Chairperson for Zambia Water Forum and Exhibition. At international level, Prof. Nyambe has been the Secretary General of the Geological Society of Africa (2004-2008) and a life Member; Vice-Chairman, Commission on Geosciences for Environmental Management (GEM) of the International Union of Geological Sciences (IUGS), 2004-2008; Vice-Chairman, Commission on Geological Sciences for Environmental Planning of the International Union of Geological Sciences (IUGS) 1999-2004, Advisor on the Scientific Advisory Council (SAC) of the European Union Water Initiative European Research Area Network (EU-WI Era-Net) – SPLASH (2007-2010) and Senior Advisor for Africa, International Year of Planet Earth (2005-2009).

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 jointly with Professor Carliss Baldwin (Harvard Business School) coined the term *design commons*.

Prof. Nicholas CHILESHE



NICHOLAS CHILESHE is an Associate Professor in Construction and Project Management in the School of Natural and Built Environment at the University of South Australia. He is also the Research Education and Portfolio Leader and Program Director responsible for the Doctorate in Project Management Nicholas obtained his PhD in Construction Management from the Sheffield Hallam University in 2004. Prof Chileshe was a Fellow of the Chartered Institute of Building (FCIOB) (1999-2016), Fellow of the Australian Institute of Building (FAIB), Fellow of the Chartered Association of Building Engineers (FCABE), Chartered Building Engineer (C. Build E), Fellow of the Higher Education Academy (FHEA), Member of the Chartered Institute of Management (MICM), and Member of the Australian Institute of Project Management (MAIPM). Nicholas's ongoing professional involvement includes membership and Chair of the Australasian Education Committee, and the CIOB International Accreditation Panel; and as acted as PhD External Examiner for Universities in South Africa, India and Australia. He also regularly reviews proposals for the National Research Foundation (NRF) in South Africa, and the Higher Education Academy (U.K) and over 42 Journals. In recognition of his scholarly and reviewing efforts, he has been a recipient of multiple awards such as the '*Outstanding Reviewer for Journal of Management in Engineering (JME)'*, American Society of Civil Engineers (ASCE) Outstanding Reviewers Program in 2016; *Outstanding Paper Award Winner* at the Literati Networks Awards for Excellence 2015 for *Construction Innovation Journal; Journal of Engineering, Design and Technology* (2008, 2010); *Highly Commended Award Winner* at the Literati Networks Awards for Excellence in 2008 and 2016 for the *Journal of Engineering, Design and Technology*.

Professor Chileshe is actively engaged in scholarly research work and has authored and co-authored more than 220 refereed journal and conference publications since joining academia in 1999. His current research interests include waste management and reverse logistics. Professor Chileshe is interested in exploring how some of the concepts - such as quality management, risk management and reverse logistics – can act as catalysts for the evaluation of sustainability issues within the Construction and Project Management disciplines.

Arch. Martin KABWIRI

MARTIN KABWIRI has over 19 years of work experience in architecture and has been serving in various capacities in this field. For 10 years, he managed architectural and construction projects with the government of Botswana mainly focusing on educational and administrative buildings. From 2006 he moved to South Africa where he provided architectural services in a consortium that managed the Fairlands Office Development project, one of the biggest construction projects in the country (at the time) worth South African Rand 1.2 billion- this particular project won the award for best office development in Africa and Europe in 2008.

Arch. Kabwiri joined the private sector in 2008 to manage his firm (Sothemu) that he had earlier set up in 2005, whose focus is to initiate the conceptualization and implementation of various development and infrastructural projects in Zambia and Nigeria. Sothemu has conceptualised and initiated a number of projects. He also set up two other firms in 2008; Aspire Architects in South Africa and A+ Urban Technics in Zambia. The firms have been undertaking several successful infrastructural projects over the past 9 years. For example, Aspire Architects has expanded to open 3 branches in South Africa (Johannesburg, Polokwane and Cape Town). Some of the major clients include: Gauteng government; Western Cape government; the Free State government and the University of Venda. On the other hand, A+ Urban Technics is one of the largest architectural firms in Zambia with branches in Kitwe and Lusaka. In addition, he has undertaken various projects in Zambia such as the Harry Mwana Nkumbula International Airport in Livingstone; shopping malls; the library and auditorium at National Institute for Public Administration (NIPA) in Lusaka and has managed construction/rehabilitation of 30 health centres in Lusaka and Copperbelt provinces on behalf of the United Nations Children's Fund (UNICEF). His international experience has exposed him to working in different contexts and with people from diverse backgrounds. He has lived and worked in Botswana, South Africa and Zambia.

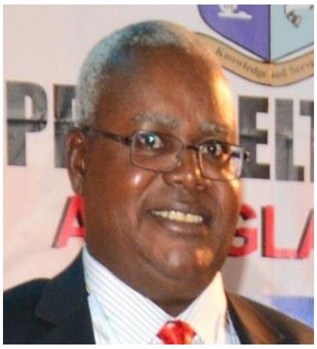
Arch. Kabwiri holds a Bachelor's degree in Architecture from the Copperbelt University. He is a Member of the Zambia Institute of Architects (**MZIA**), Member of the South Africa Institute of Architects (**SAIA**), Gauteng Institute for Architecture (**GIFA**), Cape Institute for Architecture (**CIFA**) and Chartered Architect with the Royal British Institute of Architects (**RIBA**).

QS. Matthew NGULUBE

MATTHEW NGULUBE is the Executive Director at the National Council for Construction, Zambia. He has been 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.

Prof. Overson SHUMBA



OVERSON SHUMBA is the Acting Director of the Copperbelt University Centre for Academic Development (CAD) in Kitwe, Zambia. He was the inaugural Dean of the School of Mathematics and Natural Sciences where he is a professor and the current Research and Innovations coordinator. Previously, he managed a NUFFIC supported initiative for strengthening Higher Education Research and Teaching (HEART Project). He currently manages the Copperbelt University World Bank Africa Centre of Excellence for Sustainable Mining (CBU ACESM). The CBU ACESM aims to promote excellence through education for sustainable development (ESD) and quality multidisciplinary research and teaching.

TRIBUTE TO ENGINEER CHARLES MUSHOTA

The Development and Investment in Infrastructure (DII) Conference Organising Committee would like to pay a special tribute to the immediate past Executive Director for the National Council for Construction (NCC) of Zambia, Engineer Charles Mushota. Engineer Mushota was instrumental in driving the support for the conference since its inception in 2014. The NCC, under his leadership, consistently and immensely supported the conference as the main sponsor, to ensure that it was successful each year until 2016, when he left NCC to take up a senior government position as Permanent Secretary at the Ministry of Housing and Infrastructure.

Engineer Mushota will always be remembered for his passion for research development in Africa. As a result, he showed great interest in the conference, which was exhibited through his physical presence throughout the DII conference period. The DII Organising Committee would like to wish Engineer Mushota success in his new role as the Ministry of Housing and Infrastructure. Further, we trust that he will continue to champion infrastructure development and promote research in the Zambian construction industry.

DII – 2017
30 August - 1 September 2017, Livingstone, Zambia

International Conference on Infrastructure Development and Investment Strategies for Africa

29 August, 2017

To whom it may concern

PEER REVIEW PROCESS (PRP) CONFIRMATION

On behalf of the DII-2017 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 (listed below). 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 978-0-620-74121-7** will be provided at the conference to be held in Livingstone, Zambia, from 30 August - 1 September 2017.

Regards,

Dr Justus

Agumba DII-2017

PRP Manager

justusa@dut.ac.za

Conference website:

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Development and Investment in Infrastructure (DII)

University of Zambia

Copperbelt University
Knowlege and Service

CONFERENCE PROGRAMME

WEDNESDAY, AUGUST 30, 2017		
14:30–16:50	**Book Workshop**	
17:30–19:30	**Conference Registration**	
	Networking Opportunity & Welcome Cocktail	
THURSDAY, AUGUST 31, 2017		
07:00-08:00	**Registration**	
08:30	**Welcome Ceremony & Keynotes** **Chair: Dr Erastus Mwanaumo** – Assistant Dean Post Graduate, School of Engineering – UNZA	
08:30-08:50	**Welcome address – Prof Luke Mumba** - *Vice-Chancellor, University of Zambia*	
08:50-09:10	**Welcome address – Prof Overson Shumba –** *Representative of the Vice – Chancellor, The Copperbelt University*	
09:10-09:40	Trade and regulation: The case of construction services in SADC - ***Mr Mathew Ngulube –*** *Executive Director – National Council for Construction*	
09:40-09:50	**Tea break/Networking**	
09:50–10:20	Towards understanding of environmental impacts of mining on the Zambian Copperbelt and Kabwe - ***Prof Imasiku A. Nyambe***	
10:20-10:50	Conceptualising and mapping the contribution to the built environment body of knowledge (BEBOK) – Metaphors and frameworks - ***Prof Nicholas Chileshe***	
10:50-11:10	**Tea break/Networking**	
	Technical Sessions	
11:20 – 13:00	**Breakaway Session 1:**	**Breakaway Session 2:**
	Theme: Legislative and Institutional Frameworks, and Governance in Infrastructure Development; Sustainability **Session chair: Dr Trynos Gumbo**	**Theme: Integrative Infrastructure Planning and Management** **Session chair: Dr Victor Samwinga**
11:20-11:40	Examining the impact of housing policy on urban sprawl in Harare, Zimbabwe – **Chipungu, L. et al.**	An investigation into areas of dissatisfaction in the South African residential sector post-construction: A case of Gauteng Province – **Tembo-Silungwe, C. et al.**
11:40 - 12:00	Methods of assessing the performance of international joint ventures from developing countries' perspective – **Nani, G. et al.**	An evaluation into improving facility management through the use of BIM in the Zambian construction industry – **Mutwale, J.**
12:00–12:20	Obstacles to Risk Management Implementation in Construction Small and Medium Enterprises in South Africa – **Renault, B. Y. et al.**	Financial Management: A Study of Emerging Contractors' Practices **– Aiyetan, A. O. et al.**
12:20-12:40	Investigating the impact of risk factors on project outcome of small and medium contractors in South Africa - **Renault, B. Y. et al.**	Assessing the application of strategic planning in improving competitiveness of small and medium scale contractors in the Zambian construction industry – **Chiponde, D. B. et al.**
12:40-13:00	Waste control and management system in Polokwane Capricorn Municipality District of South Africa – **Mewomo, M. C. et al.**	Assessing the effects of nodes, internodes and height position on mechanical properties of bamboo as a sustainable structure material: A case of Ghana species – **Akwada, D. R. et al.**
13:00-13:50	**Lunch Break**	
	Keynotes **Chair: Dr Trynos Gumbo**	
14:00-14:20	Between a rock and a hard place: A study of megaprojects in developing economies ***– Prof Nuno Gil***	
14:20-14:40	Facilitating experimentation in infrastructure delivery through innovative "open" governance and "open" regulatory frameworks - ***Prof Amira Osman***	

	Technical Sessions	
14:40-16:40	**Breakaway Session 3:** **Theme: ICT and Innovation in Infrastructure Development** **Session chair: Dr Balimu Mwiya**	**Breakaway Session 4:** **Theme: Integrated Infrastructure Investment, Procurement and Finance** **Session chair: Dr Ayodeji Aiyetan**
14:40-15:00	Exploring the efficacy of innovative urban public transport infrastructural systems on economic transformation: Case of Gautrain and Are Yeng in the city of Tshwane – **Gumbo, T. et al.**	Leveraging land-based resources and instruments for financing urban infrastructure development in Zambia: A case of Kitwe City, Zambia – **Phiri, D. et al.**
15:00-15:20	Performance indicators for lean construction in South Africa: Lessons from the Port Elizabeth Province – **Monyane, T. et al.**	Evaluating financial risks in Zambia's public private partnership projects: The case of the UNZA East Park Mall and Kasumbalesa Border Post – **Mukalula, P.**
15:20–15:40	E-waste mining: An alternative to traditional mining in Africa: A review – **Anane-Fenin, K. et al.**	Unpacking the impact of public transport infrastructure investments on transformations in the city of Johannesburg – **Gumbo, T. et al.**
15:40–16:00	Lightning protection and local earthing systems of weighbridges infrastructure. A case study of Kafue weighbridge - **Namukolo, S. K. et al.**	Leveraging public private partnership as an effective tool for infrastructural development in emerging economies: An integrative review **– Nnaji, C. et al.**
16:00–16:20	Importance of transport infrastructure for socio-economic development: A South African public opinion survey – **Gert, H. et al.**	A theoretical assessment of the challenges of public private partnership in improving infrastructure service delivery in Swaziland – **Mashwama, N. X. et al.**
19:00–22:30	**Gala Dinner** **Special Recognition –** ***Engr. Charles Mushota,*** *Permanent Secretary, Public Works*	
	FRIDAY, SEPTEMBER 1, 2017	
	Keynotes **Chair**: **Dr Franco Muleya**	
08:30-09:00	Challenges and opportunities in infrastructure development in Africa: Case of the new Livingstone airport **–** ***Arch. Martin Kabwiri***	
09:00-09:30	Urban entrepreneurship - ***Prof Murray Metcalfe***	
09:30-09:50	**Tea break/Networking**	
	Technical sessions	
	Breakaway Session 5: **Theme: Renewable Energy, Climate Change and Sustainability** **Session chair: Dr Chabota Kaliba**	**Breakaway Session 6:** **Theme: Human factors in Infrastructure Development** **Session chair: Mr Danstan Chiponde**
09:50-10:10	Centralised and decentralised electricity generation in Zambia: Sustainable options in the context of climate disturbances – **Ismail, M. et al.**	User perspectives on transport infrastructure in Johannesburg: Challenges and opportunities for the public sector – **Luke, R.**
10:10-10:30	Biomass pellets for application as an alternative solid fuel in Southern Africa – **Manyuchi, M. M. et al.**	Early retirement of construction workers in South Africa: case of occupation permanent disability – **Agumba, J. et al.**
10:30-10:50	Recycling of fibre reinforced composites: A review of current technologies – **Anane-Fenin, K. et al.**	Developing Africa's future Engineers – **Ibrahim, N. et al.**
10:50-11:10	Energy efficiency enhancement of off-grid photovoltaic (PV) power plants – **Dlamini, S. B. et al.**	The significance of workers' involvement in cultivating a safety culture in Zambia's electricity industry – **Mambwe, M.**
11:10-11:30	Protecting water pumps, mortuary and cold rooms equipment against power line disturbances – **Namukolo, S. K. et al.**	A conceptual model for pricing health and safety on construction projects – **Akawi, E. J. et al.**
11:30-11:50	An audit of embedding sustainability elements in built environment education in Zambia – **Zulu, S. et al.**	The effectiveness of employee retention plan as a strategy for reducing labour turnover in the Zambian construction industry **– Chiponde, D. B. et al.**

11:50-12:50	**Lunch Break**
	Theme: Integrative Infrastructure Planning, Management and Sustainability **Session chair: Dr Michael Mulenga**
13:00 -13:20	Towards optimizing the use of quarry dust in concrete production in Zambia – **Mulenga, M. M. et al.**
13:20–13:40	A comparative study between ‘traditional and green’ lease provisions in tenanted office buildings: The case of Lusaka (CBD) – **Kaunda, B. S. et al.**
13:40-14:00	A desk study of road infrastructure performance measurement criteria – **Okoro, C. S. et al.**
14:00-14:15	Effect of indoor environmental quality on the comfort of building occupants in Gauteng, South Africa – **Aigbavboa, C. O. et al.**
14:15-14:30	Awareness, attitudes and perception of green building practices and principles in the Zambian construction industry – **Sichali, M. et al.**
14:30-14:45	Environmental influences on sustainability dimensions in the South African construction industry – **Mewomo, M. C. et al.**
14:45-15:00	Modelling the duration of procurement process of public private partnership projects in Nigeria – **Baba, A. A. et al.**
15:00-15:15	Commercialisation of bamboo in Ghana: How sustainable in infrastructure development - **Akwada, D. R. et al.**
15:15-15:30	Assessing the reliability of Botswana air transportation: Means for sustainable economic development – **Iketleng, S. et al.**
15:30-16:15	**Report-back and way-forward discussion session – Conference End and Closing**
16: 30	**Sunset Cruise on the Mighty Zambezi River – (Optional event)**

TABLE OF CONTENTS

Keynote Abstracts

DII-2017-067

Towards Understanding of Environmental Impacts of Mining on the Copperbelt and Kabwe, Zambia

Prof Imasiku Anayawa Nyambe[1]

Abstract

Mining has been known to impact the socio-economic development of many countries. For example, in Zambia, large-scale copper-cobalt mining (developed since 1930s) has supported the social and economic development of the country accounting for about 93% of all Zambia's foreign exchange earnings in 1991, and up to 80% in 2016 with a current GDP of about 15%. Copper production surpassed 600,000 tonnes between 1964 and 1980, and is currently heading towards 800,000 tonnes. A century of mining these huge copper tonnages meant a production of more than double tonnages of wastes consisting of waste in waste rock (77 million tonnes), overburden dumps (1,899 million tonnes), tailing dams (791 million tonnes), and slag dumps (40 million tonnes). As at 2005, a total of 216,257 ha of arable land was covered by overburden, slag, tailings and waste rock dumps. These indeed together with the processing facilities (crushers, concentrators, smelters and refineries) have environmentally impacted negatively on the surface cover, and on a broad range of effects on the environment and the ecosystem (terrestrial systems, river drainage patterns & human health). These result from tailings (slimes), slags and minor amounts of toxic hazardous chemical wastes. The oxidation of the sulphides from chemical wastes is the source of chemical pollution to water resource. The tailing impoundments provide dust fallout on dry sections ("beaches") affecting plant life, whereas their dams leak, discharging a pulp rich in iron with concentrations varying Cu between 800 and 2 500 ppm; Co between 780 and 1 900 ppm; As 2.7 up to 350 ppm, and Pb 14 and 270 ppm.

The large-scale mining had been done with no regard to the impact on environment until in the late 1980s. During the 1980s, data on surveys of Environmental-Geochemical (E-G) on the Zambian Copperbelt and Kabwe, were non-existent. A study was therefore commissioned to understand how mining activities have impacted the environment and the ecosystem health from 2001-2008 in form of an environmental- geochemical survey based on a total of 1575 samples that included top soils, subsurface soils, agricultural plants, stream sediments, surface and ground waters, and 60 special samples (slag, tailings, ochres). The results led to a compilation of an E-G atlas and an assessment of the extent of industrial pollution. The results of the study revealed that air, soils, agricultural products and surface waters were affected at various extents by gaseous emissions, dust fall-out from smelters, dry parts of tailings ponds, crushers and mining operations. For example, the concentrations of copper in cassava leaves growing on contaminated soils reach as much as 612 mg kg^{-1} (total dry weight [dw]), whereas in leaves of cassava growing on uncontaminated soils are much lower (up to 252 mg kg^{-1} Cu dw). Concentration of copper in cassava tubers was lower (4.9 kg^{-1} and 17.4 kg^{-1}dw, respectively) when compared to leaves. Concentrations of Cu, Pb and As exceeded the maximum tolerance limits

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established by the Joint FAO/WHO Expert Committee on Food Additives (JECFA), especially around the Smelters. Health risk associated with consumption of contaminated vegetables can substantially be reduced by careful washing.

Similar sampling methods were undertaken in Kabwe. Areas surrounding old zinc and lead mines showed significant increments of copper (3500ppm), cobalt (3500pm) and cadmium (200ppm) near the old mine when compared to samples collected elsewhere where they were less than 500ppm for Cu and Co and 20ppm for cadmium. The highest concentrations of lead and zinc were above 10,000ppm. Lead in the stream sediments was 553.87ppm and that of zinc was 3343.5ppm. In surface water, lead and zinc were observed to be between 500,000 ppb to around 2,000,000 ppb in the mine area. Sulphur, chloride and phosphorous all increased from concentrations of below 10ppm to concentrations of between 4,000ppm and 5,000ppm along the mining area. Vegetation samples showed increased levels of metals such as zinc (about 8,000 ppm), lead and mercury (around 2000 ppb). For instance, the concentration of zinc, lead and copper in cassava leaves at one locality near the old mine were 273.6 ppm, 34.40 ppm, and 14.40ppm respectively whereas that of the rhizosphere soil were 102.3 ppm, 86.31 ppm, and 12.88 ppm respectively.

To assess the impact of mining and processing of ores on human health, collaboration and cooperation with medical staff is highly desirable in the Copperbelt area, whereas in Kabwe this started in the 2000s. For example, the Kabwe Scoping and Design Study showed high Blood Lead Levels (BLL) above WHO standards (<10 µg/dl), in population living near the former mining area. The results show a significant impact on the local population in Kabwe.

In conclusion, based on the results of this research on the Copperbelt and Kabwe, more efficient environmental impact assessment and reclamation of tailing ponds, spoil banks and waste repositories can be carried out by various agencies or companies, enabling them to deal immediately with the most critical issues of land and environmental management. The results are therefore recommended for use by government administrative units to up-grade their efforts in coordinating environmental management, promoting public awareness, and in minimizing the environmental deterioration in areas affected by mining and processing of ores. Local authorities such as district and city municipal councils in the Copperbelt and Kabwe can use the results as a basis for improved decision-making at all levels beginning with land allocation in urban planning to sustainable development in the exploitation of mineral and raw material resources.

Keywords: environmental-geochemical atlas, industrial pollution, mining, urban planning

DII-2017-68

Between a Rock and a Hard Place: A Study of Megaprojects in Developing Economies

Prof Nuno Gil[1]

Abstract

This study aims to further our understanding of the relationship between the development process and performance in developments of complex sociotechnical systems in contexts of weak institutions and scarce resources. We ground our research in a sample of capital-intensive infrastructure projects set up to address pressing needs in developing economies. Our analysis reveals two distinct approaches to structure the development process. In the sequential approach, the implementation stage is only allowed to start after planning is substantially completed. Hence, project suppliers are only procured after most critical resources are secured from independent organisational actors. In the overlapped approach, the implementation and planning stages overlap significantly after rushing buyer-supplier agreements. We find that a sequential approach attenuates uncertainty in requirements during implementation, but leads to development timescales that are wholly inadequate to the problem's urgency. In turn, the overlapped approach puts excessive faith on the ability to resolve bottlenecks through improvisation, problem-solving ingenuity, and flexibility, and thus also fails to speed up the development life cycle. We discuss the implications to literature and policy of this choice among these two unsatisfactory alternatives.

Keywords: development, megaprojects, performance, project process

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DII-2017-69

Facilitating Experimentation in Infrastructure Delivery through Innovative "Open" Governance and "Open" Regulatory Frameworks

Prof Amira Osman[1]

Abstract

Infrastructure provision is considered a crucial driver for economic development, job creation and poverty reduction. The delivery of infrastructure through effective implementation mechanisms that encourage public/private partnerships and facilitate ease of management and maintenance is considered crucial for a country's development. This demands a high level of innovation, efficient mechanisms and impact through an appropriate scale of delivery. However, the built environment professions tend to be conservative and do not easily accept innovation. The stakes are high if "innovations" in process or technology fail, thus the reluctance to adopt new ways of "doing". This must change if we are to address infrastructure demands in an inclusive and representative process.

The South African National Development Plan (NDP Vision 2030) focuses on the demographic shifts that will boost both productivity and consumption. This situation is similar throughout the continent; by 2030 Africa will have 760 million urban residents, increasing to 1.2 billion by 2050 according to the African Economic Outlook 2016. The infrastructure gaps that are widening are presented as both a challenge and a great opportunity for investment and large-scale developments; unlocking infrastructure backlogs and managing integrated supply chains can transform the economic performance of a country as well as achieve more equitable development by ensuring affordability and accessibility. South Africa and the continent needs resources and skills to deliver the massive infrastructure needs – however, South Africa and the continent also need forms of governance and regulatory frameworks that allow for experimentation and testing out of alternative forms of delivery.

These new forms of governance and frameworks will allow for efficient construction of infrastructure, the development of networks of suppliers to those industries and the entities engaged in operating and maintaining this new infrastructure – elements that are called for in the NDP Vision 2030. In South Africa, the state has committed substantial funding to public infrastructure to address backlogs. In Gauteng alone, during 2013-2016, an investment of R30 billion was made in infrastructure with R42 billion being planned for the next 3 years. This focus has led the Gauteng department of infrastructure development (GDID) to initiate the Lutsinga Infrastructure House, described as a "project nerve centre" which "uses technology to track developments in the planning, design and construction" of all infrastructure projects. This facility demonstrates that while a national infrastructure plan needs to be centrally driven and monitored, this also needs to be aligned with localized project management systems. If this operates efficiently, and if its mandate is extended, it will allow for the creation of conditions for embracing smaller-scale, dispersed

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projects and project packages that are more accessible to smaller firms and new entrants. A conventional understanding of infrastructure makes reference to public buildings and amenities, transport structures and roads, service lines for water, sanitation and electricity, etc. – yet the definition can be broadened. The NDP differentiates between hard infrastructure and soft infrastructure. One can also differentiate between the hardware and the software of the environment by bringing “people” into the debate around “infrastructure”. This bringing together of people and infrastructure can best be demonstrated through Open Building thinking and practice. An “open” approach to governance and “open” regulatory frameworks allows smaller projects to be aligned with larger visions, facilitates coordination, involves more people and reduces conflict.

Open Building is presented as an approach to the delivery of infrastructure at city, neighbourhood and building level. The need for viewing the built environment at different levels, requiring careful management of the relationships between the agents that operate at those levels, as well as the need to “disentangle” those levels to allow for a degree of permanence without restricting the necessity for constant transformation, is key to understanding Open Building. This “open” approach allows for distributed decision making in the manner in which the built environment is designed, funded and delivered. This “open” approach to the built environment allows for the acknowledgement of the co-existence of formal and informal systems and can address the disparity in different parts of a country and within cities. It offers a re-think on infrastructure finance and procurement strategies. The introduction of the concept of ‘base buildings’ could be considered a part of neighbourhood infrastructure – in the same way that roads and service lines are considered a part of the neighbourhood infrastructure and are accessible and used by all, irrespective of income level or social status.

This “open” approach to governance and delivery will be presented in the light of the South African NDP, innovations such as the Lutsinga example in Gauteng and reflections on applications in the rest of Africa.

Keywords: base buildings, Gauteng, governance, infrastructure, innovation, open building, regulatory frameworks, South Africa

DII-2017-70

Conceptualising and Mapping the Contribution to the Built Environment Body of Knowledge (BEBOK) – Metaphors and Frameworks

Prof Nicholas Chileshe[1]

Abstract

The ultimate test of any research whether disseminated as a conference or journal paper lies in the contributions to knowledge and the applicability of its findings. However, within the Built Environment (BE) related disciplines, little research has been conducted in demonstrating the necessary process that needs to be undertaken towards achieving the stated contribution. Consequently, the motivation of this study emanates from this background. The aims of the paper are twofold. Firstly, it is to highlight the general areas of what constitutes the potential areas for research within the various disciplines of the Built Environment (BE). Secondly, it is about matching the specific criteria of contribution to knowledge with illustrative examples that explore the application and theory development. By using the conference theme of '*Infrastructure and sustainable development – Impact of regulatory and institutional frameworks'*; selected exemplars from the Built Environment; the discipline of Construction; Project Management and undertaken research, an illustration of contributions is made. This keynote concludes with the assertion that the setting of future research agenda within the discipline of Construction and Project Management; and the overall Built Environment field, could be enhanced through the application of the proposed framework with usage of simple metaphors of knowledge. This paper can assist students in their understanding of the issues to be considered and which methodological approaches should be adopted when undertaking dissertations. It can also assist both academics and practitioners in clarifying the contribution made to knowledge in the disciplines of Construction Project Management (CPM) in the Built Environment fields by proposing an illustrative 'BEBOK framework'.

Keywords: built environment, construction and project management, knowledge, infrastructure development, methodology, research supervision

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Scientific Papers

Legislative and Institutional Frameworks and Governance in Infrastructure Development

DII-2017-054

Examining the Impact of Housing Policy on Urban Sprawl in Harare – Zimbabwe

Lovemore Chipungu[1], Hangwelani Hope Magidimisha[2]

Abstract

At the centre of some of the competing challenges city managers wrestle with in most developing countries is urban sprawl. Traditionally, the relative attractiveness of opportunities that the city offers have been associated with pull factors that have induced rural-urban migration. The situation has been exacerbated by the right to the city especially after the fall of colonial rule whose influx laws hindered free movements among the indigenous people. Indeed, this has led to increased urbanisation with most cities spatially sprawling beyond initially demarcated municipal boundaries. But what is observable in this spatial growth is housing development which has emerged as the major driver of urban development. This is not a new phenomenon since housing is one of the major spatial features that increases the city's footprint. It is from this perspective that this paper interrogates the development of housing in Harare in the aftermath of the fast track land reform programme of 2000 in a bid to assess its impact on urban sprawl. While acknowledging that the large-scale acquisition of land significantly contributed to massive housing developments, the authors also argue that contemporary housing policies and housing production systems have aggravated this situation by failing to engage sustainable policies. This emerging trend, is analysed through the lens of the ecological theory of suburbanisation which views residential spatial development as an outcome of invasion and succession of space by different competing income groups. Information used in this paper was collected from four low income housing schemes that emerged at the peak of the fast track land reform programme in Harare. While there are a complexity of forces at work, the authors conclude by recommending that the current situation requires a holistic approach that addresses structural issues embedded in the socio-economic and political realm of the country.

Keywords: housing policy, housing production systems, suburbanization, sustainability, urban sprawl

1. Introduction

While urban sprawl is a common phenomenon in most cities, the factors that contribute to its development and consequent results can be well understood from a contextual perspective. But even within any given context, prevailing factors that generate sprawl differ significantly in their impact. The complexity of forces that impinge on the urban environment require a holistic approach since they are couched in politics, economics and cultural dimensions. This paper revisits frontiers of urban sprawl and singles out housing policies as key contributors to urban sprawl in the context of suburbanisation. But it also argues that housing policies are part of an intricate web of systems that facilitate the production of housing and therefore, they accordingly respond to the wider context of the socio-political

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and economical realm. The case of Harare, (in Zimbabwe), used by the author represents such a complicated web which is underpinned by the nature of housing policies, housing production systems, the Fast Track Land Reform Programme (FTLRP) and an under-performing economy. It is from such a status quo that urban sprawl emerged as a response to the interplay of these factors.

The aim of this paper is to analyse the impact of housing policies on urban sprawl in Harare with a focus on low-income housing. In order to achieve this mandate, the author used both secondary and primary data sources. Background information on this paper in the literature review and some parts of the data presented was obtained from documented data obtained from government sources, the internet and journal articles. On the other hand, empirical data was obtained from purposely selected four housing schemes around Harare viz - Nehanda Housing Scheme (NHS); Dzivarasekwa Extension Housing Scheme (DEHS); Ushewokunze Housing Scheme (UHS) and Harare North Housing Scheme (HNHS. A number of tools were used to collect data and these include household surveys, observations, and interviews with key informants from housing cooperatives, the municipality and the central government. For household surveys, a sample size of 223 respondents was randomly chosen and interviewed in all residential schemes. In addition, focus group discussions were also held in the selected housing schemes.

2. Framework for Analysis

The spreading of the city outward largely driven by residential development is best explained by the natural ecological theory of suburbanisation. Mieszkowski and Mills (1993), attest to the view that in this theory, residential development will always develop outwards when the central business district (CBD) is the centre of employment. Development, according to this theory starts at the centre where housing will initially congregate around in proximity to employment opportunities. But as land in the inner city is consumed, housing developments will move to open tracts of land in the suburbs. Households with higher income will migrate to these areas where plots are larger and housing units more modern. The low income groups, on the other hand will filter into the inner city to occupy smaller housing units. Mieszkowski and Mills (1993), observed that this invasion-succession process in the housing market leads to income stratified neighbourhoods as affluent households migrate to the periphery of the city and the lower income groups move in the inner city with the middle income groups being in the inner suburbs which are denser.

However, in reality, this is not a linear and simplistic process since other forces come into play. Ecological processes are no longer mere natural processes since institutional factors (such as those emanating from politics and policy) equally influence the behaviour of processes in the urban environment. It is the complexity of these forces which in turn makes urban sprawl a contested concept.

In essence, urban sprawl is a multifaceted concept associated with unplanned and uncontrolled expansion of urban development into adjoining areas on the periphery of the city. Brody, (2013), associates sprawl with low density and haphazard development spiralling outwards from urban centres. While this definition can be taken at face-value, Gillham (2007) contend that despite powerful imagery and deepening national concern about sprawl, the term itself has proved to be dodgy and elusive with no succinct definition that is acceptable universally. Instead researchers converge on the understanding and acceptance of several common characteristics pervading the literature which in turn helps to understand and even measure its occurrence. These revolve around scattered (leapfrog) development, commercial strip development, low density, large expanses of single use development, poor accessibility and lack of functional open space.

However, it has to be noted that that urbanisation by nature is a function of human concentration which predominantly results in the spatial development of urban areas. It is this thin line of interface between these two concepts (sprawl and urbanisation) that have prompted the use of these terms interchangeably. In this regard, suburbs emerge as one of the frontiers of urban development and therefore urban sprawl. There are a number of compelling arguments that put suburbs in the fore-front of this phenomenon. The advent of the modernist era at the dawn of the 21st century which in essence was a response to the emergence of industrial cities saw the reorganisation of urban spatial space. In this era, as Larice and MacDonald (2007:301), observe, suburbs emerged as "*less populated outlying areas that served as bedroom communities for the big cities*." Suburban developments are further interpreted by Pacione (2001) who attests that the process of development responds to a variety of forces which range from natural ecological factors through socio-political strategies to micro-economic policy tools.

Putting housing at the fore-front of urban sprawl requires an insight into its driving forces. Gillham (2007) observes that urban sprawl as a function of housing is fuelled by four key ingredients viz: land ownership, transportation, telecommunication and technology and regulations and standards. The issue of land is central to housing development. Gillham (2007), emphasising the importance of land argues that the American Dream today is to own one's own home on one's own piece of land. In this regard, sprawl is a function of private land ownership and the rights attendant to its ownership. Jackson (1985) commenting on private land ownership, observed that principles surrounding fee-simple tenure enable households to buy, sell, rent and bequeath land with great ease and minimum government interference. In essence, private land ownership gives land value and marketability which is achieved through subdivision. However, this pattern of sprawl can partly be attributed to the abundance of relatively low cost of land which is necessary to allow dispersed housing developments within commuting distance of work places.

But the abundance of cheap land on its own does not guarantee the spread of housing development – instead, this phenomenon is supported by a network of infrastructural systems such as transportation, electricity, water and telecommunication. Russell (2000), commenting on the importance of road networks in sprawl summarises this argument by noting that what unites suburbia is not shared public space, or a coherent architectural vision, but a vast civil-engineered network of roads. Critical in this regard is the modal choice available coupled with associated costs and travelling time which allows developers and households to weigh their decisions. Therefore, accessibility to affordable land together with the presence of infrastructural systems such as road networks enhance housing development.

Any urban development such as housing operates through rules and regulations defined by the ideological stance of the state. While these laws are fundamentally created by the state, they are operationalised through different structures of the government at the national, regional, municipal and local levels. Planning law, to a large extent, is instrumental in imposing regulations and standards that govern the built environment – housing included. Commenting on the appropriateness of planning law, McAuslan (1980:296) argues that law exists to advance the public interest, if necessary, against private property. However, he also acknowledges the influence of the traditional common law perception where the existence of the law is meant to protect private property and its institutions. It is this conservative approach that defined the nature of housing development and therefore urban sprawl in most colonial cities since the right to the city was largely limited to the settler community and therefore the public interest was also couched around this privileged class. While acknowledging the universal importance of urban regulations and their impact on development, it should also be observed that there is subjectivity in their application and administration largely influenced by the prevailing ideology of the time. Wekwete (1995:14, quoting McAuslan, 1980), summarises this argument by observing that:

The use of law, of certain legal techniques, the decision to subject certain activities to a regime of legal control while leaving others free to such control, the implementation of law, the legal culture of society, are all value-laden, part of the social struggles within the society.

However, despite these contradictions, planning laws, in conjunction with other rules and regulations provide the technical basis for managing the use of land and other associated resources in the built environment. These regulations and standards, according to Larice and Macdonald (2007) have since been transformed into a "genetic code" that govern housing development but by default, has also become the major drivers of urban sprawl. The emphasis in this regard is on their undebatable value they bring to the built environment. Zoning and building codes for instance are necessary and effective in protecting public health and property values. They are geared towards establishing and creating the rationale and framework for both central and local governments to manage and promote the public interest in the development process.

But also critical to this discourse is the understanding that suburbanisation is a response to housing delivery systems engaged in the housing development process. Conceptually, authorities such as Keivani, Abiko and Werna (2004) observe that modes of housing production fall within the bi-polar structure underlined by conventional and unconventional production systems. While not undermining forces prevalent in unconventional systems, it can be argued that urban sprawl, to a large extent, has been driven by conventional systems which largely operate through private, cooperative and public housing delivery systems. These are normally in line with government regulations and are therefore used by most governments to achieve developmental goals especially in housing. However, their success, especially in developing countries, depends on government management, support and the ability of developers to mobilise resources. Pacione (2001), commenting on the use of the self-help strategy used in housing cooperatives and private housing schemes, argues that these strategies largely responded to the sale of public land by the state to developers on condition that it will be used to provide low-cost starter homes or plots which households can purchase and organise construction. Contrary to the theoretical perceptions painted above and European experiences, such emerging residential areas in most developing countries, are not only exclusive to high class suburban areas, but are also common in low-income residential areas. This paradox is further complicated by poor land management mechanisms that have also led to unconventional housing production systems mushrooming out of assumed "suburban" areas on the periphery of the city. Hence the interplay of these factors also find meaning in the Zimbabwean context discussed below.

3. Housing in Zimbabwe

This section provides a brief l overview of housing in Zimbabwe before analysing contemporary housing in the post-independence period.

3.1 Housing policy in post-colonial Zimbabwe

At independence in 1980, the government inherited a housing backlog which it is still battling to bring under control. Mafico, (1991) noted that the government recognised the need to provide adequate and decent housing conditions for its population. Hence this became a basic need and an essential element in improving the social welfare of the people. Backed by its socialist principles, the government outlined its first low-income housing policies and strategies in the First Transitional National Development Plan of 1982 and later supported by other policies. The policy framework for housing delivery in Zimbabwe anchors on 4 key tenets – viz being homeownership, minimum housing standards, self-reliance and cost effectiveness, public and private sector partnership (Table 1). The interplay of these policy instruments involve a number of deliverables but with the sole mandate of enhancing housing provision as briefly summarised in Table 2. To enable efficient housing delivery, this housing policy framework is supported by a number of strategies among which is aided self-help, building brigades and housing cooperatives.

Table 1: Key features of housing policy in Zimbabwe

Policy instruments	Details
Home Ownership	New housing schemes are based on home-ownership.
Minimum Housing Standards	Clear policy stipulation of the type of materials to be used for housing, minimum size of plots, type of infrastructure, plinth area and habitable rooms e.g. 150m2 for a plot.
Self-reliance and Cost-effectiveness	This is a multi-pronged instrument driven by self-help principles with both beneficiaries and government being involved in the housing production process.
Private and Public Sector Partnerships	This was initially driven by donor funding but which later attracted other stakeholders such as employers and financial institutions.

Sources: Author from various sources (2013)

Table 2: Housing strategies in Zimbabwe

Strategy	Description
Aided self-help	Local authorities are to provide serviced stands, technical assistance and affordable loans to beneficiaries who would build their houses using their own additional resources through sites and services.
Building brigades	These were to be formed by local authorities in order to manufacture building materials, construct houses, renovate and upgrade houses. However, they are not very active nowadays.
Cooperatives	These are formed by groups of beneficiaries who pool together resources in order to build their houses more cheaply with local authorities providing technical, administrative, financial and training assistance.

Source: Author from various sources (2013)

In addition, housing implementation in Zimbabwe is also governed by a legislative framework which is largely driven by the Regional, Town and Country Planning Act (Chapter 29:12 of 1996) and supported by other key pieces of legislation (such as the Urban Councils Act – 1996, Deeds Registries Act - 1995 and the Land Survey Act – 1992). Together, these shape the procedural requirements of the housing development process. However, the interplay of housing policy and housing strategies, to a large extend, has also contributed to the current spatial expansion of the urban areas beyond their traditional boundaries.

Above all, since 2000, two key housing policies were enacted to guide housing development in the country. Of significance is the National Housing Delivery Programme (of 2004) that was crafted to operationalize the National Housing policy of 2000. However, it was a short-term intervention programme which was supposed to run for four years from 2004 to 2008 with specific quantitative targets. Among the expected deliverables of this programme include the acquisition of 310 406.6 hectares of land, meant to provide 1 250 000 houses with an annual delivery target of 250 000 stand per year (GRZ 2005. The coming on board of the revised National Housing Policy of 2013 was meant to buttress this policy but also with a focus on decongesting cities through mixed use spatial designs on the periphery of cities. This was further supported by the revision of housing standards in the form of a policy brief enshrined in Circular No. 70 of 2004 (from the Ministry of Local Government and Public Works) which set new national housing standards by stipulating minimum requirements for planning, house construction and infrastructure. Above all, policy intervention measures also came from other government sectors such as the Short Term Economic Recovery Programme (STERP) from the

Ministry of Finance which emphasized on more land acquisition and the use of housing cooperatives and associations in housing production (GRZ, 2009). It is from this institutional perspective that emerging low income housing in Harare can be analysed.

4. Emerging Low Income Housing in Harare

The advent of the FTLRP in 2000 provided an opportunity for the acquisition of land for housing by the urban poor in most urban areas of Zimbabwe. Harare in this regard, was not an exception. The chaotic nature of the programme saw the invasion of land in all three housing schemes with the exception of DEHS. It is interesting to note that at the peak of the FTLRP, the identification and acquisition of such land was not governed by any statutory instrument other than the availability of vacant land for occupation. According to the household surveys, 70% of the respondents indicated the availability of vacant land as the major factor that attracted them in all areas. Other factors, such as availability of infrastructure and employment opportunities were never considered as shown by the low level of response registered during household surveys.

For the purpose of this study, four housing schemes whose developments emerged in 2000 were purposely selected and these are: Nehanda Housing Scheme (NHS); Dzivarasekwa Extension Housing Scheme (DEHS); Ushewokunze Housing Scheme (UHS) and Harare North Housing Scheme (HNHS)were purposely selected around Harare. With the exception of DEHS, all other schemes began by way of land invasion before regularisation was done. DEHS on the other hand, began as a holding camp for households that were moved from Porta Farm in 1993. However, the acquisition of land for this housing scheme commenced in 2000. Despite their background, all housing schemes are in areas zoned for housing development with proper development plans in place. As summarised in Table 3, all these housing schemes fall under the Harare Combination Master Plan (HCMP) of 1998 and some of them such as NHS, DEHS and UHS are also governed by local development plans. Where there is no local development plan, development proceeds by way of statutory land subdivisions as in the case of HNHS.

Table 3: Key Features of the Housing Schemes

Housing Scheme	Development Plans	Distance from the CBD	Other Remarks
NHS	HCMP and Gillingham Local Development Plan No. 47	18km	Mixed land uses including high density residential development.
UHS	HCMP and Saturday Retreat Local Development Plan No. 50	16km	Mixed land uses including housing development.
DEHS	HCMP and Gillingham Local Development Plan No. 47	18km	Mixed land-uses including high density residential development.
HNHS	HCMP but development can proceed through subdivision	19km	Mixed land uses including housing

Source: Author from various sources (2014)

The FTLRP which began as a movement for the landless people was largely supported by homeless people who saw it as an opportunity to acquire land for housing. However, most of the people who were in search of land for housing development were the urban poor who could not afford to buy serviced land or housing on the open market. The household survey results indicated that only 68% and 51% of the respondents in NHS and UHS were formally employed on full-time basis while the rest were informally employed, unemployed or employed on part-time basis.

In a bid to regularise these land invasions, the government encouraged households to form housing cooperatives as per the Co-operative Societies Act of 1996 (Chapter 24:05). However, on the part of the Harare City Council, approval of layouts from cooperatives was conditional on provision of substantial evidence to install on-site infrastructure. The creation of cooperatives in turn became a key strategy through which most post-2000 housing schemes managed to acquire land for housing development. Housing development in these cooperatives progressed through financial contribution of households towards land acquisition (which was charged at an intrinsic value of US$7/m^2), infrastructure development (roads, water and sewer) and housing development. However, this proved to be a daunting task for many cooperatives since most households were not gainfully employed and those who were employed were earning below US$300 per month.

Even for those who were formally working, the daunting economic challenges made it almost impossible to rely solely on salaries. Evidently, most households interviewed relied on their meagre personal savings with only 10% who managed to obtain financial support from banks. So serious were economic woes that the government abandoned the use of its currency (the Zimbabwean dollar) in 2008 and adopted multi-currencies – mostly the US dollar, the Rand and the Botswana Pula. Despite these economic woes, housing development was supposed to adhere to conventional principles as guided by existing by-laws and policy regulations such as submission of building plans to the local authority for approval (see Table 2 for details).

However, prevailing economic challenges forced households to engage in cost-cutting measures in the development process. Data from the household surveys shows that most households built houses on their own in UHS, HNHS and DEHS. In DEHS, only 2% of the respondents engaged contractors to build their houses. However, there are instances where cooperatives such as NHS built houses for its members by engaging professional builders (see Table 4 for details). In DEHS, most households are affiliated to the Zimbabwe Homeless People's Federation (ZHPF) which together with Slum Dwellers International (SDI) has put in place measures to build temporary two-roomed structures – hence the 100% indicated in Table 5. In addition, the SDI proposed the development of row-houses and walk-up flats. Fierce resistance from beneficiaries saw only 5 plots measuring 64m^2 and 150m^2 plots being reserved for this purpose.

Table 5: Who Built the House?

Area	**House Builder (%)**			
	Self	Contractor	P/builder	Coop
UHS	16	2	82	-
HNHS	79	-	21	-
DEHS	100	-	-	-
NHS	-	-	-	100

Source: Fieldwork, 2012

This in essence meant that these schemes had to adhere to existing by-laws and regulations in in place. As per the requirement of building ordinances in place, households and cooperatives were supposed to submit development plans (for both housing schemes and building plans) to the local authority for approval. Houses were to be built on plots with a minimum size of 150m^2 while observing building lines and using prescribed building materials (Government of Zimbabwe, 2004). Adherence to these requirements is monitored by the planning control mechanisms from the Harare City Council. Most emerging housing units are 4-roomed core houses supposed to be extended by households over a period of time as resources become available. However, due to loop holes in the system coupled with other administrative challenges, other unplanned settlements have since sprouted around the city.

5. Fitting Housing Policy in Urban Sprawl

From the data presented in Section 4.0, there are a number of salient issues that can be deduced which link emerging housing schemes to urban sprawl. These largely revolve around existing housing policies, housing production systems and the availability of land. It is to the interplay of these factors that this paper turns its focus in the following section.

5.1 Home ownership policy

Low income housing development in Harare and Zimbabwe at large is synonymous with access to a free-standing house on a separate parcel of land. This is supported by generous standards for both infrastructure and housing plots which further promote sprawl (see Table 2). For instance, in 2011 alone, 50 land surveys which were undertaken in Harare yielded 22 568 individual plots while only 54 applications were made for cluster housing (HCC, 2011). In addition, cultural and economic aspects also come into perspective. Cases have been noted where people resist high-rise developments because of lack of direct access to land ownership. Home-ownership, to most households is linked to land ownership. This has to be understood from traditional perspectives which directly link households to land as seen in their rural settings. This in turn influences people's attitudes towards housing in urban areas. Concerns are also expressed by beneficiaries who resent the restrictive nature of building designs which do not accommodate the use of houses for economic gain – specifically adding more rooms for renting out and use of the plot for urban agriculture. This was witnessed in DEHS where the proposal for cluster housing and walk-up flats was resisted by some beneficiaries.

5.2 Housing production systems

Housing production in Zimbabwe as already noted, also embraces self-help principles which are enshrined in the country's housing policies of 1982 and 1999. Initially, it was couched on the premise of the state providing serviced land to individual beneficiaries. But lack of funding in the public sector has since led to the use of housing cooperatives as key drivers of housing development. The Zimbabwe National Association of Housing Cooperatives (ZINAHCO) estimates that there are 233 registered housing cooperatives in Harare (HCC, 2011). As noted in Section 4, cooperative housing in Zimbabwe is highly individualized and incremental in nature since it depends on the capacity of households to mobilise resources. It is this propensity towards individualism which blends well with access to free-standing plots which makes housing production a success. Where the cooperative takes the initiative to build core houses, these are limited to one-bedroomed structures which still require more investment by individual households.

In addition, this mode of housing production is labor-intensive with use of localized building materials supported by intermediate technology. In essence, it revolves around mechanisms that allow affordability through cost-cutting measures. Hence most of the houses built are simple structures that neither go beyond one floor nor allow densification through semi-detached designs. Other typologies of housing (such as high rise, town houses etc.) are not common among low income people. In 2011, only one company (Pearl Properties), applied to construct 132 flats against over 22 000 plots that were granted for free-standing housing units by the Harare City Council. Even in some instances where established companies such as the Central African Building Society (CABS) are involved, construction of free-standing housing units has become the norm since it is relatively cheap. However, the situation has been aggravated by limited financial resources where households are forced to rely on their own savings.

5.3 Availability of land

A major driver of housing development in Zimbabwe is easy access to land especially after the FTLRP of 2000. The National Housing Delivery Programme of 2004 – 2008 sums up the importance of land in housing development by prioritising the acquisition of 310 406 hectares of peri-urban land in order to enhance housing production in Harare. In this policy, the government's vision was on delivering 250 000 plots per year for housing development (Government of Zimbabwe, 2005). Aspiring home owners are encouraged to join or form cooperatives to which land for housing is sold at intrinsic value. This is supported by an institutional framework mandated to fast-track land acquisition, residential layout and building plans approval. Development control mechanisms have been revised to allow households to stay on their plots while infrastructure is being provided gradually. This has resulted in the proliferation of housing developments on the urban periphery where land is easily available. In addition, poor management of land has led to illegal housing schemes sprouting on state-land – with most of them staying in environments without proper infrastructure. It must also be borne in mind that low income housing production on the outskirts is cheaper since building materials (such as bricks and sand) are locally obtained through moulding bricks and illegal mining of both river sand and pit sand.

It is clear from the data presented above that the prevailing housing policy directly contributes to the expansion of the city. Kamusoko *et al* (2013) in their study of Harare observed that the city's built-up area spatially increased in size from 11.6km^2 in 1984 to 342km^2 in 2013 (see also Table 5). The greatest growth was witnessed from 2002 – a period which coincided with the implementation of the FTLRP.

Table 5: Spatial growth of Harare

Item	Year			
Built-up area	1984	2002	2008	2013
Area (km^2)	118.6	233.9	302.7	342
Area (%)	12.6	24.8	32.1	36.3

Source: Adopted from Kamusoko et al. (2013)

That sharp increase in housing cooperatives especially through the provincial government structures made it relatively easy to access land for housing – hence the increase in the city's foot-print.

6. Discussion and Conclusion

There are a number of issues that can be drawn from this discourse and these revolve around the nature of urban sprawl, infrastructure and property ownership.

One critical observation that emanates from the context of Harare is that contemporary upsurge in urban sprawl is a function of suburbanisation largely driven by the search for housing by low income people. This development is largely due to the FTLRP which resulted in the availability of state land for housing development. Indeed this is in line with Gillham's (2007) argument that the availability of land is one of the drivers of urban sprawl. However, this have to be qualified in the Zimbabwean context in the sense that the whole process did not stem from the rational choice of consumer behavior, but an intricate process engineered by both socio-economic and political forces. To a large extent, it resonates Pacione's (2001) contention embedded in economics and politics – which in the case of Harare, is meant to improve the housing needs of the urban poor while at the same time earmarking for political control of the city by the government in power. In essence, these are political decisions which are bound by principles of social justice and which fall outside the ambits of rationality but with repercussions on urban sprawl.

Cooperative housing in Zimbabwe is mainly done by people in the low income bracket. This goes beyond the stereo-typed arguments of suburbanisation as a phenomenon associated with high income households. What is interesting is the fact that these low income residential developments, whose colonial name is "townships"; have come to dominate the urban spatial landscape despite their misfit as suburbs in the colonial genre. This contrasts developments in European countries where the phenomenon was initially associated with the increasing wealth of the middle class coupled with the introduction of the automobile (Gillham, 2007). On the contrary, these are mere low income households who are desperate for a home in an urban environment. The underlying factor is need which in essence is associated with the urban poor. It is this factor which is equally captured by the UN (2005) in their fact finding mission in Harare after Operation Murambatsvina/Remove Filthy.

Lopez's (2014) observation that the development of infrastructure perpetuates urban sprawl seems to be at variance with the emerging situation in Harare. New housing developments are not attracted by any investment in new infrastructure other than relying on existing old infrastructure which in most cases is far and not adequate to accommodate new developments. This is observable in the new housing developers' mandate which require beneficiaries to contribute towards the provision of their infrastructure – as the case of NHS demonstrates where the cooperative had to engage a private engineer to connect water mains 5km away from the housing scheme. The only other infrastructure which purports to support Lopez's arguments is the existing arterial inter-city road system which provides access to these emerging developments. It is this phenomenal observation which forces one to concur with Pacione's (2001) argument that sprawl is a rational outcome of rational locators seeking lower cost locations and less regulated environments as seen in the case of low income housing. Even in this regard, pure rationality should not be envisaged in economic terms; but in the ability of households to secure a permanent housing plot. Fundamentally, it is based on Rugglero" (2014) perception of rationality as being informed by complete knowledge of the problem, context and preferences which in the Zimbabwean case at this juncture, arises out of need and chance (in terms of land availability). It can therefore be argued that current developments in Harare are born out of a socio-political environment crafted on the need to facilitate property ownership in an environment characterised by economic challenges. Once more, Pacione's (2001) observation that suburbanisation is a response to socio-political strategies find meaning in this context since these developments are promoted by government policy.

Another aspect which is interesting about the case of Harare is that urban sprawl is linked to the housing production system i.e. cooperative housing. Its appropriateness in the cash-strapped Zimbabwean economy has been emphasised in various policy documents. However, outside the Zimbabwean context, other authors (such as Keivani *et al*, 2004; Turner, 1976) have observed that this mode of housing production is highly individualised and incremental in nature since it depends on households' capacity to mobilise resources. Individualism blends well with ownership of free-standing plots. In addition, this mode of production is highly labour-intensive, with the use of local building materials supported by intermediate technology. In essence, it revolves around mechanisms that allow affordability through cost-cutting measures. Hence most of the houses are simple structures that do not go beyond one floor level. To a large extent, these measures have been prompted by the economic down-turn which is characterised by high unemployment levels coupled with the flight of donor funding (Chipungu, 2012). These techniques do not promote densification in housing production (such as high-rise and semi-detached structures). Commenting on high-rise construction techniques, Okpala (1992) argues that such structures are complex and demand expertise beyond standard forms of work. In addition, he noted that such production systems are capital intensive and involve formal companies that use latest technology. The flight of capital from Zimbabwe has drastically reduced established companies' participation in housing. It is therefore not surprising that in 2011, only 132 flats (by Pearl Properties) were approved for construction by the municipality. In the case studies presented, only DEHS has five plots reserved for duplexes. Even in instances where private capital is involved, construction of free-standing housing units has become the norm since it is relatively cheap – as seen the case of the Central African Building Society (CABS) which was given land to build low income houses in 2010 by the Harare City Council (HCC, 2011).

To a large extent, the elevation of the cooperative approach to housing development among the poor also blends well with neo-liberal principles – a development which is converse to the egalitarian ideology of the government in power. However, the withdrawal of the government and municipalities (due to lack of funding) from being providers has allowed the government to redefine housing laws and regulations in line with demand. While still upholding conventional structures as the ultimate goal in housing construction, the availability of land is promoting parallel housing development even in areas beyond the 22.5km radius of the city where infrastructure is excessively expensive to provide.

Above all, the situation in Harare depicts fragmented developments that are driven by owner initiatives and supported by institutional frameworks of the state. While this can be commended, there is still a mammoth task of providing adequate housing as defined by access to proper infrastructure and services. Policy pronunciations alone without financial support are limited in their impact. But more so, there is need to revise the sustainability of these developments given the increased spatial dimension of the city due to availability of cheap land coupled with the negative impact on the physical environment arising out of illegal mining of cheap building materials (such as river sand and pit sand) on the urban periphery.

In conclusion, it can be argued that urbanization in Harare has had a major impact on the government's capacity to deliver services with housing being one of them. In a bid to arrest the housing demands of the urban population, the government crafted a number of policies whose liberal nature, are contributing towards urban sprawl. The paper noted that the financial dire straits of the government have resulted in households engaging in housing production with the state acting as a facilitator limited to the provision of land. Hence what emerges is the fact that a combination of housing policy, housing production systems and economic challenges are directly contributing towards urban sprawl. The solution to these developments must be found in underlying structural issues embedded in the political, economic and social realm of the Zimbabwean urban environment.

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DII-2017-061

A Factorial Analysis of International Construction Joint Venture Performance Measures: A Case of Ghana

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Abstract

International Construction Joint Ventures (ICJVs) have emerged as innovative way of undertaking projects in West Africa. The performance of such a cooperative relationship is of utmost importance to joint venture managers, since the goals for entering into such an agreement can be realized, only when the venture is successful. The perspective from which performance is evaluated as well as the measures used, are equally important to this subject matter. However, seeing the characteristic complications of construction projects, only an adequate combination of criteria allows measurement of ICJV performance. The study reported here identified the most relevant performance evaluation measures used by executive local officials (local managers and senior members) in Ghana and highlighted the underlying reasons for use of these measures in international construction joint ventures. Using a self-administered data obtained through a questionnaire survey by a purposive and snowball sampling technique, a total of 67 ICJVs established by Ghanaian construction firms and foreign firm in Western Europe, America, Asia and the Southern part of Africa were sampled for the study. Data analysis based on factor analysis shows that local managers employ contemporary non-financial measures that include ‘learning and cooperative and relationship measures of performance in addition to the popularly known conventional measures like rate of return, cash flow, growth and cost position to determine their performance. A novel finding is that local firms in ICJVs choose performance measures depending on their exposure (experience) and current stage of the firm. These findings have important implications for international businesses in choosing appropriate measures for their ICJV performance evaluation.

Keywords: construction, Ghana, joint venture, performance

1. Introduction

It is widely argued that international construction joint ventures (ICJVs) provide a platform where advanced technologies and management expertise are realized and used to improve quality, reduce wasted-work at the project level. It also mitigates the effect of cyclical domestic market conditions as well as establish continuing strategies for the balanced growth of domestic and international

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construction portfolios (Contractor and Lorange, 2004; Zhang and Zou, 2007). Nevertheless, in developing countries the attractiveness of foreign investment through JVs is because they are a means of sustaining market development, acquiring advanced technology as well as developing managerial skills necessary to create economic growth (Li et al. 2000). An international construction joint venture can be considered as an arrangement that enables two or more legally distinct firms to jointly carry out Architectural, Engineering and Construction (AEC) projects; and where the headquarters of at least one partner is situated outside the venture operation country (Hong, 2014). Girmscheid and Brockmann (2010) also argued that, if the partners come from different countries, then the venture is considered as an international joint venture (IJV).

Ghana has since the mid-1960s established an extensive joint participation programme through legislation and administration of investment codes with the objective to develop, finance and contribute to national socio-economic development by building the infrastructure and productive facilities (Boateng and Glaister, 2000). Acquaah (2009) provided evidence to support the overwhelming preference by foreign investors for IJVs in Ghana. A report from the Ghana Investment Promotion Centre as in table 1 and 2 below shows that, of the 1821 registered projects between the years of 2011-2016, a total 595 projects (32.7%) were executed with JV arrangement by firms. However, from Table 2, out of the 595 joint ventures projects, 206 (34.6%) were building/construction projects.

Table 1: Approved recorded projects in Ghana by ownership type (2011 – 2016)

	Without JV arrangement		**Joint venture**		**Total**	
Year	Number	(%)	Number	(%)	Number	Column (%)
2011	327	63.6	187	36.4	514	28.2
2012	239	59.9	160	40.1	399	21.9
2013	311	74.4	107	25.6	418	23.0
2014	135	73.4	49	26.6	184	10.1
2015	110	64.7	60	35.3	170	9.3
2016	104	76.5	32	23.5	136	7.5
Total	**1226**	**67.3**	**595**	**32.7**	**1821**	**100**

Source: Ghana Investment Promotion Centre (2016)

Table 2: Sectorial composition of recorded projects in Ghana under joint venture (2011 – 2016)

	Construction		**Others**		**Total**	
Year	Number	(%)	Number	(%)	Number	Column (%)
2011	49	26.2	138	73.8	187	31.4
2012	55	34.4	105	65.6	160	26.9
2013	61	57.0	46	43	107	18.0
2014	8	16.3	41	83.7	49	8.2
2015	19	31.7	41	68.3	60	10.1
2016	14	43.8	18	56.2	32	5.4
Total	**206**	**34.6**	**389**	**65.4**	**595**	**100**

Source: Ghana Investment Promotion Centre (2016)

Though foreign direct investment in Ghana through international joint venture has gain widespread attention, yet still, the rate at which it is growing is slow as compared to the previous years. At times, government policy encourages JVs to enable local partners tap into the knowledge and technology of foreign partners. In case of such a policy, like that, with time they deliberately reduce the inflow. Not to talk about the dissolved once, others do not deliver the hope-for results and fail (Talman, 2009).

As a result of this trend, companies are evaluating their joint venture strategies, and part of this assessment there are implications for the measures employed by local firms in evaluating performance of ICJV.

Literature indicates that a number of studies have focused on ICJV performance measurement in specific countries and region in both developed and developing countries (Boateng and Glaister, 2002; Ozorhon et al. 2010; Larimo et al. 2016). Yet, in the context of sub-Saharan Africa (SSA), performance evaluation of ICJVs has received virtually no attention, this is more evident from the perspective of the local business partner. This paper identifies the most relevant performance measures employed by the local firms to assess their performance in ICJVs in Ghana. The study offers several implications for international businesses in choosing appropriate measures for their ICJV performance evaluation and opportunities for further research.

2. Literature Review on International Joint Venture Performance Measurement

Accompanied by the growing body of related benefits associated with IJVs is the high degree of instability and poor performance. Results in several studies show high estimated rate of about 30% to 70% IJV failure (Bamford et al. 2004). It is therefore not surprising that a large number of studies have focused on how to determine the existence of key explanatory factors of the joint venture performance, and even more into international case (Ozorhon et al. 2010). The establishment of international joint ventures is based on a number of different reasons in a variety of circumstances (Acquaah, 2009). Accordingly, Child and Yan (2003) revealed that there existed some relationship between an IJVs performance evaluation and the objectives under which an IJV is formed. They however stressed that the JV partners may have different objectives as well as conflicting agendas which in other words, suggests different performance criteria used by the partners. The situation becomes more complicated when the different perspectives on performance and the diversity of performance measures are examined simultaneously (Ozorhon et al. 2010; Larimo et al. 2016). While in many cases the partners may share some common objectives and use similar performance measures, in many other cases each party's idiosyncratic perspective is combined with a quite distinct set of performance criteria (Yan and Luo, 2016).

According to Hong et al. (2009), there has been no consensus on an appropriate conceptualization and measurement of IJV performance over the past decades. Generally, from the viewpoint of managers and results in previous studies performance measurement is categorized into two main groups. They are financial and non-financial measures. The financial measures of performance are reliant on traditional indicators like profitability, growth and cost information which are short-term in nature (Jusoh et al. 2008). Non-financial measures are used to capture different aspects of the performance of the firm like management related, strategic related and learning related (Larimo et al. 2016). Thus they are quantitative measures of either an individual or an entities performance that are not expressed in monetary terms. They are used to evaluate non-financial aspects of the firm and include client satisfaction, attainment of strategic objectives, market share, efficiency and productivity. Another stream of research also advocate that performance measurement can be seen as either subjective (perceptual) or objective measures (Julian, 2005). Subjective measures include partners' satisfaction, perceived financial performance, the overall JV satisfaction, partner relationship, market position, JV's returns from the Client, parent firm's returns from JV. Objective measures on the other hand are based on independent data that can be obtained from third parties (Mohamed, 2003). They include longevity, survival, profitability, and stability. Studies by Larimo et al. (2016) throws more light on these measure of performance in international construction joint venture.

2.1. Choosing performance measures: A multidimensional perspective

A review of past literature revealed some underlying reasons for choosing one performance measure over the other. Boateng and Glaister (2002) reported that the choice of performance measures sometimes depended on the organisational objectives to be achieved. This is evident in the works of Sim and Ali (2001) and Larimo et al. (2016). To measure the efficiency and market gaining of IJVs, firms need financial measures including return on investment, profit and loss account, which best evaluates efficiency. From another perspective, the cultural differences amongst parties to an IJV is a driving force particularly behind the use of objective financial measures (Mohr and Puck, 2005). Chong (2009) pointed out that national culture has a strong impact on IJV operations and performance measurement. In solving this problem local managers may want to use more objective measures such as financial measures to evaluate the performance of their firms. Since financial measures use numbers in the measurement, they are clear and easy to read and to understand by parties to the JV arrangement. Abdel-Maksoud et al. (2008) found that firms having prior experience in managing IJVs focus less on financial control. Similarly, the experience of local managers in a particular host country is very valuable because this provides insight for the parties to help cope better with uncertainties. Prior experience is therefore a major contributing factor to choosing one performance measure over another. Environmental uncertainty of the target country can be referred to as unexpected changes in regulation, legislation, judicial decisions or changes in demand (Mahmood et al. 2008) or social uncertainty. Operating in countries where there is high legal and social uncertainty, businesses may want to avoid the measures that may be easily affected by the changes or uncertainty. These measures include, for example, non-financial measures such as the venture market positions or the level of satisfaction of clients.

3. Research Methods

3.1 Data, sample and validity checks

The data for this study was part of a large sample, which consisted of 595 IJV companies selected from the Ghana Business Directory from the year 2011-2016. Within these years mark a huge upsurge of foreign direct investment for economic development in Ghana. Out of the 595 IJV companies, 206 were building and construction firms (Ghana Investment Promotion Centre, 2016). These 206 companies were IJVs between foreign firms and Ghanaian firms with the foreign firms holding at least 10% equity shares in the IJVs. Foreign partners were from Western Europe, America, Asia and the Southern part of Africa. The data was collected from senior management personnel of the local partner of the IJVs, which were made-up of mostly executive officers (project managers), directors of human resources and contractors (for strategic, organisational and performance information) operating in Ghana. Questionnaires and interviews were employed in collecting data for the study. Interviews were conducted to collect further data on issues not explicitly addressed in the questionnaire. Responses were received from 108 ICJV firms. This represents a response rate of about 52%. Care was taken to ensure questionnaire respondents hold senior management positions in their firms. This was intended to prevent potential response bias and common method variance problems. An examination of the job title of the respondents indicated the following: Executive Officer (Project Manager) (30%), Director of HR (23%) and Construction Manager (47%). Averagely, the respondents have worked for the ICJVs for 12 years and have held their respective position in the ICJVs for nearly 6 years. A non-response bias was tested for by applying a t-test comparing the early responses with the late responses along with some key descriptive variables found no significant difference between the two groups. Indicating that non-response bias is not a major problem in this study.

3.2 Factor analysis

From a review of past studies, a considerable number of dependent variables were identified. A reduction technique was therefore needed in order to identify the possibility that some of the variables will result in effects which are directly related and to ascertain which of the specific variables could be measuring aspects of the same underlying facet. The analysis used principal component and varimax rotation method, which optimized and improved the clarity of the results. A reliability alpha test conducted indicated a reliable measure of consistency of correlations (greater than 0.7) amongst the items in each component (Nunnaly, 1978).

4. Results

The analysis of twenty (20) items on the ICJV performance measures yielded four factors and together these factors account for about 64.2% of the variance. Descriptive identification of these factors are as follows:

i. Cooperative relationship measures - this construct places emphasis on a long term goal achievement of the ICJV as numerous authors have denotes it as process oriented goal (Girmscheid and Brockmann, 2009). It and includes commitment, trust, work satisfaction, overall ICJV satisfaction, stability, complementarity and relationship with authorities (seven items, reliability alpha at 0.89);
ii. Financial measures, which include return on investment, cash flow, cost control growth and cost position and asset turnover (five items, reliability alpha at 0.79);
iii. Strategic measures, which include productivity, reputation, innovative strength, market share and resource safeguarding (five items, reliability alpha at 0.78); and
iv. Learning measures, this places emphasis on the importance of expertise and technology to African firms who go into ICJV agreements, it include, management know-how, technology know-how and market know-how (three items, reliability alpha at 0.71). The results of the factor analysis are presented in table 3 and table 4.

Table 3: Initial matrix and rotated matrix of performance measures of ICJVs

	Extraction sums of squared loading			Rotation sums of squared loading		
Factor (Measures)	Total	Variance (%)	Cumulative (%)	Total	Variance (%)	Cumulative (%)
Cooperative relationship	5.868	29.340	29.340	4.440	22.202	22.202
Financial	2.581	12.905	42.245	3.082	15.410	37.612
Strategic	2.338	11.691	53.936	2.895	14.474	52.086
Learning	2.051	10.256	64.192	2.421	12.107	64.192
Extraction method: principal component analysis						

Table 4: Factor analysis of ICJV performance measurement items

Variable items	Factor loading				Cronbach's alpha
	1	2	3	4	
Cooperative relationship measures					**0.892**
Commitment	0.771				
Trust	0.843				
Work satisfaction	0.779				
Overall ICJV satisfaction	0.863				
Stability	0.897				
Complementarity	0.643				
Relationship with authorities	0.470				
Financial measures					**0.793**
Return on investment		0.787			
Cash flow		0.758			
Cost control		0.607			
Growth and cost position		0.502			
Asset turnover		0.874			
Strategic measures					**0.775**
Productivity			0.681		
Reputation			0.660		
Innovative strength			0.603		
Market share			0.770		
Resource safeguarding			0.693		
Learning measures					**0.705**
Management know-how				0.646	
Technological know-how				0.720	
Market know-how				0.801	
Extraction method: principal component analysis					
Rotation method: varimax with Kaiser normalization					

4.1 Discussion of factors

4.1.1 Factor 1 (Cooperative relationship measure)

A good relationship is invaluable, where two or more construction firms seek to join forces in order to achieve their goals (Hauck et al. 2004). It is noteworthy that most of the factors under this component are subjective in nature, thus, they capture the opinions of managers (Mohamed, 2003). These process-oriented performance evaluation measures are not based on specified output goals, but on an evaluation of the company's internal transformation, transparency, clear responsibility, the ability to deal with conflicts and continued survival versus premature dissolution of the joint venture. A possible explanation is that, due to the unstable nature of this hybrid form of alliance in the emerging economics, cooperative relationship has always been the issue with direct implication on performance. Local businesses feel that a good relationship opens greater opportunities for them in the long-run as it creates informational and reputational benefit of dense network from their foreign partner. Businesses also feel that building a strong cooperative relationship serves as a competitive edge that creates a repeated tie of the same network with the foreign partner firm to develop a cohesion-exclusion mechanism for their alliance.

4.1.2 Factor 2 (Financial measures)

The main aim of contractors is to assume the risks associated with putting up structures so as to make profit. In order to measure the extent to which such financial objectives have been achieved, businesses resort to the use of financial measures of performance. Local managers therefore agree on the need to adopt profitability in order to evaluate the returns made by the IJV. Accordingly, JVs returns from the client was also considered a relevant measure of performance. JV's return from the client is a financial measure that deals with cash in-flow to the ICJV's accounts from the client. The independent ICJV on a project is paid for what is due them and this remuneration can be used as basis to evaluate the performance of an ICJV. In the same vein as JV's returns from the client, the partners' returns from the client was identified as a relevant measure in evaluating a JV's performance. Growth and cost position was also identified as a relevant measure in evaluating performance of joint ventures. Construction firms join forces with larger ones through ICJV agreements to grow their business. Through an IJV cooperation, firms benefit from more resources, sharing of managerial load, bigger pool of contracts, reduced commercial risks amongst others. The use of growth as a performance measure by local businesses of ICJVs thereby becomes relevant in such a situation.

4.1.3 Factor 3 (Strategic measures)

With the relevance of IJV as a medium of operating businesses in and across national boundaries, managers adopt ICJVs as part of their firms' business plan, as a strategic means of achieving the short and long term goals of their organisations. Contractor and Lorange (2004) attest to the fact that the formation of IJVs is not necessarily to achieve conventional business goals but for other qualitative objectives. The setting up of ICJV's is to increase the capability of the parties to undertake large projects where independent contractors find it difficult to do so. In view of this, it is no doubt that respondents consider productivity as a relevant measure of performance. Also, Ochieng et al, (2013) stated that a strategy for firms to gain a positive cash flow is to expand their markets. Notwithstanding the exposure to risks, Chen and Messner (2010) stated that a higher control of a construction market is directly related with higher profitability. Innovation is the result of an interactive process in which different specialized agents exchange, absorb and assimilate knowledge in a physical or socially shared context (Autio et al., 2004). This process does not depend solely on the knowledge that a firm develops internally, but also depends on a firm's capacity to assimilate the knowledge of other firms.

4.1.4 Factor 4 (Learning measures)

Dlungwana and Rwelamila (2014) emphasized the importance of external expertise and technology to African construction companies who go into international joint venture agreements. A joint venture provides an appropriate context so that learning processes may take place simultaneously, for example, cooperative learning (Kale and Singh, 2007). Organisation identifies and learn specific knowledge which exists in another organisation or in its different parts. This learning process can provide new knowledge which provides firms with the capacity to cooperate and, furthermore, acquire the knowledge they need in order to innovate. The success of an organisation in today's competitive business environment is strongly related to its ability to utilize knowledge and build their capacity and sustain its competitive position in the changing business environment. Local businesses see the importance of acquiring knowledge as the most strategic significant resource of a firm, and performance winner in any collaborative form they enter. For organisations that have a high level of knowledge of diverse experience/exposure to foreign culture have a deeper understanding of how to deal more effectively and efficiently within local environment, and thus be more successful than their less knowledgeable local counterparts.

5. Conclusion

With the coming together of two or more organisations with different cultural backgrounds, performance evaluation is inevitable where firms seek to develop strategic plans, evaluate the achievement of their goals and in rewarding businesses. In this paper, the relevant measures used in evaluating performance are examined. This could form a basis for building a framework for evaluating the performance of international construction joint ventures in developing countries. It differs from prior studies in that it provides the underlying reasons for the use of the relevant performance measures, from the perspective of local managers. Results from principal component analysis grouped the measures into four components, namely; cooperative relationship measures, financial measures, strategic measures and learning measures.

The identification of relevant performance measures for use for construction joint ventures would guide managers in selecting performance measures to use amongst the lot during the period of evaluating performance. The information obtained from performance evaluation would lead managers to initiate a chain of actions that will enhance the ability of the firm to achieve its short- and long-term aims.

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DII-2017-027

Assessing the Effects of Nodes, Internodes and Height Position on Mechanical Properties of Bamboo as a Sustainable Structure Material: A Case of Ghana Species

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Abstract

Bamboo, a regenerative plant has been used as a structural material for ages, due to its mechanical properties. As a structural material, bamboo has similar properties as that of timber and often uses related approaches of structural framing, though the suitability of bamboo for structural works largely depends on the species. Bamboo's usage in recent years is increasing due to its promising applications as non-wood material. Its superior properties make it an excellent material for infrastructure development. Despite its impressive mechanical properties, it is characterised by some weaknesses, being a nonhomogeneous material, culms not uniform, on the culms guiler node and its cross section is hollow.The study on the effects of node, internode and height position on mechanical properties of bamboo were evaluated on Bambusa Vulgaris species in Ghana. The mechanical properties determined in the study included (compression, fatigue, shear and tensile) and tested in dry air conditions. The findings on mechanical properties of culms, located at various heights were investigated by ISO 22157 and ASTM standards. Samples were cut into specimens and tested to obtain the mechanical properties, ranging from the bottom to the top of each sampled specimen. The analysis of variance (ANOVA) showed the effects of nodes and internodes were of least significant difference (LSD) in all the species. However, tensile parallel to the grain was of significance in all the samples. The effect of height position on the culms was significant across the culm (bottom, middle and top) except the tensile strength perpendicular to the grain was of LSD. The interaction between the node, internode and height position was of (LSD) in all the parameters for these tests except for the tensile strength parallel to the grain which had a great LSD. Results showed a significant influence of node, internode and height position has effects on mechanical properties such as shear, compression and tensile parallel and perpendicular to grain strength which increase from bottom to top. The study shows that Bambusa Vulgaris has a high mechanical properties, and as an alternative to wood in structural engineering. A further study is required to be carried on other species available in the country.

Keywords: bamboo, height position, internode, mechanical properties, node

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1. Introduction

Bamboo is a composite material by natural occurring which is mostly and abundantly found in tropical countries such as Asia, Africa, and America (Gratani *et al.*, 2008). It is a composite material because it consists of cellulose fibres embedded in a lignin matrix. Cellulose fibres are aligned along the length of the bamboo providing maximum tensile, flexural and rigidity strength in that direction Lakkad and Patel (1980). There are over 1,500 bamboo species which have been identified globally and are classified into 70 genera Kushwaha and Kumar (2013), Chattopadhyay *et al.* (2011). Bamboo has its nature as a hollow tube with thin walls. However, it is harder to join bamboo than pieces of soft or hard wood Liese (1980). Bamboo can be group into two (2) distinct types namely herbaceous type (for food and medicine) and woody type (for industrial ply boards) Tara Sen and Jagannatha (2011). Bamboo has a very long history of humanity and is also one of the oldest building materials used by humankind Wooldridge (2012), Yu *et al.* (2011). It is a regenerative natural resource which has a solution to the Product Lifecycle Phase which results from extraction of deposition waste materials that are not disposed of properly according to Ljungberg (2007), Bovea and Vidal (2004). It sequesters carbon dioxide (CO_2) from the atmosphere and releases 35% more oxygen into the atmosphere than an equivalent stand of hardwood trees Janssen (2005). Bamboo has been used widely for household products and extended to industrial applications in its raw or processed state due to advances in processing technology and increased market demand. In most Asian countries, woody bamboo is being used for household utilities such as containers, handicrafts and chairs. Several researchers have used it as a raw material for structural composites such as Oriented Strand Board (OSB) etc. (Qisheng e*t al.*, 2002; Edward and Doing, 1995; Janssen, 2000). Findings on the mechanical properties of bamboo are paramount to aid in its suitability for various end-products (Sattar *et al.*, 1994). The appropriate use of any material depends on its properties to a large extent. The mechanical properties to be evaluated include bending strength, tensile strength, compressive strength, shear resistance and fracture resistance. This study aimed at evaluating the mechanical properties of Bambusa vulgaris, a native bamboo species in Ghana. The properties were assessed on the node, internode and height position of the culm. The results were helpful and gave basis to identifying other bamboo species in the country which could also be useful in the structural engineering.

2. Bamboo Culm

Bamboo is a tall grass, fast-growing perennial grass with large woody culm belonging to the family Poaceae, subfamily Bambusoideae (Zhang *et al.,* 2002). The bamboo plant is complex, having two sets of identical vegetative structure axes: a section of the part is above the soil and the other below the ground. The primary above the ground axis consists of joined tall cylindrical stems, called culms. The part beneath the ground axis is a robust rhizome system with roots and buds (Zhang *et al.,* 2002). It is an anisotropic material with mechanical properties in the three principal directions vary in the longitudinal, radial and transverse directions (Ahmad and Kamke, 2005). Bamboo is very advantageous in load carrying structural components, where mechanical such as tensile strength, compressive strength, shear strength, flexural strength and bending elasticity modulus are importantJiang (2007). Bamboo culm has been used in building applications, such as flooring, ceiling, walls, windows, housing, etc. It has been used in construction works as structural materials for bridges, water transportation facilities and skyscraper scaffoldings (Edward and Doing, 1995; Janssen, 2000; Qisheng *et al.,* 2002). A bamboo culm has a hollow cylinder that tapers and narrows towards the top as shown in Figures 1 and 2. They mature between 4-5 years, and it also attains its maximum mechanical strengths. The culms of bamboo are of different colours ranging from purple-black, green, black, yellow, etc. Liese (1980). The native species in Ghana is Bambusa vulgaris, constituting 95% and Oxytenanthera abyssinica with

5%. Some foreign species such Dendrocalamus strictus, Dendrocalamus membranaceus and many others have also enriched the bamboo resource base in Ghana.

Figure 1: Bamboo culm tapers and narrows towards the top

Figure 2: Shows hollow cylindrical section of bamboo culm

3. Materials and Methods

The materials were taken from Central and Western regions of Ghana while the laboratory use for this study is in the Mechanical Engineering Science Departments of the University of Johannesburg. The bamboo species selected for the survey is Bambusa vulgaris of ages; one, three and five for this study. The ages of the bamboo were monitored by the farm owners as well as the forestry department of Ghana. This process includes cutting off the matured ones and planting new ones. The samples were air-dry and treated with the insecticide Dursban mixed with gasoline. The samples were categories into three sub-groups with three different parts; top, middle and base. For the assessment of the mechanical properties, the Bamboo was evaluated using samples of full-bamboo and split at 15% moisture content. From observation, the effect of the nodes, specimen samples were marked in such a way that internode and node samples were taken from a neighbouring position along the culm and tested under the same circumstances. The results indicate that tensile strength of the node region was only about 30% than that of the internode. There was a significant difference in the value of the elastic modulus. Node elastic modulus was about 40% that of the Internode'sJanssen (2005) and Jiang (2007). The study of mechanical properties of Bambusa vulgaris indicated that the nodes did not impart any adverse effects on tensile strength, bending strength and compressive strength parallel or transverse to the grain Shao *et al.* (2010). Many factors do affect the mechanical properties of bamboo such as moisture content, species type, age, green or conditioned, form and size of the specimen node or internode, position along the culm, testing speed and short or long-term loading Janssen (2005). This study aimed to determine the mechanical properties such as tensile, shear, compression parallel and perpendicular to the grain of the bamboo culm. These properties assessed include the node, internode and height position so that their influence level will be known on Bambusa vulgaris.

4. Mechanical Properties

The specimens for mechanical properties are composed of the tensile test, the shear test, and the compression test; samples of shear and compression test produced with the same model, with the specimen height taken equal to the outer diameter and prepared from the full culm bamboo ISO 22157 (2004); setup tests for specimens of shear and compression (Figures 3 and 4); specimens of tensile parallel and perpendicular to grain prepared from split bamboo culm; and setup tests for tensile parallel to grain (Figure 5) and tensile perpendicular to grain (Figure 6). The shape of the specimen for the test, tensile parallel to grain is created to follow ISO-22157 standard with node and internode culm; while the sample's tensile perpendicular to grain is made to follow ASTM standard ASTM (2007) with all properties on node and internode classified into three groups: bottom, middle and top.

Figure 3: Setup of shear test of bamboo

Figure: 4: Setup of compression test of bamboo

Figure 5: Setup of tensile test parallel to grain of bamboo

Figure 6: Setup of tensile test perpendicular to grain test of bamboo

5. Statistical Analysis

An analysis of variance (ANOVA) was adopted to verify the relationship between a dependent variable with one or more an independent variable Gozhali (2011). In this study, the one dependent variable and two or three an independent variable is called two-way ANOVA. The data were analysed using the Statistical Package of Social Science version 15 (SPSS 15). Analysis of two-way ANOVA was used to determine the effects of the node, internode and height position of mechanical properties of bamboo culms. The significance value in the calculation which is smaller than probability 5% (sig.< 0.05) is called significant (*), while the significant value in the computation which is larger than probability 5% (sig. > 0.05) is called least significant difference (LSD). Effects were reviewed in the analysis of two-way ANOVA as main and interaction variables. The independent variable of F1 was a variable of node and internode sections while the independent variable of F2 was a variable of height position at the bottom, middle and top sections. The main effects were independent variables of F1 and F2, while the interaction effect was a combination of the independent variable of F1 and F2 respectively.

6. Results and Discussion

From specimen samples of 30 bamboos without node, the moisture content was found to vary from 12.94% to 16.16% with an average of 15.09%. The requirement as a building material was limited to 15% moisture content Ljungberg (2007). Tables 1 and 2 illustrates average mechanical properties obtained from three repetition test of mechanical properties. The average values of shear strength on internode and node of mechanical properties are 7.787 MPa and 7.747 MPa from 30 samples of 15 node and 15 internode specimens, in Table 1. The shear strength of samples with internode and node was almost similar in the species. The average values of shear strength were observed of the node and internode at the bottom, middle and top respectively, in Table 1. Results analysis of variance (ANOVA) performed on the data of mechanical properties in a relationship of the effects of node and internode at height position are shown in Table 2. The results analysis of variance (ANOVA) of shear strength of F1, F2 and F1*F2 were 0.03, 15.22 and 0.01 respectively which values significantly were a least significant difference (LSD), significant (*) and least significant difference (LSD). Variable of node and internode (F1) was a least significant difference (LSD) against shear strength, so the research on shear strength may only view node or internode section. Variable F2 of height position (bottom, middle, top) was significant (*) against shear strength, and so the research of shear strength may be reviewed as a complete variable of height position on the bottom, middle and top section. Variable of interaction (F1*F2) was the least significant difference (LSD) against shear strength, so the research on shear strength may only view of variable node or internode on the bottom, middle and top section.

The average values of tensile parallel to grain strengths of 30 samples having 15 internodes and 15 nodes are 253.33 and 110.67 MPa respectively, while the tensile strengths perpendicular to the grain of 30 samples with 15 internodes and 15 node samples are 2.723 and 2.727 MPa respectively. The strengths of samples of tensile parallel to grain with node show a significant difference, while it is tensile perpendicular to grain was almost similar. Shear strength and tensile strength perpendicular to grain increase with height from the bottom through the middle and the top section of culms (Figures 7 and 9). The differences in the tensile strength parallel and perpendicular to grain on the bottom, middle and top section of culms (Figures 8 and 10). Based on analysis of variance (ANOVA) computed F1, F2 and F1*F2 value, the independent variables for tensile strength parallel to grain were 645.954, 19.476 and 5.271 respectively, while the independent variables for tensile strength perpendicular to grain were 0.005, 3.396 and 0.016 respectively. The different independent variables of F1, F2 and F1*F2 for tensile strength parallel to grain was all significant (*), whereas the tensile strength perpendicular to grain was of least significant difference (LSD). In another word, determining of tensile strength parallel to grain should be reviewed as complete against variable F1 (node and internode), F2 (height position on the bottom, middle and top section) and F1*F2 (node and internode on the bottom, middle and top section). Determining of tensile strength perpendicular to grain may only be review against variable F1 (node or internode section), F2 (bottom or middle or top section) and F1*F2 (node or internode on the bottom, middle and top section). Also, the hypothesis of tensile strength parallel to the grain of the same sample is rejected, but the hypothesis of tensile strength to grain difference was accepted. Similarly, the hypothesis of tensile strength perpendicular to grain same sample was accepted, but the hypothesis of tensile strength perpendicular to grain difference was rejected.

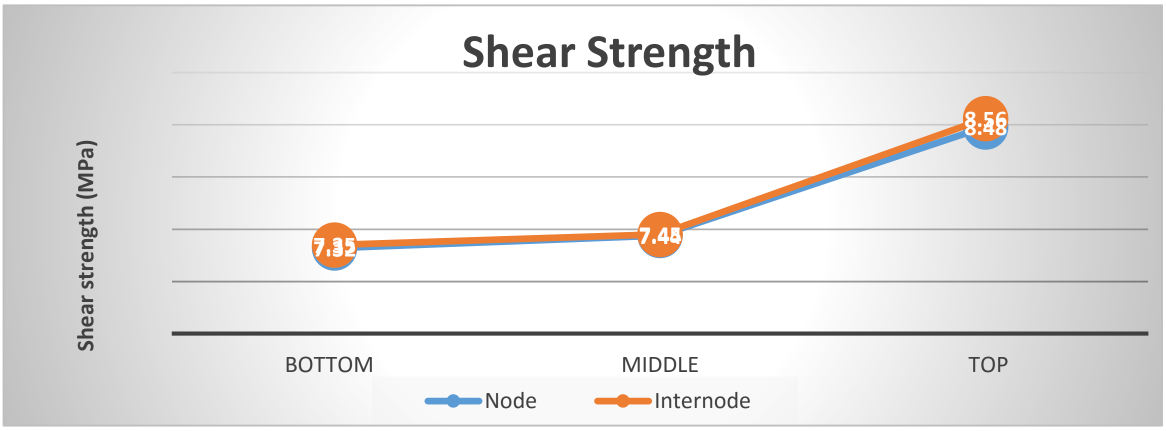

Figure 7: The difference of shear at the bottom, middle and top.

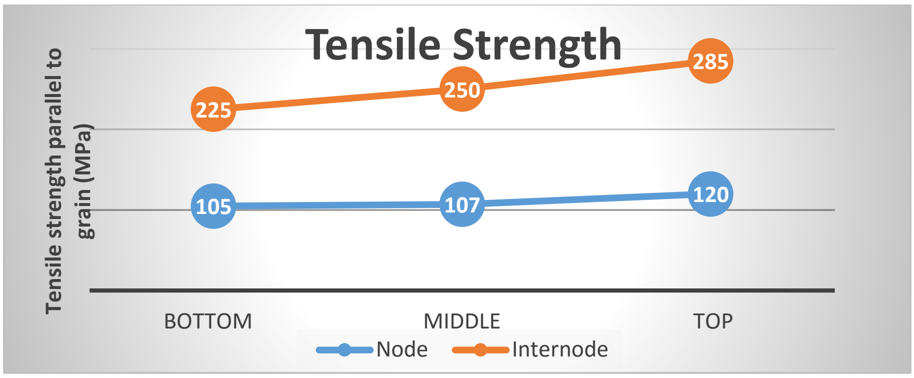

Figure 8: The difference of tensile strength parallels to grain at bottom, middle and top

From 30 specimens for compression strength showed 15 with node and 15 without a node. The average values of compression strength in Table 1 showed on node and internode of 51.43 MPa and 52.27 MPa, whereby values differences on height position at the bottom, middle and top were showed in Fig. 10. Base on the analysis of variance (ANOVA) computed F1, F2 and F1*F2 value, the independent variables for compression strength were 1.63, 7.31 and 0.33 respectively. The significantly different of the independent variable of F1, F2, and F1*F2 for compression strength was the least significant difference (LSD) for variable F1, significant (*) for variable F2 and least significant difference (LSD) for variable interaction F1*F2. Variable F1 of node and internode was the least significant difference (LSD) against compression strength, so research of compression strength may only view node or internode section. Variable F2 of height position (bottom, middle, top) was significant (*) against compression strength, so research of compression strength should be reviewed as complete of height position on the bottom, middle, and top section. Variable interaction F1*F2 of node and internode on the bottom, middle, and top section was the least significant difference (LSD) against compression strength, so research of compression strength may only view node or internode on the bottom, middle and top section.

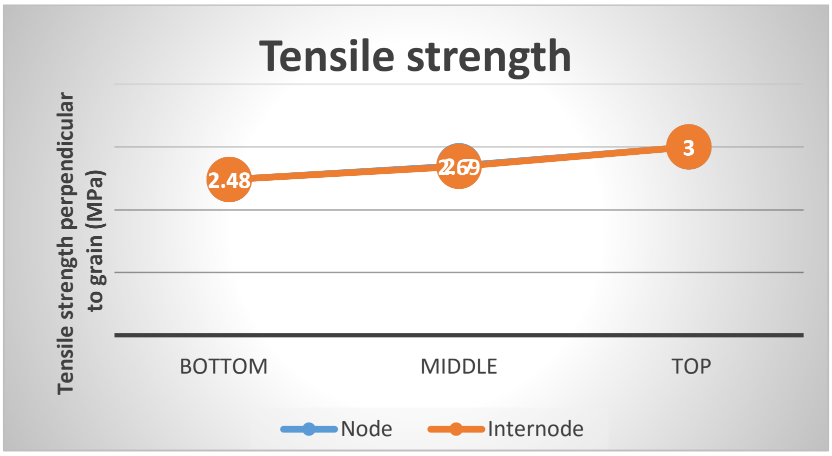

Figure 9: The difference of tensile strength perpendicular

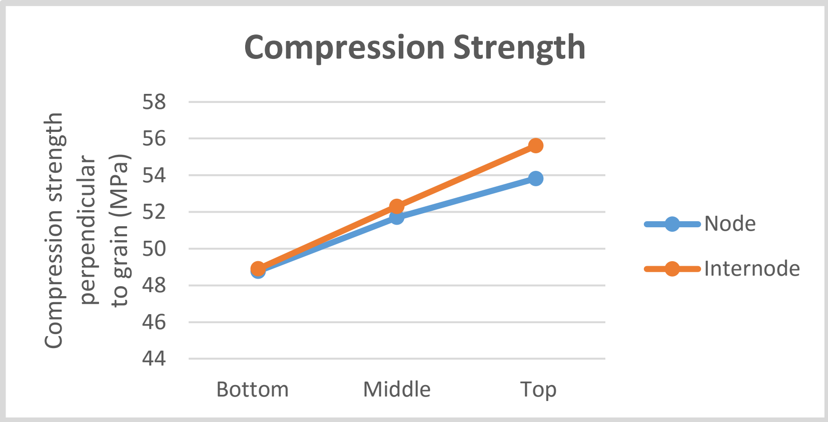

Figure 10: The difference of compression strength parallel at thebottom, middle and top

Table 1 Mechanical properties of bamboo

Character	Unit	Node Samples				Node Samples			
		Bottom	Middle	Top	Average	Bottom	Middle	Top	Average
Shear strength	MPa	7.32	7.44	8.48	7.75	7.35	7.45	8.56	7.79
Tensile strength parallel to grain	MPa	105	107	120	110.67	225	250	285	253.33
Tensile strength Perpendicular to grain	MPa	2.48	2.70	3.00	2.73	2.48	2. 69	3.00	2.72
Compression Strength Parallel to grain	MPa	48.77	51.70	53.82	51.43	48.90	52.30	55.60	52.27

Table 2: Influence of node, internode and height position of mechanical properties

Character	**Analysis of ANOVA**					
	Main effect				**Interaction effect**	
	F1	**Sig.**	**F2**	**Sig.**	**F1*F2**	**Sig.**
Shear strength	0.03	0.87LSD	15.22	0.00*	0.01	1.00LSD
Tensile strength parallel to grain	645.95	0.00*	19.48	0.00*	5.27	0.02*
Tensile strength perpendicular to grain	0.01	0.94LSD	3.40	0.06LSD	0.02	0.98LSD
Compression strength	1.63	0.22LSD	7.31	0.01*	0.33	0.73LSD

7. Conclusion

The study effects of the node, internode, and height position on Bambusa vulgaris species both split and full bamboo culm test configuration was evaluated. Mechanical properties of shear, compression, tensile parallel and perpendicular to grain strengths on node and internode increased from bottom to top. The strength on node and internode of the samples was almost similar to all mechanical properties, except tensile parallel to the grain. The node and internode do have a significant influence on the compressive strength of bamboo. Bamboo with low moisture content has a higher compressive strength than bamboo with high moisture content. Also, shear stress parallel to grain is approximately ten (10) times less than compressive strength and twenty (20) times lower than the tensile strength of the culm at the three points of consideration. Moisture content was different at height position along the culm. Moisture content decreased as the height of culm increased. However, height had almost no effects on the modulus of elasticity (MOE) and modulus of rupture (MOR). As a natural regenerative composite material, bamboo has a high potential of being an infrastructure and a sustainable material for many developmental works in Africa. Investing into its development for both wood and non-wood industries in Africa is a potential strategy to reduce importation of costly raw materials for structure works. Being a less costly and readily available in Ghana, with its high potential in mechanical properties which is averagely close to steel in tension, it is seen as a potential material which would help the Ghanaian building and infrastructure industries as well other African countries. When cultivated commercially, its significant impact on the people would assist in eradicating/reducing poverty and would bring development to the people. Its importation into other African countries for structure works would assist in the economic growth of Ghana and other African countries as its processing does not require much energy and transportation. Also, bamboo releases about 30% of oxygen higher than that of hardwood and its cultivation would serve as a process to reduce the carbon dioxide in the atmosphere to enhance the health condition of its inhabitants. Bamboo is a versatile material and could be adopted in any industrial sector to produce product ranging from architecture, textile, food, construction, building, medicine and many other industries. Hence, if these properties are utilised very well by authorities and governments, there is going to to a huge positive impact on most economies of Africa as the material can be seen in many African countries and also is cheap and readily available in most countries across the continent.

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DII-2017-013

Assessing the Reliability of Botswana Air Transportation: Means for Sustainable Economic Development

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Abstract

The importance of research on performance measurement to monitor operational, safety and reliability aspects of air transportation for sustainable economic development has been long recognised. Performance data is required to evaluate customer response to services and to maintain management control of geographically disparate route networks. The purpose of this study was to assess the reliability of air transportation in Botswana as a measure of passenger airline competitiveness. The whole study examined the airline industry in Botswana, particularly the national flagship, Air Botswana. The study was guided by the three primary research questions, which were inclusive of; the dynamics resulting in schedule delays of air transport in Botswana; the advantages of a reliable air-transportation system to the Botswana economy; and strategies that could be suggested to improve service reliability and address future air transportation issues in Botswana. The study looked into the components that impact on-time performances of the carrier, by adhering to the 15 minute on-time performance (15OTP) metric. The results from the study acknowledged the null hypothesis that air transportation in Botswana was indeed reliable, and this statement was upheld by the way that 69.8% of the departure flights were on-time, and 71.2% of all landings were also on-time for the period running from June 2014 – August 2014. The key findings of this research were that air transportation is reliable in Botswana. The study made a couple of recommendations for implementation that would help the passenger airline competitiveness by comparing operational performance both within the airline and in relation to the performance of other airlines with focus on the impact which regulations have on general sustainable infrastructure development and investment in Botswana.

Keywords: air transportation, Botswana, reliability, sustainable development

1. Introduction

Performance management for competitiveness of passenger airlines has become increasingly important in aviation as managers look for ways to cope with the complexities of their environment. Markets have become more competitive, the industry has experienced asymmetric shocks and there are increased pressures to operate within more stringent social and environmental restrictions. The air transport system of a nation needs to provide safe, reliable, efficient and completely coordinated operations. This

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will best address the issues of competitiveness of passenger airlines as well as enhance levels of administration and expense, in a manner which will support government systems for financial and social advancement whilst being ecologically and monetarily sustainable (Visser et al., 2015). The continuing speed of change and rapid growth has resulted in a complex array of challenges for passenger airline managers. These include increasing congestion of infrastructure, safety, sustainability, environmental and social opposition to aircraft operations, airport and air traffic privatization and commercialization, as well as alliances and mergers between airlines, deregulation of markets, the operation of new larger aircraft and the continued rise of low-cost carriers. Such pressures have led managers, planners and regulators to use a variety of performance management techniques to measure and manage airline performance (Francisa et al., 2005).

Fleet management also plays a significant role, as generally aircrafts got hauled out of powerless markets and sent to stronger routes relying upon the interest. Since aircrafts flew various routes every day, changing the season of one flight would compel altering different flights for that solitary aircrafts. That would alter connections for a huge number of passengers. Weather conditions also contribute significantly as time delays are frequently a consequence of monstrous climate, whereby travellers discover themselves helpless before unforgiving climate that would not clear in days. At most times, numerous flights are cancelled on days when awful climate grounds aircrafts; and on days when tempests clear, however carriers would attempt to recoup (McCartney, 2014).

Botswana being a diminutive sparsely populated country has only one airline that dominates, the national carrier, Air Botswana. It holds the monopoly in the commercial domestic sector flight operations, but not regional flights. The aviation market in Botswana currently is very much sluggish, with a development rate that is proximately comatose. This engenders a very jagged competition for market share, which Air Botswana vies for belligerently with regional airline giants like South African Express and South African Regional Air Link, with which regional sector routes are communal (Dahwa, 2014).

Airport operations scheduling with an airline are ordinarily in light of extremely complex streamlining applications, which merged airport terminal landing and departure schedules, aircraft fleet distribution, and in addition crew scheduling (Hessburg, 2015). The reliability of air transportation management, characterized as the contrast between the scheduled time of arrival and the observed landing time, is interpreted into financial efficiency (Sherry, 2011). In order for the dependability of air transport to be assessed, certain perspectives need to be given consideration. The changes, withdrawals, and re-bookings, some of which change plans by hours, can create a wide range of issues for customers. The progressively outstretching influences of these progressions for the most part groups pressing results as rental-car reservations and lodgings need to be re-booked regularly at higher rates. Mergers and partnerships contribute greatly to these disruptions as some passenger airline carriers have had to re-schedule on account of the turbulence experienced in the business by converging with different carriers, consequently disturbing their past schedules.

This study strived at the assessment of the reliability of air transport in Botswana, looking mainly at the on-time performances and causes of delays and the predicaments they posed to the reliability and competitiveness of air transport in Botswana.

The extent of flight disruptions was calculated by denotes of a schedule/dispatch reliability scale, which was the rate of recurrence of incidents that a flight was away from the gate on time, and was conventionally an analysis of the scheduled departures or a given aircraft type. The decision to consider delays relative to published schedule was primarily made because it is by far the easiest to quantify, and is the most commonly adopted metric in the industry.

The specific objectives of the study were:

1. To identify and assess the dynamics resulting in schedule delays of air transport in Botswana.
2. To suggest strategies that would improve service reliability and address future issues for competitiveness of Botswana passenger airline.

Statement of Hypothesis

1. Hypothesis 0 (H0): Air Botswana was unreliable.
2. Hypothesis 1 (H1): Air Botswana was reliable.

The study contributed to existing knowledge and added to the learning with respect to the configuration of a reliable air transportation framework and assessment in Botswana, as very little research had been done in this field especially in Botswana. A tremendously required interrogation helped by giving crucial data on the sorts of approaches that had been reinforced by distinctive countries that could work in Botswana, the structures and the lessons learnt in attaining to a very solid and practical air transport framework to enhance the competitiveness of passenger airline for sustainable development.

2. Literature Review

2.1 Air transportation in Botswana

A reliable airline flight schedule basically addresses effective employment of accessible assets and additionally enhances on-time performances, bringing about the dedication of an airline to offer a competitive and reliable air transport administration (Air Botswana, 2015). A colossal open door lies for the carrier because of the Diamond Park, which has displayed an opportunity to catch new world markets as there will be a noteworthy number of precious stone merchants going all through Botswana. Hence the need to keep on enhancing the operations and have as of late extended the freight offices and handling space, situating them well (Dahwa, 2014). While a portion of the reasons for delays, for example, climate conditions are outside the ability of control of the airlines, past research demonstrated that a few reasons for postponements are owing to the network and scheduling design decisions of a carrier. Case in point, while a carrier builds up its hub-and-spoke network, it commonly does not represent the blockage externality forced on different airlines working out of the same hub stations (Sohoni et al., 2008). The demand for transport therefore is a derived demand (Visser et al., 2015). On time performance is a measure of the ability of transport services to be on time. The ability of different airlines to meet on time performance statistics depends on the degree to which they are affected by external factors. To calculate the percentage of vehicles on time, comparison is needed with the timetable. A comparison is often completed for arrival time rather than departure time, but both are common. Departure times are normally more on-time than arrival times, as incidents and breakdowns occur that reduce the on-time performance. When the comparison is made between the timetable, and the actual arrival or departure time, a rule is applied to determine how much of a deviation is permitted, which was 5minutes for purposes of this research (Belobaba et al., 2013).

2.2 Passenger airline operations, reliability and competitiveness

Airline schedule development still remains a standout amongst the most difficult forecast activities for any airline. An airline schedule includes a rundown of flights and indicates the origin, destination, scheduled departure, and landing time of every flight in the carrier's system. An indispensable element of the schedule development activity is the estimation of flight block-times. A flight block-time is characterized as the aggregate elapsed time between the time an aircraft pushes back from its departure gate and arrives at its destination gate. The block-time is inclusive of numerous components including taxi-out time, en-route time and taxi-in time. Every one of these parts is liable to diverse reasons for deferral and aggregate block-time delay is the whole of all individual segment delays (Sohoni et al., 2008).

Significant part of the reliability of any airline is the development of its network timetable given a list of guidelines to be worked in an airline network. These include; number of flights to be offered on every course, non-stop versus multi-stop is indispensable. Increments in the recurrence of flights on a course can enhance the expediency of air travel for commuters, bringing about high reliability levels (Sohoni et al., 2008). Factors that impact the reliability of airlines are very critical in determining the on-time performance rate of airlines. The information is being gathered and used to identify performance improvements that can be made and to highlight specific operational problems on certain sectors. Performance data that is often collected in real time is to be reviewed by an operations department and used to manage flight operations. It is also reviewed by network planning analysts to feed medium and long-term planning decisions, enabling management to react to market changes swiftly and survive (Francisa et al., 2005).

The most visible delays that are noticed by passengers are once the airplane arrives. It usually taxis to the entry gate, and upon arrival that is when these are eminent. At times, the delay maybe caused by the wait for ground team to arrive and open an entryway or for the end of the turmoil created by another plane's maintenance delay. Indeed, even champion airliners that are on top of their game, keep some of their most valuable staff in-operational, leave late, and have billions of their finances lost in chronically underutilized airplane and other massively lavish resources (O'Brien, 2015).

The development of airline timetables is an exceptionally complex activity which considers various diverse elements internal and external to airline operations (Hafner, 2008). Enhancing the consistency of airline timetables has been a steady attempt, especially as system impediments develop with an ever-expanding interest. Airline schedules need to be impervious to disruptions in the system, including ground deferral plans and severe climate (Hafner, 2008). Regardless of how unrivalled the schedule map is, sadly airlines every now and again experience different unforeseen occasions called disturbances, on day by day operations that counteract them to work as arranged. The manner in which airlines plan their network systems has a huge effect on overall passenger trip delay. The ratio between direct and connecting itineraries; the time between banks at the hubs; the regularity of service; and the selection of aircraft size and target load factor assume a huge part in deciding travellers' trip reliability (Sherry, 2011).

3. Methodology

The techniques explored during the initial research after both the analysis of literature, which enhanced the comprehension of realistic and useful processes for researching on the reliabilities and competitiveness of air transportation as well as new knowledge in research and descriptive strategies are hereby being presented. Moreover, in this section a portrayal of research methodology experiences was outlined, as well as a summary of the approach.

3.1 Research design

For purposes of this research, quantitative research techniques were utilized for information gathering. The reason being the way quantitative examination answers the inquiries of "how much, how many, how regularly, and to what degree", and the aim of this research was to quantify the reliability of air transportation by taking a gander at the frequencies in delays by breaking down statistics. Quantitative techniques were best for this sort of research as findings from quantitative examination can be prescient, informative, and affirming. The research approach included the gathering of information so that data could be analysed and subjected to measurable treatment so as to bolster or nullify alternate knowledge claims. Qualitative techniques were also utilized to add a humanistic touch to the examination, as understanding is sought after by taking a comprehensive point of view/ approach, instead of looking at an arrangement of variables only.

3.2 Population and sample size

The population of this research was the national carrier's, Air Botswana's total 116 flights per week, for 12 weeks, as it confronts firm rivalry from other regional airlines (South African Express and South African Regional Air-link) for the Botswana business shown in Table 1.

Table 1: Air Botswana flight records (Source: Feed data 2014)

Air Botswana flights	Inbounds per week	Outbounds per week	Total per week
Total	58	58	116

The whole population was used as it was of a small size. The target of sampling is to give a logical method for empowering the data collection and processing parts of the research to be done whilst guaranteeing that the sample gives a decent representation of the populace, i.e. the sample is representative. The sample was chosen using stratified random sampling as it helps with more precision regarding information inside the subpopulations about the variables we are studying. The subpopulations created were: 1. On-time flights cluster; 2. Delayed flights cluster and 3. Non-scheduled flights cluster.

3.3 Data collection methods

For purposes of this examination, the primary source of information to gauge dependability was through direct observation. The comparison of real-time statistical data alongside the flight schedules, together with statistical analysis and participation were utilized as tools for gathering information and a touch of documentary review. This was resultant in a mixed method design of both qualitative and quantitative data collection methods.

This strategy for information gathering was done amid the three months' internship position with the Civil Aviation Authority of Botswana's, Air Traffic Control Centre at the Sir Seretse Khama International Airport (S.S.K.I.A) in Gaborone. During this time, the researcher was in charge of analysing statistical data of all aircraft movements within the Botswana airspace. Airlines are closely monitored on their on-time performance. Therefore, the airlines use a rule that aircrafts that depart/arrive within 15 minutes of their scheduled departures/arrivals are on time. The 15-minute rule for on time performance is commonly applied throughout the airline industry. Airlines typically perform well when their on-time performance reaches 90%.

The quantitative data collected was the through flight plans that Air Traffic Controllers used, as aircrafts enter and depart the Botswana Flight Information Region (FIR) in real time. Within these flight plans was the full data of each aircraft that used the Botswana airspace with regards to: Date, registration, call-sign, type of aircraft, operator, departure/arrival point, route, destination, scheduled time, flight level, number of passengers on board including crew members, fuel capacity, flight level etc. The real times of arrival and departures were measured against the scheduled times, to get the on-time performance results. From working alongside Air Traffic Controllers, the causes of delays were also established.

This evidence assisted the researcher in determining which incidents occurred frequently and could mainly affect the reliability rating of the airline. The data collected during that time also supported the researcher in comprehending which of the aircrafts within the Air Botswana fleet triggered the delays recorded, leading to an enquiry in the maintenance routine of the company. Collectively the information would assist the airport planners together with the airline management on exactly how best to condense delays with the results given.

3.4 Validity and reliability

Validity is portrayed as the extent to which a research study measures what it plans to gauge. It could likewise be portrayed as the extent to which an assessment tool produces steady and reliable results when applied to the same specimen. Drawing in numerous techniques, for example, observation, and documentary reviews prompted more substantial, dependable and different construction of realities. Airline reliability was measured using the 15 minute on-time performance (15OTP) metric, also called the airline dependability statistic. This was done by measuring the real times of arrival and departures against the scheduled times, to get the on-time performance results. Therefore, the selected methods for information accumulation were thought to have the capacity to empower the researcher to answer the examination inquiries brought forward.

3.5 Data analysis

Data analysis covered the procedure of deliberately applying measurable strategies to depict and delineate, consolidate and recap, and assess information. Different analytic methods gave a result for drawing inductive inferences from data and distinguishing the signal (the phenomenon of interest) from the noise (statistical fluctuations) present in the data. Diverse sorts of instruments result in distinctive sorts of information, for instance the survey could have been utilized to evaluate the human recognition reliabilities of the airline business in Botswana and the observation technique measured the constant episodes as they happened and the real time of these occurrences.

Statistical methods that were utilized to investigate the quantitative information that was gathered were descriptive and inferential statistics. The descriptive statistics were utilized to report what happened with the cluster sample, and the inferential statistics were utilized to sum up the outcomes to the more extensive populace. With the qualitative investigation of the information gathered, participative observation was the measure that was utilized as there was a need to lessen an extensive variety of data into a more restricted set of attributes with something in like manner.

4. Results and Discussion of Findings

The principal motivation behind this study was the investigation of the reliability of air travel in Botswana, taking a gander at the on-time performances and reasons for deferrals and the problems they stance to the unwavering quality of air transport in Botswana. The direct observation technique for information accumulation was utilized to gather data relating to on-time performances of airplanes from the air terminal, through data entry into the billing system as flying machines were taking-off and arriving at the airport terminal progressively in real-time. Microsoft Excel was the fundamental software tool that was utilized to capture and break down information, and the presentation of the discoveries of the exploration was further spoken to by the utilization of percentages and frequency tables as shown in table 2 and figure 1 below.

Table 2: Percentage of delayed and on-time arrivals and departures at S.S.K.I.A

Percentage Of Delayed And On time Arrivals And Departures At S.S.K.I.A						
Flight / Month	**Delayed arrivals**	**On time arrivals**	**Delayed departures**	**On time departures**	**Non - scheduled arrivals**	**Non -scheduled departures**
June	24.6	74,19	21.59	77.97	1.21	0.44
July	20.56	78.23	17.72	80.31	1.21	1.97
August	30.53	62.6	36.64	57.25	6.87	6.11

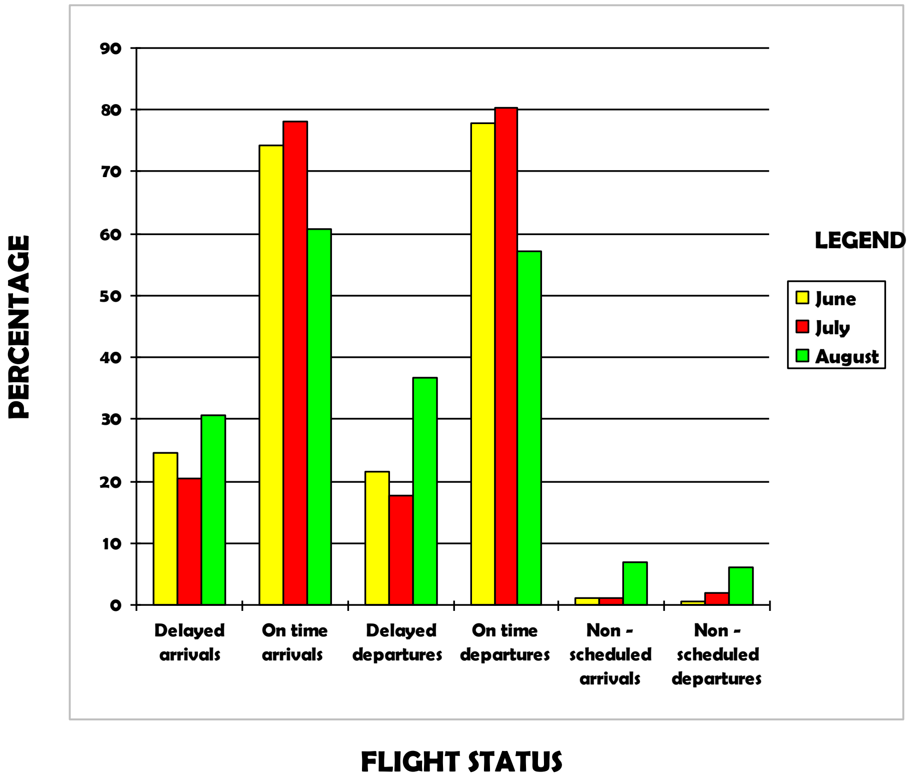

Figure 1: Percentage of delayed and on-time arrivals and departures at S.S.K.I.A

The illustrations above show the aggregate sum and percentage of delayed and on time both arrival and departures of Air Botswana at the S.S.K.I.A during the months of June, July and August of 2014. Table 2 and figure 1 basically delineate how flight-statuses fared out amid the three-month period. It could be seen that on-time entries (which are landings or takeoffs inside of the 5-minute time-bracket; being 5minutes preceding scheduled time or 5 minutes after scheduled time) in June had the lion's share with an aggregate rate of all flights, with a 38.9% rate of event. This was trailed by on-time takeoffs with 37.2%, trailed by delayed arrivals with a 12.6% rate of event; deferred flights with 10.3%, followed respectively by non-scheduled arrivals and non-scheduled departures with both 0.8% and 0.2%.

Accordingly, the month of July witnessed a few changes with regards to the on-time performance rates. A 4.04% increase with the on-time arrivals which was a worthy move as an increase in performance demonstrates a sign of progress in the framework; a 4.04% decrease likewise with the delayed arrivals, which is a decent sign of further developments within the airline management; a further 3.87% decline with the delayed departures which is additionally a move in the right direction, as declines in delay percentages means that management is trying their best to escalate on-time performance rates. The non-scheduled arrivals remained stagnant at 1.21%, which is a possibility, since defects are always expected in the system.

August was an unusual change for the delayed arrivals, as there was a 9.97% increment in the amount of deferred Air Botswana landings in that month. This is because the month of August witnessed the removal of one of the aircrafts from the schedule, for maintenance reasons, which was one of the top performing aircrafts with regards to on-time performance. On-time arrivals encountered a 15.53% decline, and this demonstrates an unreliable stream within that grouping, whilst delayed takeoffs were hard-hit with an 18.92% increment with their delayed flights. A 23.06% drop of on-time takeoffs, a devastating increment of 5.66% in their non-scheduled arrivals and another 4.14% increase in the non-scheduled departures were observed. Figure 2 shows the average incidents per flights departure to different destination from S.S.K.I.A

Figure 2 is consequential to delayed averages that are complimentary to the on-time performances, i.e. higher on-time performances result in lower delayed averages and vice-versa. So the main trend of figure 2 is that, as the on-time performances progress, the delayed and non-scheduled performances regress. Reliability ought to be a pioneer at this air terminal since the activity is not a big deal. Since flights to all destinations are not accessible every day, it would just be reasonable to give a rough estimation of the limit of the terminals airspace on a week by week and consistent schedule.

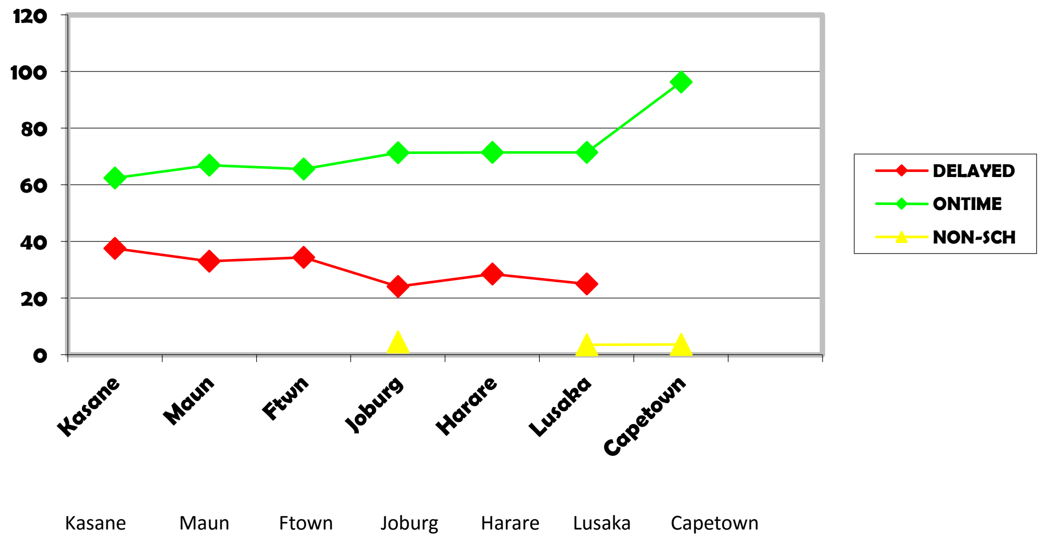

Figure 2: Average incidents per outbound flight

Figure 3 shows how the reliability margins are distributed. For the 80% - 90% margin, we see that most of the highly reliable flight departures are the morning international departures, which are said to be the cash-cows. BOT331, the morning flight to Cape-town is leading the way with an on-time performance of 96.3%, followed by the flights to Johannesburg, Lusaka, and Johannesburg with 94.12%, 92.86%, 88.24%, and 85.29% respectively. Maun follows them with an on-time performance rate of 81.08%, being the only domestic route with such a high rate from S.S.K.I.A. The 70% - 80% margin also constitutes mainly international flight departures, with the highest being the Francistown early morning flight at 79.37% followed by five flights to O.R. Tambo international airport in Johannesburg and the morning flight to Harare with a rate of 71.43%.

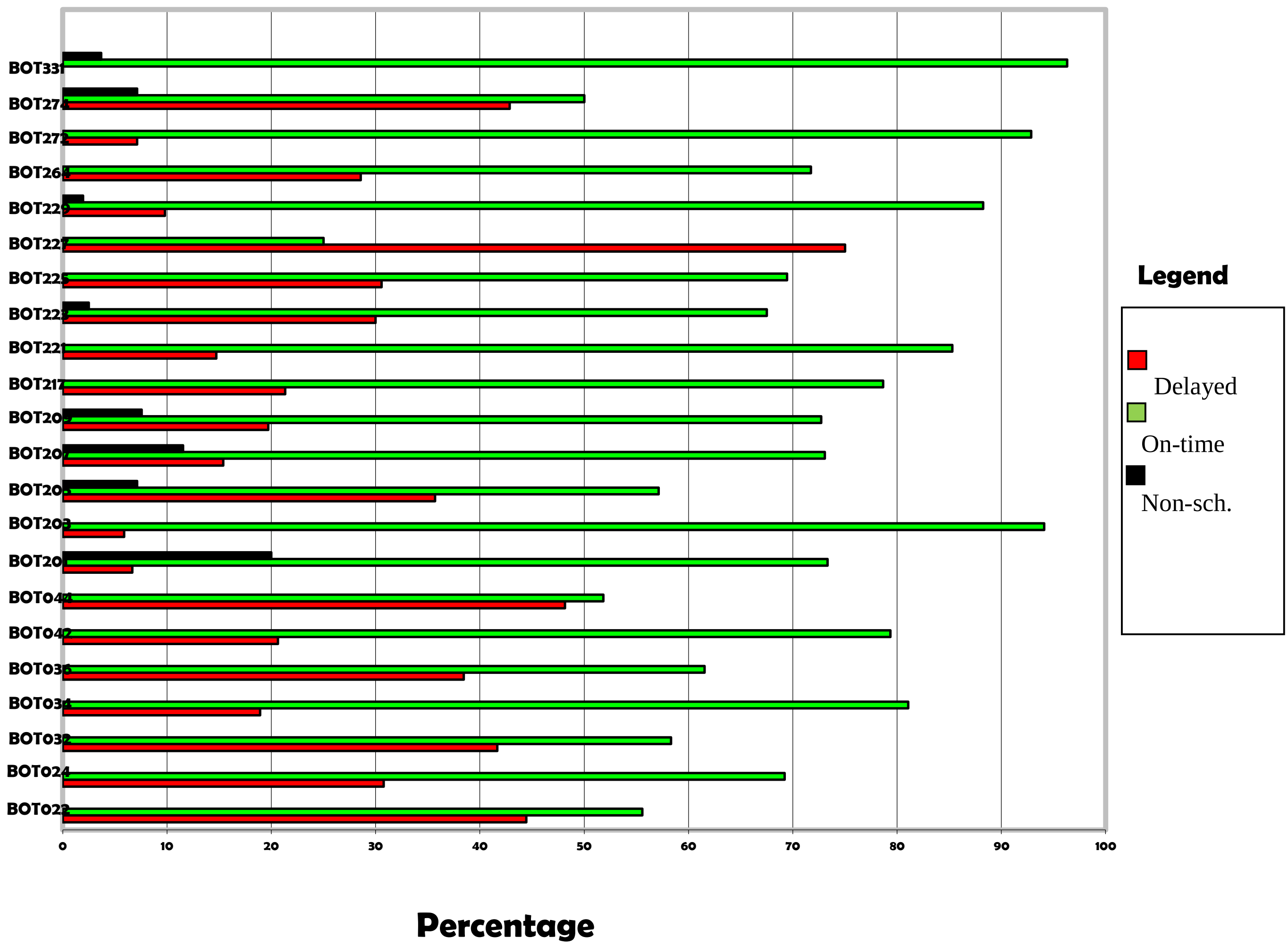

Figure 3: Flight status percentages per outbound flight from June- August 2014

Figures 1, 2 and 3 obviously demonstrated that majority of the Air Botswana flights are on-time. It could then be presumed that air transportation in Botswana is reliable, and this statement is upheld by the way that 69.8% of the departures were on-time, and 71.2% of all landings were on-time for the period running from June 2014 – August 2014.

4.1 Testing of Hypothesis

For this study, the hypothesis was tested utilizing the Pearson chi-square technique for testing. The chi-square testing method, is mainly used when researchers are interested in comparing observed data, with data that they expect to obtain according to a specific hypothesis. The study was predominantly in view of two speculations.

1. Hypothesis 0 (H0): Air transportation in Botswana was unreliable.
2. Hypothesis 1 (H1): Air transportation in Botswana was reliable.

And the formula that was used to calculate chi-square was: $$X^2 = \frac{(O - E)^2}{E} \quad (1)$$

Table 3: Chi - Square analysis result

Category	Observed (O)	Expected (E)	Chi-squared (X^2)
June ontime arrivals	184	248	16.52
June ontime departures	177	227	11.01
July ontime arrivals	194	184	0.54
July ontime departures	201	177	3.25
August ontime arrivals	164	194	4.64
August ontime departures	150	201	12.94

From the table above, it could be said that the Chi-square statistic was 48.9, with regards to this analysis. The result was significant at $p < 0.05$, with a level of significance of 11.07. Therefore the results rejected the null hypothesis, that Air Botswana was unreliable for the period June 2014 – August 2014, thus acknowledging the alternate hypothesis. This was for the reason that there were other factors involved with regards to maintaining reliability and improving the airline's on-time performances. So with everything taken, taking a gander at the Chi-square test, Air Botswana could be said to be reliable, considering both landings and takeoffs. Though the airlines on-time performances may not have been at the ideal 90%+ score during those three months, it created room for much improvement and growth.

The results from the study revealed that at the point when the study was begun, the null hypothesis H(0) expressed that Air transportation in Botswana was unreliable. A chi-square test was utilized to determine whether this statement was genuine or not, and it came out that the null hypothesis was rejected therefore acknowledging the alternative hypothesis which stated that the air transportation in Botswana was indeed reliable.

5. Conclusions and Recommendations

The essential objectives of this paper were to assess the reliability of air transport in Botswana, looking at schedule adherence or on-time performance, which refers to the level of success of the airline service with regards to the published schedule. Botswana is such a little economic system at the heart of the Southern African region, which suggests ideally that it ought to be the core of aviation in the region. A look into the ways in which the airline could be assisted in improving its on-time performance rates was also undertaken. The study was guided by the four primary research questions, which were inclusive of; the dynamics resulting in schedule delays of air transport in Botswana; the relationship between delays and aircraft type; the advantages of a reliable air-transportation system to the Botswana economy; and strategies that could be suggested to improve service reliability and address future air transportation issues in Botswana. The study additionally looked likewise into the components that impact ontime performances of the carrier, which was the measure of reliability utilized for purposes of this research.

At the point when the study was begun, the null hypothesis H(0) expressed that Air transportation in Botswana was unreliable. A chi-square test was utilized to determine whether this statement was genuine or not, and it came out that the null hypothesis was rejected therefore acknowledging the alternative hypothesis which stated that air transportation in Botswana was indeed reliable. Figures 1 and 2 obviously demonstrated that majority of the Air Botswana flights are on time. It could then be presumed that air transportation in Botswana is reliable, and this statement is upheld by the way that 69.8% of the departures were on-time, and 71.2% of all landings were on-time for the period running from June 2014 – August 2014.

From the above, it could be concluded that the airline is truly pulling up its operations to be competitive by attempting to surpass the 69.8% score. It is recommended that in the future, as it is clear that the majority of the expenditure goes into trying to maintain the aircrafts. Verifying that non of the scheduled flights are disturbed because of maintenance issues is also key, except circumstances beyond the airline's control like for instance the weather.

These are the recommendations that would help the passenger airline competitiveness by comparing operational performance both within the airline and in relation to the performance of other airlines.

1. First and foremost, the airline ought to attempt and enhance their customer service as these are the frontline staff that interface straightforwardly with their clients and have the chance to characterize how your clients see your company's products or service
2. The airline ought to make the business turnaround proposal accessible freely; as Air Botswana are a government-linked company and the national flagship.
3. Keeping the present organisational structure and altering the duties of individuals within the Air Botswana system, would be better than an absolutely new structure bringing about cutbacks.
4. Airline managers should compare operational performance both within the airline and in relation to the performance and competitiveness of other airlines. Inter-organisational learning is one way in which airlines can try to meet the challenges facing them.

Acknowledgment

This is to acknowledge Civil Aviation Authority of Botswana for granting research permit for the direct observation information gathered and the consent to gather information during the research study. The issue of authorship was likewise looked into as all people that made a noteworthy commitment to the research are hereby acknowledged.

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Integrative Infrastructure Planning and Management

DII-2017-008

An Investigation into Areas of Dissatisfaction in the South African Residential Sector Post-Construction: A Case of Gauteng Province

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Abstract

Quality is one of the measures of a satisfied client and one of the parameters for gauging satisfactory project delivery. Satisfactory quality is normally achieved by adhering to a design or industry standard and specifications. However, in the South African construction industry the residential sector is the least satisfactory as reported by the Construction Industry Development Board (CIDB). This research established the areas of client dissatisfaction as a starting point for improving quality in the residential sector from the clients or end-users perspective. A questionnaire survey comprising closed and open-ended questions was used in seven residential Estates targeting medium and high cost houses that were built in the last 10 years to determine areas of dissatisfaction. The identified areas of dissatisfaction included poor durability of design, poor aesthetics measures, poor quality of materials, lack of attention to detail due to leaks and dampness. The identification of areas of dissatisfaction is helpful for contractors and designers to deliver satisfactory buildings to client(s).

Keywords: client satisfaction, quality, residential sector

1. Introduction

Traditionally one of the parameters of client satisfaction is the high quality of the finished construction product. The perception of quality varies from client to client and possibly from consultant to consultant depending on discipline. The view for perception of quality could differ based on different parameters such as aesthetics, function, durability, and cost metrics. The Construction Industry Development Board (CIDB) report of 2011 in South Africa pointed out that the residential sector had the highest number of dissatisfied clients compared to other sectors such as the commercial and industrial sector. In 2012, R50bn was used to rectify substandard housing projects throughout South Africa. Additionally, Emuze and Mhlwa (2015) point out that quality in the construction sector generally needs improvement. Therefore, the quality of construction in the South African construction industry needs improvement. Quality may be affected by numerous factors throughout the life of a project. These factors therefore need to be determined to provide a basis for quality improvement. The research focussed on the residential sector within the South African construction industry to determine the factors that affect the quality post-construction in Gauteng province.

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Quality within the construction industry has always and will always be a problematic issue, especially when the satisfaction standards of the client are involved, as well as the reputation of the organisation providing the service (Mazher, Gharleghi and Chan, 2015). Identifying and satisfying the needs of clients is critical for the existence and competitiveness of firms in the construction industry (Cheng, Proverbs, and Oduoza, 2005). Quality for client satisfaction is normally associated with the standard and performance of the product. Ahmed and Kangari, (1995), argue that quality is one of the important forces leading to organisational success and company growth in national and international markets. If an organisation is able to produce quality work at all times, their clients will be satisfied, their reputation will grow and they will be able to manage and to build large client bases to maintain a strong organisational profile (Ahmed and Kangari, (1995). Mazher et al, (2015) suggested that quality in a construction company is the key focus for competitiveness. Considering the important role quality plays in satisfying the client and the survival of the construction firm, establishing areas of departure for quality in the residential sector is justified. Furthermore, most small to medium scale contractors in both developed and developing countries usually start-up by engaging in residential construction as they build capacity and go on to build more complex structures. This study focussed on the clients' perspective to understand what they need post-construction in their dwellings to be satisfied.

The following sections give an understanding of the concepts of quality, client satisfaction, quality management systems and identification of factors affecting quality. This is followed by the description of the methodology used in the study. A discussion section that combines findings and the analysis and gives an interpretation of the data. Conclusions are then drawn from the findings.

2. Quality

Opoko et al. (2016) explain that there is no generally accepted definition for quality in terms of the home construction. Quality can be seen as a rather variable factor and refers to how well the house satisfies the owner's requirements. It also implies that the product must show elements of excellence, and above standard components when measured against other products or benchmarks. A study conducted by Rad et al, (1998), does not define quality in a single sentence but rather as a set of attribute factors of what project quality is. Quality may include aesthetics, amount of defects, time used until completion, fitness for intended use, backed up with sufficient guarantees, economical running costs, and acceptable durability (Rad et al, 1998). The aforementioned factors may be easily measured or interpreted post-construction. They may also result in a high quality project should they be considered during design and construction phases. Al-Naked (2016) states that quality is complex, multidimensional, and prone to personal interpretations. This statement is a representation that quality can have different definitions for different people in different disciplines or spheres of life, depending on the complexities or emphasis of the different spheres of society or disciplines. It is multidimensional in the sense that it features not only in the construction practice but also in various other practices. Opoko et.al. (2016) set out a wider definition of quality stating that quality should include longer-term sustainability in technical, economic, socio-cultural, and environmental considerations. This interpretation means that housing quality must look after the wellbeing of its immediate occupants and those living around it to make it a whole product.

Hoonakker, Carayon, and Loushine, (2010) defined quality as several characteristics instead of one exact characterisation. Characteristics of quality may include features such as 'meeting the expectations of the client', minimising rework and defects', 'ability to create future business', conformance to relevant standards and codes', and 'completing the project on time and in the prescribed budget' (Hoonakker et al, bid). This reiterates that it is difficult to refine quality into a set definition and rather that it is preferable that several criteria are met before a project can achieve high quality as a whole. Karna (2004) defines quality in terms of how it affects client satisfaction that is the product meets and/or surpasses the client's needs and expectations for it. This creates a platform that means quality cannot be exactly understood as a set definition or prescribed standards but rather that the quality is an interpretation (to a certain degree) of what the client desires or experiences. Therefore, the client defines quality using various parameters of interest implying that the perception of quality for different clients may differ.

3. Client Satisfaction

Client satisfaction can be seen as a key performance indicator in any industry and therefore it is important to know what it is and how it can be achieved. Customer satisfaction may be described as a function of quality and expectations (Kärnä, 2004). The client looks for quality of the construction or the final product to determine the extent to which the contractor has met the requirements of the client. Clients tend to compare their experience of a product with some sort of norm or standard in the industry. This sort of experience has also been found to show a big difference in loyalty of clients to companies when they are slightly satisfied and those that are completely satisfied (Kärnä, 2004). It is therefore a vital aspect for companies to know and attempt to measure their clients' satisfaction in order to improve performance. In an attempt to understand client satisfaction, parameters, features, or characteristics need to be carefully examined. Lovaglio (2004) identified numerous parameters for valuing client satisfaction, such as disconfirmation of expectations, distance from ideal service, overall satisfaction, price for fixed quality, and quality for fixed price. One of the main factors, amongst other factors, in the client satisfaction attributes is that of quality of construction, (Chinny, 2012). According to the CIDB, (2011) the residential sector constitutes the highest number of clients that are either dissatisfied or neither satisfied or dissatisfied with the quality of work produced by contractors. Only around 55% of clients are fully satisfied with the work produced. Karna (2004) believes that the problem in construction is that it focusses on the problems of the contractors and with implementation during construction rather than looking to add value to the client's desire for the project. Quality may therefore be improved drastically if one looks at it from the client's perspective (Bowen et. al., 2012). Client satisfaction is determined based on a combination of characteristics, which influences the overall satisfaction of the client.

4. Factors Affecting Quality

Rad et al. (1998) and Hoyle (2001) identified different factors that affect quality in the construction industry. Common factors that are present in both studies include aesthetics, value for money, ability to perform, inherent defects, time used to complete, ability to exceed expectations, and running costs. Jha and Iyer, 2006) identified the following as factors that affect quality:

- The use or incorporation of unskilled labour force within the project itself.
- Corruption of the major professional players involved in that particular project.
- Lack of planning, leading, organising, coordinating, regulating and controlling within the site by the site manager.
- The provision of inadequate works information by the Architects and engineers.
- The lack of clear progress evaluation concerning problems that occur towards obtaining the goals set.
- Ethical, political and legislative interference

The CIDB (2011) have identified that some main factors that act as barriers to achieving high quality projects are related to construction and procurement. These factors are as follows:

- Design related factors- Issues with architectural or structural design resulting in poor quality
- Procurement related factors- The use of an inappropriate form of procurement which results in poor quality
- Construction related factors- Capability of contractor and materials used in construction which results in poor quality

Tables 1 and 2 summarise the factors identified from literature. It appears that there are more factors to consider during the pre-construction phase for quality as shown in Table 1 compared to Table 2. This means that the majority of the quality issues should be guarded against before construction.

A study conducted by Forcada et al. (2014) in Spain, revealed that some of the common defects or barriers to quality in the residential sector, are incorrect fixtures and fittings in bathrooms and kitchens, tile grouting, failure to apply a second coat of painting, unevenness of floors and walls, contractors leave a mess which is not presentable to the client, stains on walls and floors, and a few minor cracks in the walls. Good quality is not always achieved in the construction industry therefore it would be insightful to understand some of the quality management systems in place.

Table 1: Factors affecting quality during construction

Factor affecting quality during Construction	**Sources: Authors/boards/standard**			
	CIDB (2011)	**ISO 9000**	**Palaneeswaran et al. (2006)**	**Jha et al. (2006)**
The use or incorporation of unskilled labour force within the project itself				X
Corruption of the major professional players involved in that particular project	X			X
Lack of planning, leading, organising, coordinating, regulating and controlling within the site by the site manager.	X	X	X	X
The provision of inadequate works information by the Architects and engineers	X	X	X	X
The lack of clear progress evaluation about problems that occur towards obtaining the goals set.	X	X	X	X
Ethical, political and legislative interference		X	X	X
Poor constructability in essence	X	X	X	X
Design related factors	X			X
Procurement related factors	X			
Construction related factors	X	X		X

Table 2: Factors affecting quality post construction

Factor affecting quality: Post Construction	**Sources: Authors/boards/standard**				
	(CIDB 2011)	**(Rad et al. 1998)**	**ISO9000**	**(Palaneeswaran et al 2006)**	**(Jha et al. 2006)**
Finishes		X		X	X
Aesthetics		X			
Time	X	X		X	
Economical running costs		X		X	X
Acceptable Durability		X	X	X	

5. Quality Management Systems in the Construction Industry

Quality management systems in the residential sector have received considerable attention because of defects. The impact of defects is tremendous to the occupants, whether they are the owners or tenants of the house. The factors behind housing defects always lead to occupant's dissatisfaction while satisfaction is the main key towards the customer's loyalty behaviour (Thaddi et al., 2015). Additionally, apart from defects in a building the quality of the building services provided in completed houses influences the customer satisfaction (Ibid). ISO 9000 Quality management Systems (QMS) are the systems adopted and incorporated within organisations, in this case construction organisations, to help these organisations function as well as to also conform to the standards specified in the design document, in assuring the best quality for the construction projects is produced. ISO 9000 QMS standards have been widely used in the construction industry in recent years as in all industries of the world (Turk, 2006). In addition to this, building regulations, codes and standards play a vital role in achieving quality. While standards and regulations are normally mandatory in most construction industries, adoption of quality management systems such as ISO 9000 is generally not mandatory. Therefore, adoption of such a management system could account for differences in the quality of products between companies that employ such standards and those that do not. Notwithstanding, most construction industries have standards that must be followed to ensure that a minimum quality standard is maintained in the construction industry. In the South African construction industry the National building regulation and building standards Act of 1977 is applicable. Others include the Health and Safety (SANS10400).

6. Methodology

The study was cross-sectional in nature using a self-administered questionnaire. The questionnaire had closed and open questions resulting in the collection of both qualitative and quantitative data. Open-ended questions were used to understand the client's perspectives while the closed questions were mainly used to evaluate how wide spread practices are (Bryman and Bell 2015). Residential developments in the Gauteng province built at least in the last ten years were targeted. These included Blair Atholl, Eagle Canyon Estate, Jackal Creek Estate, Waterfall Estate, Blue Valley Golf Estate, Waterfall Equestrian Estate and Kyalami Estates. Ten residential dwelling were targeted in each development, as the houses were homogeneous in nature in terms of size, age and developer. The developments comprised of medium and high cost dwellings. The sample was random in nature. The data from these were analysed using content analysis for the qualitative data resulting in some common categories while for the quantitative data descriptive statistics such as frequencies, means and standard deviations were calculated.

7. Results and Discussion

This section presents the results and offers the interpretation of findings.

7.1 Respondent profile

Response rate from the estates included in the study are as follows: Blair Atholl (10/10), Eagle Canyon Estate (10/10), Jackal Creek Estate (8/10), Waterfall Estate (9/10), Blue Valley Golf Estate 8/10, Waterfall Equestrian Estate 8/10 and Kyalami Estates 8/10. A total of 62 participants were involved in this study. This represents an 88.5% response rate. The majority (60%) bought the houses from previous owners, 24% bought the house immediately after construction while 16% worked with the contractor and designer. Over 50% of the houses were not more than 6 years old.

7.2 Factors contributing to the quality of a home

7.2.1 High quality home factors

The clients or tenants indicated that high quality homes can be achieved through clear consideration of the design, the materials used and the workmanship as indicated qualitatively by respondents (see Table 3). The functional requirements of the occupants cannot be ignored, as these would influence client satisfaction. The factors indicated by respondents are not so different from findings of Rad et al, (1998), Hoyle (2001) and Jha et al. (2006) although in their research aesthetics were the most cited issue resulting in a dissatisfied client. Additionally, this study suggests that spaces in terms of size and function matter to the client.

Table 3 Factors contributing to high quality home

Category	Factor
Building materials	good quality services, good quality materials (11)
Workmanship	Consistency in finishes- no rough edges and incomplete painting, good workmanship, good finishing
Design	Good aesthetics (3), design and attention to detail (3), shape and interior design this will be determined by shaping and design of the house as well as the interior of the house, such as spacing (2), lighting, good acoustics (2)
Contractor experience	skills of the construction workers
Planning	Good planning
Function	Functional installations (2), good spaces and lighting, Overall all the occupant's requirements are satisfied, spaces in the house (3)
Energy efficiency	energy efficient home (3)

7.2.2 Low quality houses

The respondents were asked what, in their opinion, makes up a low quality home. Several responses were advanced, the responses once grouped into categories bordered around categories shown in Table 4. Clearly, the quality of building materials plays an important role in client satisfaction. Selection of building materials should be well considered during the design stage to fulfil durability, aesthetics and functional requirements of occupants. It was evident that the level of engagement of the homeowner had a bearing on the factors seen to contribute to low quality home. Those involved during the construction phase were able to identify factors related to the construction phase while those who were not involved in the construction process could only identify factors post construction.

Table 4: Factors contributing to poor quality home (qualitative responses from respondents)

Category	Factor
Building materials	Poor durability (2), "Poor quality finishes", Low quality building materials, use of Inferior materials (2), Poor quality materials used in construction (15)
Workmanship	Poor workmanship (4), unskilled construction workers (2)
Design	Poor aesthetics, poor design, inappropriate positioning of the house, Poor natural ventilation (2)
Supervision	Poor or lack of supervision (4)
Contractor experience	Inexperienced contractor (1), , ill-informed contractors, expenditure due to contractor errors, or issues, laxity of contractor
Planning	Poor planning (2), delays
Client involvement	Poor or lack of client involvement (3)
Other	Deliberate cost cutting leading to an inferior end product

7.3 Perception of quality satisfaction in the current dwellings

The satisfaction rating for the dwellings visited was indicated by using a closed question based on a five point Likert scale (one on the scale indicating low quality and five indicates high quality was used). Therefore, responses 1 and 2 would result in a dissatisfied client, three would result in a neutral client, and four and five would result in a satisfied client. The mean was 3.78 showing that on average items above the mean were found to be satisfactory by the respondents and an indication that the remainder on items below the mean needed some improvement (see Table 5).

The areas that could be said to be less satisfactory include finishes and internal conditions (ambient temperatures, natural lighting, and services-air-conditioning). This is slightly similar to findings of Forcada et al. (2014) in Spain and their findings point to issues with finishes (paint and tiling).

Table 5: Client satisfaction of aspects of a residential dwelling.

Factor	Mean	Standard Deviation
Electrical lighting	4,15	1,04
Doors	4,08	0,98
Services- hot water	4,05	1,15
Bathrooms	4,02	0,91
Finishes- walls	4,00	1,04
Materials used in building	3,98	0,97
Bedrooms	3,95	0,95
Perceived durability	3,92	0,93
Kitchen	3,89	1,13
Living areas	3,87	1,11
Design- Does the home provide for desired personal functions	3,79	1,06
Finishes- floors	3,77	1,18
Running costs	3,77	1,09
Outside Areas	3,76	1,14
Finishes- General aesthetics	3,73	1,07
Ambient temperatures	3,69	1,05
Natural lighting	3,68	1,33
Parking area	3,56	1,28
Amount of defects (1 being many defects and 5 being no defects)	3,52	0,94
Delays in construction (if applicable)	3,24	1,30
Services- air conditioning	3,02	1,36

7.4 Common defects experienced in residential dwellings

Any construction project going through the natural phases of its life cycle may have defects of various types. The homeowners felt that the defects highlighted below occurred prematurely with the major category related to dampness. The comments below show the qualitative responses indicating some of the defects found in the dwellings. These were found to be common for households in existence for less than 6 years.

From the defects highlighted, it shows that the genesis of the defects could be design related (cracks, material selection) and workmanship related (dampness, cracks and electrical). This calls for designers to pay particular attention to the mentioned areas when designing while contractors should pay particular attention to supervision and engagement of skilled project crews to achieve the desired level of workmanship. The aforementioned measures would add to good service quality that in turn would satisfy the client (Rahman and Alzubi, 2015).

Dampness related	*"Dampness coming in through wall and floor causing mould in a small section of the house"* *"Roof leakage"* *"Dampness"* *"Roof leaks, skew walls, unsymmetrical rooms"* *"Long delays in construction due to financial constraints as a result certain important things could be completed-like waterproofing which lead to some damage"*
Cracks	*"A crack in the foundation formed a few years after house was finished"* *"A large crack in foyer wall"* *"Structural (Crack on walls)"*
Electricals	*"Problems with electrical wirings, plugs sockets often burnt out, as an enormous amount of electricity was been pulled"*
Other	*"Polystyrene ceiling boards were used which have poor acoustic values therefore outside noise is not blocked out well"*

8. Conclusion

Quality as a concept has no consensus of what it should constitute. The quality of a home has contributing factors from both the pre-construction and construction phase. The defects or shortcomings become clear and evident during occupancy. This therefore implies that both the contractors and designers are responsible for the quality of a home. Additionally, there is evidence that the client or future homeowner could contribute positively to the quality of a home by pointing out areas of possible dissatisfaction before construction completion. In this paper the areas of defects and factors contributing to the quality of a home a have been pointed out. These offer a basis for Improvement for designers and contractors to ensure that measures are taken to satisfy clients. Future research could focus on improvements in quality that could be made in low cost residential housing, industrial and commercial sector. Additionally, other parts of the country could be studied as this study only focussed on Gauteng province.

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DII-2017-052

Effect of Indoor Environmental Quality (IEQ) on the Comfort of Building Occupants in Gauteng, South Africa

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Abstract

There is continual argument about the potential negative impacts that poor indoor environmental quality can have on the wellbeing and comfort of occupants. The aim of this study is to investigate the effect of indoor environmental quality on the comfort of occupants of social mass housing projects in South Africa. The study was conducted in Ekurhuleni Metropolitan Municipality (EMM) where low-salary earners mostly reside in South Africa. The descriptive survey research method was adopted and the questionnaire used for the study was targeted at occupants of low-salary housing units in South Africa. The convenience sampling technique was employed for the study. The methods of data analysis basically include percentages and mean item scores. The results of the study indicate that furnishing, quality of air and thermal comfort on the fourth floor does not give occupants satisfactory comfort. The thermal comfort on the third floor is also unsatisfactory. Cleanliness and general maintenance and acoustic quality on the first floor are unsatisfactory to building occupants. Based on these, it was recommended that the acoustic designs of units on the first floor should be increased beyond those of second floor and above. It also recommended that attention should be specially paid to general cleanliness and maintenance of the first floors of building units. Finally, it was recommended that the thermal comfort of building units needs to generally be improved from the design stage. The significance of this study is that building designers and clients will subsequently see the reason to pay more attention to the thermal comfort during construction planning and increase acoustic and cleanliness activities for the first floor of buildings

Keywords: building occupants, housing project, indoor environmental quality, low-salary earners, South Africa.

1. Introduction

After the South African apartheid that ended in 1994, providing accommodation for citizens especially the poor has been a major challenge for the government according to the Department of Housing. In a bid to solve this problem, various policies, strategies, programmes and projects were introduced. In spite of these policies, housing problem remains unsolved (Othman and Mia, 2008). In view of this, government started social and rental lodging programs which concentrated on encouraging access to rental housing and supporting urban rebuilding and incorporation.

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Social housing primarily seeks a formal technique for recovering and taking care of valued housing for low-salary workers, with the point of giving adequate comfort to low-wage families. Therefore, social housing ventures are accepted to address more extensive personal satisfaction needs (Onatu, 2010). Also, most people have been said to spend much of their time in their homes, in which they direct the primary exercises of day-to-day living and rest consequently (Afacan and Demirkan, 2016). As a result, houses ought to be given in the right areas with vital social luxuries which eventually prompts enhanced personal satisfaction (EMM IDP, 2012). For this reason, it is imperative that an investigation of occupants' comfort level with indoor environmental quality (IEQ) in social housing projects in South Africa.

There is steady civil argument about the potential negative impacts that poor indoor environmental quality can have on the wellbeing and comfort of occupants (Afacan and Dermikan, 2016). The need to guarantee quality and clients' fulfilment has become noteworthy to government and those involved in housing arrangements in many nations (Ibem, 2012). According to Ngxubaza (2010) the South African housing delivery plan is faced with various economic and social challenges which include a high unemployment rate, low income, huge housing backlog and lack of infrastructure.

Moreover, Suleiman *et al.* (2013) noted that IEQ is often not considered as a major aspect of design during development planning and management. This leads to imbalance indoor environmental quality which consequently results in negative impact on facilities, building and occupants. The imbalance contributes to the health quality of occupants and Sick Building Syndrome (SBS) in most cases.

According to Afacan and Dermikah (2016) there are continual debates about the potential negative effects of poor indoor environmental quality on health, quality of life, user satisfaction, comfort, performance and productivity. In addition, the Department of Local Government and Housing explained their awareness of poor development quality of houses and urban offices for new ventures. In addition, the effect of poor indoor natural conditions, such as high indoor contamination, low or high indoor temperatures, absence of light, commotion and so on can be lead to discomfort for occupants (Lavelle, 2010).

Therefore, ensuring high IEQ requires a complete approach towards lighting, acoustics, commotion control, ventilation and warm solace. Although, many studies have been conducted on IEQ; none has been found to examine the IEQ of social housing projects in South Africa. Having a solid indoor environment is essential for occupants and it is based on this position that the study evaluates the effect of IEQ on the comfort of occupants in social housing projects in South Africa. The findings of the study are mostly beneficial to designers such as architects and services engineers as design areas with shortcomings will be highlighted in this study for further design attention.

2. Literature Review

Indoor environmental quality (IEQ) refers to the environmental qualities within a building and it is commonly utilized as a part of connection to the well-being and comfort of building occupants (Samari *et al,* 2013). It covers variables such as temperature, ventilation, indoor air quality, day lighting quality, warm solace and access to see. In addition, indoor environmental quality makes up one of the five classes of the Leadership in Energy and Environmental Design (LEED), created by the Green Building Council of the United States of America (USGBC).

IEQ influences client fulfilment and efficiency. Also, guaranteeing high IEQ requires a thorough approach towards lighting, acoustics, clamour control, ventilation and warm solace. Solid indoor environment is essential for tenants and diminishes the requirement for reconstruction and renovation (Afacan and Demirkan, 2016). The theory relating to indoor environmental quality is extremely wide and fuses different components which incorporate temperature, relative humidity, air speed, wind stream, inhabitancies, clamour, and lighting (Almeida et al., 2015). Furthermore, Liang *et al.* (2014) stated that IEQ refers to the ability of a building to deliver an indoor environment to occupants beyond their expectations. These expectations include occupants' health, comfort, well-being and productivity.

Thermal comfort is that state of mind that expresses fulfilment with thermal environment (Frontczak and Wargocki, 2011). Navai and Veitch (2003) described acoustic condition as a condition of happiness with acoustic conditions. The nature of sound environment is connected to various physical parameters, which incorporate both the physical properties of sound itself and the physical properties of a room. Sound is described by the sound weight level in a fleeting and long-haul period and by sound recurrence. The acoustic environment is affected by such physical room properties as sound protection, assimilation and resonation time.

The term comfort is not regularly utilized as a part of connection to indoor air quality and it is mainly associated with the absence of distress because of smell and tactile aggravation. Satisfactory air quality is characterized as air when there are no known contaminants and with which a dominant part of the general population does not express disappointment.

3. Research Method

This study was conducted in Ekurhuleni Metropolitan Municipality (EMM) where low-salary housing projects are concentrated in South Africa. The targeted respondents were the occupants that dwell within the social housing projects that are managed by the Ekurhuleni Development Company (EDC), an organisation that was set up in 2000 for the advancement and administration of rental lodging for low and direct pay families in South Africa. The rationale for choosing buildings managed by EDC is that, many of the housing units managed by the company are occupied by low income earners and it is not unlikely that some design deficiencies will be present in those buildings due to the cost of provision of those houses. Thus, this study was conducted only on the social-housing projects that are under the management of EDC.

Hence, 150 copies of structured questionnaire were administered on occupants of social housing projects in EMM in South Africa. All occupants of the housing projects in EMM were qualified for this study but for convenience, those that were interested in participating in the study were given the questionnaire. Hence, the convenience sampling technique was adopted for this study and only 50 questionnaires were returned. The methods of data analysis include percentages, mean scores, t-test and analysis of variance (ANOVA).

4. Data Analysis

Table 1 shows the general information of respondents and their houses. 66% of the respondents were females while 34% were males. This shows that there are more female respondents in this study than males. Also, 2% of respondents were 20-25 years, 20% were 26-30 years, 32% were 31-35 years, 22% were 36-40 years, 16% were 41-45 years and 8% were above 45 years. This indicates that majority of the respondents fall within 26 and 45 years. In the same vein, 74% of the respondents are Africans by ethnicity while 22% were mixed-race.

Table 1: General information about respondents and their houses

	Percentage (%)
Gender	
Male	34
Female	66
Age	
20-25	2
26-30	20
31-35	32
36-40	22
41-45	16
Above 45	8
Ethnicity	
African	74
Mixed-race	26
Number of years in building unit	
Less than 1 year	16
1-5	44
6-10	40
Floor level of respondent	
First	50
Second	22
Third	18
Fourth	10
Direction of occupants' buildings	
North	20
East	26
West	8
Core	18
Do not know	28
Type of unit occupied	
2- bedroom unit	74
1- bedroom unit	26

Table 2 indicates the mean scores and ranks of the effect on indoor environmental quality on the comfort of occupants based on the floor level they stay. The results revealed that lighting quality was ranked first by occupants at first floor (MIS =3.68). It also ranked first in the overall analysis of respondents (3.70), However occupants in the second (3.36), third floor (3.67) and fourth (4.60) floor ranked it second. In addition, cleanliness and maintenance of buildings ranked first amongst occupants in the second floor (4.46) and third floor (4.00). First floor occupants ranked it fifth (2.88), occupants in the fourth floor ranked it third (4.20) and the overall ranking was third (3.56).

The study further indicates that on the fourth floor, furnishing (2.20), quality of air (1.60) and thermal comfort (1.40) do not give occupants satisfactory comforts. The reasons for these were not investigated in this study; hence it may require further investigation. Also, the thermal comfort on the third floor is also unsatisfactory (2.78). The reason for this too may be subjected to further investigation. Lastly, the cleanliness and general maintenance (2.88) on the first floor is unsatisfactory just as acoustic quality (2.80) is not satisfactory. It is understandable that first floors are closer to surrounding noise and dirt.

Therefore, sounds from vehicles, moving objects and persons may easily penetrate apartments on first floor and as such, they are susceptible to acoustic and cleanliness problems.

Table 2: Effect of IEQ elements on the comfort of social housing occupants based on floor level

IEQ Elements	1st floor Mean	Rank	2nd floor Mean	Rank	3rd floor Mean	Rank	4th floor Mean	Rank	Overall Mean	Rank
Lighting quality	3.68	1	3.36	2	3.67	2	4.60	2	3.70	1
Cleanliness and Maintenance of the building	2.88	6	4.46	1	4.00	1	4.20	3	3.56	2
Unit layout	3.32	3	3.00	5	3.56	5	4.80	1	3.44	3
Furnishings	3.44	2	3.00	5	3.56	5	2.20	5	3.24	4
Air quality	3.32	3	3.36	2	3.67	2	1.60	6	3.22	5
Acoustic Quality	2.80	7	3.36	2	3.67	2	3.40	4	3.14	6
Thermal comfort	3.24	5	3.00	5	2.78	7	1.40	7	2.92	7

5-Very high; 4-High; 3-Average; 2=Low; 1=Very low

Table 3 shows the mean scores and ranks of the effect of IEQ elements on occupant comfort based on type of units they occupy. The results are set against each other in order to study the variance in perception amongst different groups of occupants in the social housing project. The table reveals that lighting quality was ranked first by both the 2 bedroom (3.57) and 1 bedroom occupants (4.08) occupants. Also, Thermal comfort was ranked last by two bedroom (3.03) and one bedroom (2.62) occupants. Generally, the occupants agree that lighting quality (3.70) affects their comfort the most, followed by cleanliness and maintenance of building (3.56), layout of unit (3.44), furnishing (3.24), air quality (3.22), acoustic quality (3.14) and thermal comfort (2.92). It is noticeable that thermal comfort has low effect on the comfort of one bedroom occupants. This may be determined by the number of occupants in the apartments because the more people in an apartment, the less the thermal comfort will be.

Table 3: Effects of indoor environmental quality on the comfort of social housing occupants based on type of unit

IEQ Elements	**2-bedroom Mean**	**Rank**	**One bedroom Mean**	**Rank**	**Overall Mean**	**Rank**
Lighting quality	3.57	1	4.08	1	3.70	1
Cleanliness and maintenance of the building	3.38	4	4.08	1	3.56	2
Unit layout	3.35	5	3.69	3	3.44	3
Furnishings	3.43	2	2.69	6	3.24	4
Air quality	3.41	3	2.69	5	3.22	5
Acoustic Quality	3.03	6	3.46	4	3.14	6
Thermal comfort	3.03	7	2.62	7	2.92	7

5 = Very high; 4 = High; 3 = Average; 2 = Low; 1 = Very low

5. Discussion of Findings

This study investigates the effects of IEQ on the comfort of occupants of low-incomes houses in South Africa. The study revealed that the thermal comfort of the buildings is generally not acceptable to the occupants. Besides, the quality of air and furnishings in some of the apartments are also not satisfactory to occupants. The thermal condition of a building, whether too hot or too cold will not make occupants to enjoy the house, thus affecting their health negatively as claimed by Afacan and Dermican (2016). This is consistent with the findings of Lavelle (2010) that the effect of poor indoor natural conditions such as high indoor contamination, low or high indoor temperatures and absence of light can be lead to discomfort for occupants.

Furthermore, Liang *et al.* (2014) stated that IEQ refers to the ability of a building to deliver an indoor environment to occupants beyond their expectations which include occupants' health, comfort, well-being and productivity. This is in recognition of the fact that, a poor indoor environment will lead to sick building syndrome for occupants. As claimed by EMM, IDP (2012), this situation would leave to search for house in urban centres, hence the prompt for enhanced social personal satisfaction. Therefore, it is important to state that, regardless of the kind of houses or people to be catered for, indoor environmental quality should not be compromised because of the adverse effects it has on the occupants. Hence, designers are required to pay attention to thermal quality and indoor air quality when buildings are being designed for construction purposes.

6. Conclusion

Based on the findings of this study, the study concludes that generally, except for thermal comfort in building units, lighting quality; general cleanliness and maintenance; units' layout; furnishings in the units including chairs, dining set, wardrobes and kitchen cabinets; air quality and acoustic quality give satisfactory comfort to building occupants. The study further concludes that on the fourth floor, furnishings, quality of air and thermal comfort do not give occupants satisfactory comforts.

Also, the thermal comfort on the third floor is also unsatisfactory to occupants. Moreover, the cleanliness and general maintenance and acoustic quality on the first floor is unsatisfactory to building occupants. Finally, the study concludes that the thermal comfort in one bedroom units gives unsatisfactory comfort to building occupants.

Based on these conclusions, the study recommends that the acoustic designs of units on the first floor should be increased beyond those of second floor and beyond. It was also recommended that, attention should be specially paid to general cleanliness and maintenance of the first floors of building units. Also, the study recommends further investigation into the reason for poor thermal comfort and air quality on some floors of building units. Finally, it was recommended that thermal comfort of building units needs to generally be improved from design stage.

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DII 2017-012

An Evaluation into Improving Facility Management through the Use of Building Information Modelling in the Zambian Construction Industry

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Abstract

Facility management forms an important support service aimed at creating successful and profitable maintenance, operation, and monitoring of buildings or properties. It ensures an appropriate and optimum working environment that yields high productivity, ultimate use of buildings and a health and safe work environment for occupants of a building. This paper accesses the integration of Building Information Modelling (BIM) to building maintenance and operations as a way of improving facility management against the background of the Zambian construction industry experience. The research made use of primary and secondary sources of data obtained from literature, questionnaires and interviews administered to consultants, contractors and statutory bodies respectively in Zambia. The research outcome indicated that BIM can enhance facility management. However, its implementation is hindered by a number of factors. These include the cost of implementation, lack of knowledge about BIM by clientele and professionals involved in maintenance and a lack of best practice studies on how to implement BIM. Software costs, copyright restrictions and mere reluctance by construction professionals were also listed as some of the hindrances. By taking an interest in the integration of BIM in facility maintenance and operations, maintenance and operations of buildings can be improved in the Zambian construction industry. Firms are able to reduce operational life cost of buildings while maintaining a health and safe working environment. Mandating the utilization of BIM for public works and introducing BIM in universities to reduce cost of training professionals in the long run can go a long way in combating some of the hindrances observed implementation of BIM.

Keywords: BIM, facilities management, information, maintenance, operation, Zambia

1. Introduction

Facility maintenance is the total of activities serving the purpose of retaining the condition of a facility in a state considered necessary for the fulfilment of its production function (Alhman, 1998). It covers a range of activities aimed at reducing the occurrence of failures, ensuring safe and satisfactory operation and productivity, and extending the life of the facility and all equipment found therein (Alhman, 1998). It is an element that ensures that a company’s investment is retained in an acceptable state. Therefore, the efficient and effective management of this support service is crucial to an organisation’s interests.

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For it to be efficient and effective it is cardinal that information about the facility is readily available to the personnel involved in the maintenance works (Atkin and Brooks, 2009).

A lack of proper generation, storage and sharing of necessary information to track and coordinate maintenance can hinder maintenance activities. For an organisation's core business to thrive, an environment deemed fit for purpose must be created in buildings that may or may not have been designed for the purposes for which they are now used. Without this an organisation can fail to deliver its promise to the customers and provide an environment that supports health, safety and wellbeing. Maintenance is an important support service which works to create an appropriate and optimum working environment that yields high productivity. For it to be efficient and effective it is cardinal that information about the facility is readily available to the personnel involved in the maintenance works (Atkin and Brooks, 2009).

2. Criticism of Traditional Approach to Facility Management

The three main approaches to building maintenance are planned maintenance, predictive and corrective maintenance (Lindley *et al*., 2008). Planned maintenance is an approach to maintenance where routine actions are undertaken to keep a facility in working order. Reactive maintenance is an approach where fixing of any building component is done when it becomes faulty or out of order. Predictive maintenance focuses on assessing the areas of possible trouble in a facility and repairing it without following any predetermined schedule but as and when components display significant wear and tear and may cause trouble if not checked (Alhman, 1998).

The most widely utilized maintenance approach is reactive maintenance (Lindley *et al*., 2008; Alhman, 1998). Reactive maintenance tasks have been reported to cost three to four times more than the same repair activity if it were to be performed as planned maintenance [Sullivan, et al., 2004]. Additionally, it further increases the frequency and cost of repairs and maintenance due to repeated repair. Cost inefficiencies are as a result of failure by most maintenance departments to plan and implement proper maintenance strategies. This failure is a result of lack of adequate and vital information either because no maintenance manual was provided upon completion of the facility or it is missing, or the information is just not accessible because it was not generated or not in an easily accessible format (Lindley *et al.*, 2008).

3. Information Management

Information management is the application of management techniques to collect information, communicate it within and outside the organisation, and process it to enable managers to make quicker and better decisions (Dalkir, 2005). It involves the collection and management of information from one or more sources and distribution of that information to one or more audiences (Anon., 2014). A good information management approach should be capable of managing captured information throughout a building's lifecycle regardless of the source or format of delivery through multiple channels that include cell phones and web based devices. In this context the sources of information include Architects, Engineers or Contractors and formats include paper documents, electronic documents, audio, video, data or any combination of the enlisted categories (Dalkir, 2005). The traditional format in which information is generated by the design team and transferred to the client for use by facility managers upon completion of construction works is mostly through two Dimensional (2D) drawings and 3D models in hardcopy and seldom in softcopy (Teicholz, 2013). The software formats widely employed for transfer and manipulation of information at both construction and operation stages are not designed especially for use in efficiently handling facility information and are incapable of interoperability between professionals that are involved in the procurement (Teicholz, 2013). Atkin and Brook (2009) argue that the generation of information and its storing format does not allow for information to be fully utilized for maintenance and operations with a substantial amount missing at post construction e.g. maintenance manuals, warranties, construction technology employed. Information storage formats i.e. hardcopy makes it difficult to share information and risks it being lost or damaged with the passage of time (Atkin and Brooks, 2009). Hardcopy documents that hold maintenance information are ambiguous, ineffective and inefficient especially if the building is large and complex in design (Teicholz, 2013; Atkin and Brooks, 2009). By its very nature, paper is not very durable, and this coupled with the manner in which hardcopy documentation is stored in the maintenance departments leads to much information being lost during the lifecycle of the project (NIBS, 1998). Furthermore, more information is also lost during handovers as new facility management staff is ushered in. As a result, an inordinate amount of time is spent locating and verifying specific facility and project information from previous activities for maintenance activities.

The traditional approach of responding to faults as they manifest in a facility has become inadequate to meet the demands of clients (Sullivan *et al.*, 2004). Delays in the information exchange are common, Misinterpretation of the information from drawings and records, lack of access to much needed information to carry out maintenance works and poor record keeping (Pugh, 2010). Even when reference is made to original blueprints and as-built drawings by maintenance staff, in some cases most of these have been rendered useless by decades of upgrades and retrofits. The bulk of these documents renders information transmission between interdisciplinary divisions of the maintenance department inefficient and thus causes low productivity which leads to labour wastage and high cost of works (Clayton et al., 1999). It has become incumbent to optimize the approach to facility maintenance management by anticipating areas which require attention before they become an issue. This can be achieved by having foreknowledge on how the facility behaves [i.e. how the facility deteriorates] and keeping track of past maintenance records (Akcamete et al., 2010). Therefore, this inefficient handling of low quality information is a source of most of the challenges in facility maintenance. Therefor, information management is a critical aspect of facility management and maintenance.

4. Building Information Modelling

Building Information Modelling (BIM) is an information technology (IT) enabled approach that involves the application and maintenance of integral digital illustrations of all building information for different phases of the project life cycle in the form of a data repository (Gu, 2010). A complete 3D digital representation of a building system including its subsystems (e.g. HVAC, electrical, etc.), this sophisticated technology is both a visually accurate model of a building and a database for recording the breadth of information developed and associated with building components. In BIM, elements are virtual simulations of building components i.e. a wall exists as a wall; all objects have an identity and attributes. BIM as a comprehensive concept of process and tools which integrates all projects required data and information. As a management paradigm, it can be implemented through building software such as Revit, Primavera, etc. by utilizing the managerial processes and concepts such as critical chain project management, critical path method and concurrent engineering at all stages of projects' life cycle (Shorangiz, 2011). As a data application, BIM can track the types and quantities of materials, equipment and spaces used and needed in a facility. Under the BIM umbrella are many interoperable software applications that lead to an efficient design of space, generation of information, as well as sharing and storage of this information throughout the lifecycle of a building (Sabol, 2008). Beyond being a drawing and documentation tool, BIM offers a platform for enhanced interdisciplinary collaboration, the capability to manage change, and the ability to extend information support throughout the building lifecycle (Payne, 2010). Hence for supporting maintenance work, software like BIM that provides a reliable maintenance database that stores history of maintenance work and the associated change information in an easily manageable and accessible format is necessary.

BIM can be used to reduce operational costs; BIM can create a platform for analysis and comparison of available energy options that enables the facility manager to reduce operating cost and environmental impacts of building (McNeill, 2010). BIM provides a living model that presents an easy representation of three-dimensional aspects of the building. Having a living model helps facility manager's access information about an existing building that can be used in renovations and retrofitting. As a result, change orders that arise from unexpected in built condition are significantly eliminated. Many professionals are of the misconception that the process of implementing BIM requires the knowledge in 3D modelling and CAD software to make use of information. BIM provides a platform were 80% of the data required for BIM probably already exists in the current facility management records (Gee, 2010). Content is of paramount importance, the decision on the level to which detail is attached should lie in the needs of an organisation.

Despite the benefits of using BIM, according to (Oskouie et al., 2012) BIM is beneficial to FM but limitations exist. These limitations include the cost of software, copyright restrictions and the cost of training (Teicholz, 2013) and the reluctance of users to switch from drafting to modelling (Sabol, 2013). BIM for FM is an emerging field and is yet to be proven compatible with Computer-Aided Facilities Management systems (CAFM) (Gee, 2010). The lifecycle of software is around 12 months, whereas the lifecycle of a building typically around 100 years, meaning data standards are critical. It is of vital importance that organisations do not fit their business to suit a technology, otherwise they will struggle to adapt to new software as technology develops. Again, this may save time and costs associated with design and provide more accurate representations for strategic decision making from a management perspective. BIM can be referred to as a modern approach to age old problems (Kurul *et al*. 2013). The use of BIM in FM transforms the traditional approach of documentation, control and maintenance operations by helping reduce maintenance cost, providing cost, lowering operational costs, providing accurate control system and helps in delivering cost effective services for building occupants (Kurul *et al.* 2013).

5. Methodology

Questionnaires and interviews were administered. The survey focused on accumulating evidence from facility maintenance managers from large organisations i.e. shopping malls, hospitals etc. to make implementation of BIM economical and professionals in firms involved in design and construction of infrastructure. Purposive sampling was employed to ascertain the facility managers to be included in the survey and random sampling for professionals in the construction industry. Purposive sampling was guided by the criterion that the facilities to be approached were to be large enough for the economic implementation of BIM and to provide critical challenges faced in facility maintenance owing to the size of the organisations within which they work. From an identified population of 690 participants a sample of 70 participants representing 10% of the population were selected. 45 (75%) were valid responses hence making the sample representative and the inference made from it valid for analysis and generalization. For the purpose of economy and time, Lusaka and Copperbelt Provinces of Zambia were chosen as the study area in which to conduct the field survey.

6. Results and Discussion

6.1 Current state of facility maintenance and maintenance information management

Maintenance departments use reactive maintenance approach to respond to emergency defects that are rampant due to the old state of buildings in Zambia. The findings indicate that 88% of the respondents use a combination of hardcopy and softcopy tools to generate, send, and store maintenance information, none of the respondents use only softcopy. This can be attributed to lower cost of acquisition and accessibility, absence of significant setting up cost and familiarity. Additionally, using hardcopy together with softcopy tools prevents alterations to original documents i.e. contract documents (Gee, 2010). 80% of the respondents indicated that hardcopy documents used in maintenance information management are in good condition. This data information includes everything generated from the design and construction stages, and information about past maintenance works during the operational stage of the facility. It was noted that only one respondent was using a maintenance management system application while the rest used software applications that even though capable for use for the task are not designed for efficient maintenance information management. The majority of respondents indicated that the software employed are not efficient, however they are effective. It is safe to note that software tools employed are effective in that maintenance works have been done all along with them however a large percentage of the respondents submitted that they are inefficient.

6.2 Challenges associated with facility maintenance information management

About 80 % of the respondents' experience challenges with exchange of maintenance information. The most prevalent challenges both during emergency and routine works include lack of information about past maintenance works, followed by lack of vital information necessary to carry out maintenance works and lack of knowledge about the root cause of defects. Inefficient information transfer methods within the maintenance team and a lack of proper knowledge about the location of building components within facilities being managed were noted to be among the high ranking challenges during routine maintenance works. These challenges can be attributed to the information management approach being employed in that they all emanate from a lack of easily, and sufficiently accessible information about maintenance works (Shorangiz, 2011). Client's ignorance about the importance of maintenance works was found to be a problem as well. Literature suggests that often time's clients do not understand the need for certain works being carried out (McNeill, 2010). Often the client fails to appreciate the need to replace such a component if it appears to operate well despite the professional advice and will delay till it fails to secure another one. The causes of these challenges from the findings indicate that the highest cause include delays in information exchange, poor information exchange tools and poor record keeping, followed by difficulty in accessing information which is most likely as a result of poor information exchange tools and poor record keeping. Failure to accurately interpret information was highly prevalent and this is because of depending on few members of staff that understand the facilities well to proper function as a maintenance department; the absence of which causes delays and inaccessibility to vital information necessary for maintenance works (Pugh, 2010; Shorangiz, 2011).

Table 1: A summary of challenges faced in conducting routine maintenance

Challenges Faced During Routine Maintenance	Percentage
Lack of information about past maintenance	36
Inaccessibility of vital information necessary for effective maintenance	29
Inefficient information transfer methods within the maintenance team	18
Lack of knowledge about building components locations and specifications	14
Inefficient notification mechanism	4

6.3 Feasibility of using building information modelling to improve facility maintenance information management in Zambia

62% of the respondent's knowledge about BIM was not extensive whilst 38% of the respondents were extensively knowledgeable about BIM, with 4% of this population being very extensively knowledgeable about it. However, an introduction provided gave the respondents enough insight to make informed responses to the questions posed. Using their understanding of the current trends and challenges in maintenance information management, and the capabilities of BIM as provided in the introduction and their knowledge about it, respondents answered with regard to whether they believe BIM can improve facility maintenance information management in Zambia. 89% of the respondents agreed that BIM can improve maintenance information management in Zambia. 80% are willing to use BIM for facility maintenance information management and to procure more hardware to build their capacity to use BIM and train staff to use it. However, it was found that only 64% of the respondents were willing to pay for licenses for the BIM software evidently due to high costs of acquisition. It can be deduced from the findings that the majority of respondents agreed that BIM can improve facility maintenance information management in Zambia and that this will be beneficial to them and their stakeholders. The respondents were at the time sufficiently knowledgeable about the capabilities of BIM and well vested with the trends and challenges in facility maintenance information management over an average period of 10 years, hence making their response valid for consideration. Evidently the current situation of facility maintenance information management has created enough demand for the majority to be willing to make changes that favour the successful implementation of BIM.

Table 2: Respondents' knowledge of BIM

Scale	Frequency	Percent
Very extensive (1)	2	4.4
Extensive (2)	15	33.3
Not Extensive (3)	28	62.2

6.4 Challenges towards the implementation of building information modelling in Zambia

Nine factors that may hinder the implementation of BIM were compiled and respondents were asked to rank them in order of their possibility of occurrence. The findings revealed that the factor most likely to hinder the implementation of BIM is the cost of software, followed by the lack of clear guidance or best practice studies from which people can learn and build up their capacity for using BIM and cost of hardware respectively. Copyright restrictions, lack of about knowledge on return on investment when BIM is used and client's unwillingness to take chances on unfamiliar technology followed respectively. Reluctance on the part of construction industry professionals to implement BIM and staff training were the least factors in that order. 68% of the respondents face challenges in implementing new technology i.e. cost of acquisition, implementation and maintenance, copyright issues, cost and time for staff training, reluctance to accept and adopt new technologies, lack of equipment and support to sustain new technologies, lack of support from government to implement new technologies, in government run facilities and construction industry at large, some applications, like BIM requires high speed internet services to efficient share information and access updates and the internet speed is very low, employers are unwilling to adopt new technologies. The findings revealed that despite the fact that there may be a general willingness to effect changes necessary for the implementation of BIM, the cost of setting up will prove to be quite high considering the fact that the majority of respondents do not have the software and hardware required for BIM and need to procure most of it. The lack of clear guidance or best practice studies from which people can learn and build up their capacity for using BIM leaves a knowledge gap that makes professionals and client's alike unfamiliar with the approach.

7. Conclusion and Discussion

In order for any organisation to change their processes, there must be tangible business value. BIM brings an element of smart rather than hardworking. The use of BIM in FM is still an emerging field whose business value is yet to be demonstrated. BIM offers FM gains in efficiency by reducing iterations through its various processes in updating building drawings and information. Organisations face challenges in keeping updated operations and maintenance schedules. Facilities Management activities should aim to encourage the efficiency of an organisation and make it easy for occupants to carry out day to day activities. Integrative facility management systems that use BIM combat the deficiencies of traditional facility management like inaccessible data. Organisations need to take advantage of such systems so as to capitalise on the benefits that can be gained.

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DII-2017-065

Financial Management: A Study of Emerging Contractors' Practices

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Abstract

Funding is a critical component regarding the realisation of a project. The extent of funds management indicates the following: competencies, competitive advantage level of contractor, the probability ratio of delivery of a project, and so on. This study aims to assess factors influencing funds management of emerging contractors'. The study was conducted in KwaZulu-Natal province of South Africa using a questionnaire. Respondents for the study are emerging contractors'. Random and systematic sampling techniques were employed in the selection of samples. A total of forty questionnaires were analysed for the study. Inferential statistics was employed for the analysis of data. Findings include that non-payment for completed work, mistakes during construction, late delivery of materials, late identification of errors and resolution of drawings specification and weather conditions are the factors that negatively affect emerging contractors' funds management. When adequate attention is given to these factors by stakeholders of a project, it may result in project success. Recommendations include that the emerging contractors' need to be properly trained firstly in managing finances and relative to the technology of construction from inception to completion of projects.

Keywords: emerging contractors, financial management, project management, strategic planning

1. Introduction

The development and promotion of small firms that are owned by historically disadvantaged individuals (HDI's) is one of the major goals of the South African government. This development in construction terms relates to promoting small emerging contractors to become fully fledged sustainable contractors that will assist the South African government to reduce poverty, create employment opportunities and also promote the economy of the country. Developing countries with developing economies have shown a rapid growth over the years with an increasing demand for basic services and South African is not an exception to that growth. However, due to the volatility of the South African economy, the construction industry is directly affected by fluctuations in price of goods which leads to changes in the cost of labour, transport and materials as well as increases in overheads and administration costs (Mashatole, 2014 and Meyer-Stamer, 2003).

The South African construction industry has, over the years, trained a vast majority of small indigenous firms, and has called them emerging contractors that have unique characteristics and face different financial management challenges due to their level of education. The South African construction

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industry that has once undergone a major recession in the 1940's and is mostly dependant on government projects for its survival, it becomes extremely difficult for many emerging contractors to survive the rife competition and overcome the difficulties experienced on day-to-day operations of these small businesses. These challenges range from tendering on a project and managing business finances before, during and after completion of the project. The inability to raise and manage cash flows as a result of poor planning and not knowing the available financial institutions that assist small businesses \with funding or not having trained financial advisors and accounts that assist in financial management, being unable to get credit from commercial banks as lack of proper technical skills required to execute construction projects due to most emerging contractors not being technical people as well as being unable to employ and pay relevant qualified technical people who can assist them in managing their projects. They have little or no knowledge of business and financial management as a result of not being able to plan strategically before deciding to tender on a project and manage business finances before, during and after completion of the project; being able to get credit from commercial banks as a result of not having collateral or getting enough credit from material suppliers; inconsistent work flow as a result of the high bidding competition; late payments due to late submission of claims by contractors and or consultants and other related internal challenges from clients; capacity and performance constraints due to not having the required working equipment and financial back-up which ultimately lead to project delays and in some cases, project failures (Thwala and Mofokeng, 2012); (Kulemeka; Kululanga, and Morton, 2015) and (Mashatole, 2014).

Based on the foregoing, this study was initiated to assess funds management challenges, causes and impact of emerging contractors in the Kwazulu-Natal province of South Africa.

2. Literature Review

The literature to this study is divided into three parts, namely, the challenges of emerging contractors with respect to funds management, causes of these challenges and their impact.

2.1 Challenges facing emerging contractors

There are many challenges that face emerging contractors in the construction industry. They range from unique characteristic that small businesses possess and these challenges at times lead to business and project failures. Following are the discussion of factors identified from several authors regarding emerging contractors' challenges.

2.1.1 Inability to get credit from material and plant suppliers, inability to raise and manage cash flows and to secure bank loans

Emerging contractors struggle in obtaining and raising finances to start and run projects from banks due to not having sureties or collateral that banks can hold on too when payment is not received. Their inability to raise funds upfront leads to suppliers being very sceptical about giving material and plant on credit due to fear of not getting paid, it also stems from not having a good credit record (Mashatole, 2014; Kulemeka, Kululanga and Morton, 2015).

2.1.2 Inability to employ competent staff due to affordability

The majority of emerging contractors use unqualified personnel mainly because they cannot afford to pay qualified staff market related salaries and wages (Mashatole, 2014) and (Thwala and Mofokeng, 2012). This becomes a big problem because incompetent staff make a lot of mistakes and end up wasting material, compromising quality and delaying the project all together.

2.1.3 Poor contract documentation skills

As a result of cheap labour and incompetent of staff (Thwala and Mafokeng, 2012), contract documentation skills are lacking in most emerging companies. This results in incomplete documents, incorrectly filled documents and not understanding the importance of documents required by clients and consultants (Mashatole, 2014).

2.1.4 Fronting for established contractors

Competition is tough in the industry and projects are limited (Chilipunde, 2007). In order to obtain jobs and make quick money, established contracting companies use emerging contracting companies as fronts so as to qualify for functionality and certain prerequisite of projects.This becomes a challenge in the sense that no skills are transferred to emerging contractors in this fronting as most of time upon appointment, they are bought out of the contract or get very little money out of the project because the actual work, plant, and material are supplied by the established companies (Kulemeka; Kululanga, and Morton, 2015).

2.1.5 Lack of entrepreneurial skills

Majority of emerging contractor's lack of entrepreneurial skills and this leads them to making decisions that affect the running of their companies (Ntuli, 2008). The lack of these skills makes majority of these companies insolvent in the first few years of existence.

2.1.6 Lack of proper training

Little or no training in emerging firms leads to many mistakes being made because the owners and people who work in these have no idea how to do the work. This leads to poor products being produced which at the give a bad name to the industry as a whole. Other emerging contractors have no idea that training programmes are available to help with their growth and sustenance (Ofori, G. 2000 and Mashatole, 2014).

2.1.7 Lack of resources for either large or complex construction work

The challenge of not having sufficient financial resources leads to challenges in obtaining the correct plant and material for their respective projects. This becomes a challenge in the quality of work project produced due to cheap material or defective plant being used in most projects (Palani, K. 2000) and (Memon; Rahman; Abdulah and Azis, 2011).

2.1.8 Lack of technical, financial, contractual, and managerial skills

According to Mashatole (2014), the lack of technical, financial, contractual and managerial skills are the some of the biggest obstacles facing emerging contractors. All these skills seem to be lacking in a lot of these firms and are what determine success or failure of their business. Emerging contractors need to acquire and master these skills if they are to run sustainable and stable business as well as to make a good name for them with suppliers, financial institutions and prospective clients.

2.1.9 Late payment for the work done which ultimately causes project delays

Late payments by clients is one of the challenges that cripple emerging contractors. For any project to proceed, it needs finances. When payments are processed late by clients, it delays the project as a whole because emerging contractors struggle in obtaining finances to complete their projects as well finances to procure plant and material. This also dents the image of these contractors as they cannot honour their debts in time or get discounts if payment is done upfront. This in the long run affect even their planning because they are not sure when payments due to them will be paid out (Thwala and Phaladi, 2009 and Mashatole, 2014) and Aiyetan, (2010).

2.2 Causes regarding challenges of emerging contractors in funds management

Sunjka and Jacob, (2013) state that projects can be delayed due to a number of different factors. Each factor plays a significant role in the success or failure of a project and can either have a positive or negative effect on the client, consultant, contractor or the beneficiaries of the project.
These factors have been categorised in eight key main points and are discussed as follows:

2.2.1 Clients' related issues

Clients contribute either positively or negatively to funds management of emerging contractors'. The constant flow of funds could assist in good planning of funds by these contractors. The lack of constant flow of funds may disrupt plan and lead to lack of materials, payment of wages and adversely affect the project. The factors that measures clients' contribution to poor funds management of emerging contractors as identified by Abdul-Rahaman; Takim and Wong Sze Min, (2009) and Sunjka and Jacob, (2013) are: insufficient funding, interference with project performance, delay or non-payment for completed works, impractical allocation of resources, unrealistic contract duration, wrong choice of consultants and contractors, slow decision making and design alterations and change orders.

2.2.2 Contractor-related issues

In the same vein that clients' contribution to emerging contractors' poor funds management the emerging contractors also contribute in many ways to this phenomenon. The level of accounting management capabilities of an emerging contractors' affects his/her success in funds management. Arslan and Kivrak, (2008) and Chilipunde, (2007) identify factors that can be attributable to poor funds management of emerging contractors'. These include: poor coordination of subcontractors, inappropriate construction methods, inadequate planning, inadequate experience, mistakes during construction stage, incompetent site management and wrong choice of bankers.

2.2.3 Labour and equipment related issues

The level of management of labour and equipment has direct impact on the availability of funds of emerging contractors in the continuity of the project. There is a time to engage labour and also a time to lay off labour. Knowledge of this assists in funds management of contractors'. Regarding equipment, they need regular maintenance and be adequate for high productivity with respect to on time completion of project. Factors that measure labour and equipment related issues affecting emerging contractors' funds management are: unskilled site manpower, improper equipment selection and faulty equipment and labour dispute (Memon; Rahman; Abdulah and Azis, 2011) and (Aiyetan, 2010).

2.2.4 Materials-related issues

The ability to adequately estimate materials requirement and produce schedule for on time delivery affects emerging contractors' profit. This is in order to avoid waste and excessive waiting time for materials. Aiyetan, (2010) and Pourrostam; Ismail and Mansounejad, (2011) identify factors that measures materials influences on contractors' funds management as: poor quality materials, material shortages, late delivery of material and material shortages resulting from damages. These factor are applicable to emerging contractors'.

2.2.5 Consultant-related issues

The capability of consultant directly or indirectly affects the funds management of an emerging contractor. Delays resulting in contractor staying long on site may incur additional overhead and other cost. The factors that measures consultant contribution to emerging contractors' poor funds management as identified by Chen, (2007) are: inappropriate design, poor contract management, late identification of errors and resolution of drawings; specification errors and omissions, late preparation of drawings and other contract documents, improper contract packaging/delivery strategy, over inspection, long waiting time for inspection and testing, inappropriate coordination of information, inappropriate construction methods and poor supervision resulting in rework (Sunjka and Jacobs, 2013).

2.2.6 Community related issues

The issues of community relate to the participation in a project by the community members, which may be in the form of labour supply, thereby reducing the cost of importing labour for the project. This affords the opportunity to management funds well. Chen, (2007) and Meyer-Stamer, (2003) state that the factors that measures the community related issues having negative impact of emerging contractors' funds management are: lack of community buy-in, delay or non-payment of compensation and community unrest, militancy and communal crises,

2.2.7 Contractual relationship related issues

Pourrostam; Ismail and Mansounejad, (2011) declare that it is important for the contractor to maintain a healthy communication with professionals on a project. A healthy communication affords accessibility to each other, the clarification of issues, promotes an avenue that workers look forward to, regarding meeting and working. It aids in the elimination of disputes and litigation. These all affects funds management. The factors that could be attributed to contractual relationship are: lack of adequate communication between the parties, major disputes and negotiations and wrong organisational structure linking to the project (Chen, 2007; Pourrostam; Ismail and Mansounejad).

2.2.8 External issues

Aiyetan (2010) declares that external factors such as rain, flood fire and so on, are factors that man has no control over. Their occurrence could be devastating resulting in negative impact on funds of contractors. Aiyetan, (2011) identifies these external factors as: weather conditions, change in government's leadership and policies, natural disasters (e.g. floods, lightning strikes) and interference by political leaders.

2.3 Impact of emerging contractor challenges on project delivery time

From Aiyetan (2010), Chen (2007) and Thwala and Mofokeng (2012), twelve factors that influence project delivery time were identified. They are:

- The client's understanding of the design, procurement, and construction processes;
- Quality management during design;
- Quality management during construction;
- Management techniques used for planning and control;
- Economic policy;
- Constructability of design;
- Site ground conditions;
- Motivation of staff;
- Management style;
- Site access;
- Physical environment considerations, and
- Socio-political considerations.

All these factors have a huge impact on the project delivery time. Emerging contractors who know their trade are able to overcome most of these challenges and finish their projects within time however for those who rarely have technical and project management skills, business and financial management skills, it becomes almost impossible for them to finish projects in time, within budget nor to ensure that quality is being upheld to the highest standard. All stakeholders have a contribution and a role they play in the life cycle of a project.

The key challenges to the failure of emerging contractors is linked to access to credit, financial mismanagement, delayed payments by clients, inconsistent work flow, procurement practices, poor quality of work resulting from poor supervision, inadequate training as well as little or no planning from emerging contractors. Some of the challenges that have been identified by different scholars over the years are due to poor planning and have an effect in the construction industry as well as in the financial standing of emerging contractors. Business management, financial management and strategic planning are the fundamental requirements that business owners should possess to ensure sustainability of their businesses.

3. Research Methods

The sample frame for the study consisted of emerging contractors in KwaZulu Natal Province, registered on the CIDB construction register between CIDB grades 1 – 5 in the general building category. The research instrument for this study was a questionnaire survey. Simple statistical tools, such as the mean score, percentages and frequencies were used to analyse data obtained. The research is exploratory in nature. It used qualitative, quantitative and triangulation methods. Information or research data is collected in the form of questionnaires from Emerging Contractors on issues relating to challenges they face and funds management.

CIDB registered contractors between (CIDB grades 1 to 5) in the general building category within the selected geographical area of KwaZulu-Natal. For selecting samples, recommendations from Leedy and

Omrad (2014) were employed. The probability sampling technique was employed for sample selection. A random sampling technique was employed. The research instrument was administered to respondents by means of the email or given out in site visits. These were received through the same means. KwaZulu-Natal was divided into three main administrative regions, i.e. Southern, Northern and Midlands region and a total of 40 responses were received. The average years of respondents' experience is 8 years. Most of the respondents were aged between 31 years to 40 years. The highest formal qualification was diploma at (42.5%), BTech degrees and Matric certificates at (27.5%) respectively and lastly other related qualifications at (2.5%). Majority of respondents were registered on CIDB grade 5 (50%). Respondents had been involved in constructing various types of building structures with up to three floors. Based on these demographic findings, the data can be deemed reliable.

4. Findings

Table 1 presents challenges of emerging contractors based upon their average mean scores. From Table 1 it can be concluded that most of the challenges contribute to starting and managing a project. From the table, late payments for the work done (MS=3.00), which ultimately leads to project delays has a mean score (MS) of three (3), from a scale of 0 – 5. This agrees with the findings of Mashatole (2014) as one of the challenges facing emerging contractors. It indicates that the factor has a moderately high influence in the challenges faced by Emerging contractors. Payment may not be effected as a result of poor work standard, which negatively affects the funds management of these contractors. The lack of funds affects the purchasing power of these contractors' relative to resources required (MS=2.95) for the execution of project, hence they fail. The inability to secure credit for materials and bank loans (MS=2.71) adversely affects their funds management. This could be as a result of credit worthiness or lack of adequate knowledge to obtain them. This two factor agrees with the finding of Chen, (2007) contributory factors to emerging contractors' failure.

Table 1: Challenges of emerging contractors relative to funds management

S/No.	Challenges of Emerging Contractor	Mean Score	Ranking
1	Late payment for the work done which ultimately causes project delays.	3.00	1
2	Lack of resources for either large or complex construction work	2.95	2
3	Inability to get credit from material and plant suppliers, inability to raise and manage cash flows and to secure bank loans.	2.71	3
4	Inability to employ competent staff due to affordability	2.68	4
5	Lack of technical, financial, contractual, and managerial skills	2.50	5
6	Poor contract documentation skills	2.45	6
7	Lack of proper training	2.7	7
8	Lack of entrepreneurial skills	2.35	8
9	Fronting for established contractors	1.59	9

Tables 2a and 2b present the respondents' rating regarding the causes of challenges of emerging contractors in funds management. The causes of challenges have been divided into eight main factors which are client related issues, contractor related issues, material-related issues, consultant related issues, community related issues, contractual relationship related issues and external issues, under each main factor, there are sub-factors. The factors with the most influence in these categories have MSs > 1.46 ≤ 3.03, which indicates that these factors have between a near minor to moderate / moderate influence on the challenges of emerging contractors in funds management. The factors that have the most significant influence in each category are: *delay or non-payment for completed works; mistakes during construction stage; unskilled site manpower; late delivery of material; late identification of* *errors and resolution of drawings, specification errors and omissions; community unrest, militancy and communal crises; lack of adequate communication between the parties* and *weather conditions*.

The probable reason for the sixth factor can stem from disputes within the community leadership structures or lack of buy-in from the community, this usually results if stakeholders were not well informed from the onset or interest are different from the stakeholders. The seventh factor is directly linked with all the other factors, without proper and open communication channels, contractual relationships are likely to suffer and lead to disputes within the project stakeholders. The eighth factor is beyond human control, weather can affect the programme of works and needs to be taken into careful consideration when drawing up the construction programme as well ensuring that there is enough insurance to cover any damages that my result from effects of weather conditions. The least significant factors in these categories are “improper contract packaging/ delivery strategy” and “natural disaster (floods, lightning strikes)”. Although these factors are the least influential in these categories, it does not imply their effects are negligible because of the challenges they pose in the funds management of the project. These factors with the most influence in each category agree with the conclusion of studies by Sunjka and Jacob (2013), Mashatole (2014) and Kulemeka, Kululanga and Morton (2015).

Table 2a: Causes of challenges of emerging contractors in funds management

Causes of challenges of emerging contractors in funds management	Mean Score	Ranking
Client related issues		
Delay or non-payment for Completed works	2.58	1
Interference with project performance (vested interests)	2.34	2
Slow decision making	2.25	3
Insufficient funding	2.23	4
Design alterations and change orders	2.20	5
Impractical allocation of resources	1.94	6
Wrong choice of Consultants and sub-contractors	1.76	7
Unrealistic contract duration	1.64	8
Contractor-related issues		
Mistakes during construction stage	3.00	1
Inadequate planning	2.85	2
Inadequate experience	2.68	3
Incompetent site management	2.68	4
Poor coordination of subcontractors	2.63	5
Inappropriate construction methods	2.58	6
Wrong choice of Bankers	1.59	7
Labour and equipment related issues		
Unskilled site manpower	2.65	1
Improper equipment selection and Faulty equipment	2.61	2
Labour disputes	2.58	3
Materials-related issues		
Late Delivery of Material	3.03	1
Material shortages	2.53	2
Material shortages resulting from damages	2.31	3
Poor quality materials	1.96	4
Consultant-related issues		
Late identification of errors and resolution of drawings; specification errors and omissions	2.04	1
Poor contract management	1.98	2
Inappropriate coordination of information	1.93	3
Late preparation of drawings and other contract documents	1.85	4
Inappropriate construction methods	1.83	5
Inappropriate design	1.74	6
Long waiting time for inspection and testing	1.71	7

Table 2b: Causes of challenges of emerging contractors in funds management

Poor supervision resulting in rework	1.70	8
Over inspection	1.49	9
Improper contract packaging/delivery strategy	1.46	10
Community related issues		
Community unrest, Militancy and communal crises	1.78	1
Delay or Non-payment of Compensation	1.76	2
Lack of community buy-in	1.75	3
Contractual relationship related issues		
Lack of adequate communication between the parties	2.13	1
Major disputes and negotiations	1.93	2
Wrong organisational structure linking to the project	1.69	3
External issues		
Weather conditions	2.56	1
Interference by political leaders	2.54	2
Change in government's leadership and policies	2.10	3
Natural disasters (e.g. floods, lightning strikes)	1.46	4

Table 3 presents the respondents' rating regarding the impact of emerging contractor challenges on project delivery time. The factor that has the most significant impact in this category is the “site ground conditions” (MS=2.83). The probable reason for the lack of proper investigation in geotechnical studies is: KwaZulu- Natal province has a very steep terrain and this makes it extremely difficult to access most sites, based on this, most emerging contractors do not bother to conduct this test, which often times result in structural failure culminating in rework. This corroborates with one of the findings of Sunjka and Jacob, (2013) on causes of delay affecting contractors. This adversely affects the funds of emerging contractors' and project failure. The least significant factor in this category is “the client's understanding of the design, procurement, and construction processes” (MS=1.48). Although this factor is the least influential in this category, it does not imply that its effect is negligible because of the impact it has on project delivery time.

Table 3: Impact of emerging contractors' challenges on project delivery time

S/No.	Impact of emerging contractors' challenges on project delivery time	Mean Score	Ranking
3.1	Site ground conditions	2.83	1
3.2	Physical environment considerations	2.68	2
3.3	Site access	2.59	3
3.4	Management style	2.55	4
3.5	Socio-political considerations	2.50	5
3.6	Motivation of staff	2.35	6
3.7	Constructability of design	2.09	7
3.8	Management techniques used for planning and control	1.98	8
3.9	Economic policy	1.88	9
3.10	Quality management during construction	1.73	10
3.11	Quality management during design	1.65	11
3.12	The client's understanding of the design, procurement, and construction processes	1.48	12

5. Conclusions

Delay and non-payment for completed works; mistakes during construction stage; unskilled site manpower; late delivery of material; late identification of errors and resolution of drawings, specification errors and omissions; community unrest, militancy and communal crises; lack of adequate communication between the parties and weather conditions are the main factors that influence emerging contractors in funds management. Emerging contractors experience different challenges at different phases of the project but these challenges can be overcome with proper professional training, proper and adequate planning of project delivery strategy as well as securing sufficient funds prior to the commencement of the project. Emerging contractors need to equip themselves with experienced personnel who will assist them in starting and managing a project so as to avoid mistakes during construction as well as have deeper understanding of the site ground conditions relative to construction site they are working on. It is therefore, recommended that emerging contractors need to be properly trained in managing finances from inception to completion of their projects to ensure sustainability of their businesses. Secondly, emerging contractors need to possess technical skills in order to understand the requirements of each project as well as the processes to be followed when a project is constructed.

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DII-2017-030

Assessing the Application of Strategic Planning in Improving Competitiveness of Small and Medium Scale Contractors the Zambian Construction Industry

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Abstract

Most contractors in the Zambian construction industry (ZCI) are small or medium scale and are mostly viewed as uncompetitive as they normally fail to survive. This research endeavoured to establish whether small and medium scale contractors (SMCs) in the ZCI employ strategic planning to be competitive. A questionnaire survey was used to collect data from contractors in ZCI. The findings indicate that there is a low level of application of strategic planning among SMCs in the ZCI. Findings show that the most utilized strategic planning tools include vision and SWOT analysis with PEST analysis being the least used. The study revealed that major factors leading to poor competitiveness include poor workmanship and managerial skills. This study is significant because performance and growth through the application of strategic planning may help develop and improve delivery of infrastructure and development of SMCs, which is important in the improvement of livelihood in the developing countries. Therefore, in order to compete favourably in the highly competitive industry, small and medium scale contractors should apply strategic planning.

Keywords: construction industry, competitiveness, small and medium scale contractors, Zambia

1. Introduction

Small and Medium scale Enterprises (SMEs) in Zambia like any other country contribute significantly to the economy in various ways such as, gross domestic product (GDP), job creation and taxation, hence the need to ensure that this sector survives the competition resulting from globalization (Wang et al. 2007). However, past research conducted on SMCs in Zambia established that, poor managerial skills, incompetent key personnel (NCC, 2005) and unstructured strategic planning practices (Papulova and Papulova, 2006) are some of the intangible causes of failure in SMCs. In addition, Zambian local SMCs do not have stable job inflow as the nature jobs vary from time to time, which entails change of organisational design as per project requirement (Zulu and Chileshe 2008). Hence, the need to have a tool that helps with organisational changes and alignment of departments is inevitable. Comparatively, in order to achieve the desired competitive advantage local SMCs need to employ appropriate management. It is for these reasons that adopting appropriate managerial tools that are able to enhance managerial skills, competence and planning skills is vital for the SMCs' to enhance

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their competitiveness. Therefore, this research was conducted in order to assess how Zambian SMCs can use strategic planning in gaining a competitive advantage. The specific objectives of the study were:

- To investigate the perceptions of SMCs towards strategic planning.
- To identify the tools used and focus areas by SMCs in strategic planning.
- To identify the challenges faced in implementing strategic planning in SMCs.

1.1 Strategic planning

Strategic planning is the process of defining an organisational strategy or direction, and making decisions on allocating its resources to pursue this strategy (Wang et al. 2007; Porter 1980; 1985). On the other hand, strategies are long-term managerial guidelines guaranteeing the permanent accomplishment of the company's overriding goals and objectives (Zavadskasetal. 2011). A strategic planning process that adheres to the key elements of prescriptive strategic management theory through the planning of a mission, the setting of objectives, and the implementation of strategies and control systems is critical. This is in order to ensure that the objectives are achieved which may lead to indirect improvements in performance by enhancing the effectiveness of management throughout the organisation. The standard approach to strategic planning would also need to incorporate an external environmental analysis to identify the opportunities and threats facing the organisation, and an internal analysis to identify the organisation's strengths and weaknesses (Dancer 2006). In order to achieve this, tools that can be used for planning include Mission statement, Business plan, SWOT (Strength, Weakness, Opportunity and Threat) analysis, PEST (Political, Economical, Social and Technological) analysis, breakeven analysis and Scenario analysis. SWOT analysis can as well be utilised as an analysis tool which may involve a number of different forms of analyses, for example, an examination of the industry structure and an examination of the resource base of the organisation including the identification of core competencies (ibid). With this knowledge, the company is able to create or review organisational values, vision statement and mission statement. Thereafter, the company develops the goals that will be achieved by the end of the planning period and the comprehensive strategies it will employ to achieve them. Thus for each goal and strategy performance indicators are identified.

1.2 Types of strategies

Strategic planning has attracted debate for over two decades; however, this research discusses most prominent debate between Porter's (1985) and Mintzberg (1994) schools of thought in relation to the deliberate and emergent strategic approaches respectively. Deliberate strategy or formal strategy is where the intended strategy is actually realized and emergent strategy is the realization of unintended strategy. Deliberate strategies follow a formal deterministic process that involves controls and measurements that lead to an intended outcome even if it may or may not be achieved. Emergent strategies on the other hand are because of a pattern of decisions that a company makes resulting in an outcome that was never intended (Whittington and Cailluet, 2008).On the other hand, a positive relationship between strategic planning and company performance could not be determined empirically (Wulf et al. 2010). However, growing environmental turbulencehas made strategic planning increasingly difficult. Notably, in his influential book 'The rise and fall of strategic planning' Mintzberg (1994) laid the foundation for the (emergent) process school of strategy arguing that successful strategies cannot be analytically planned but rather emerge in a process that involves creativity, intuition and learning. In this context, open strategic thinking becomes more important than (formal) strategic planning (Mintzberg, 1991). While seeing creative strategic thinking as the basis of successful strategy creation is theoretically appealing, but it cannot be easily applied in practice since a clear set of tools and strategy frameworks is missing and the turbulent environment (ibid). This might be one of the reasons why top managers to date consistently rate (formal) strategic planning as one of the most important management tools (e.g. Rigby and Bilodeau, 2007). Nevertheless, the frequent changes in the practices of formal strategic planning, which have been observed in empirical studies, indicate that also practicing managers are not fully content with current methods of strategic planning (Ocasio and Joseph, 2008). Formal strategic planning seems to be lacking flexibility and openness, which allows for responsiveness and improvisation that is needed in today's dynamic, complex and volatile environment (Wulf et al., 2010). Mintzberg (1994) argues that only open and creative strategic thinking will lead to the emergence of those innovative strategies that lay the basis for superior performance. However, Mintzberg does not provide a clear set of tools, which fosters implementation of strategic thinking in companies. Thus, a synthesis is needed that combines the flexibility and openness typical of strategic thinking with the clear frameworks and application-orientation of strategic planning (Whittington and Cailluet, 2008).

Overall, formal strategic planning is characterized by the systematic use of various frameworks and tools that allow a company to analyse its environment and position where it can attain competitive advantage (Stonehouse and Permberton, 2002). They are many strategic planning processes and it is important to choose the one that best fits your organisation or company. These frameworks and tools include SWOT Analysis, Porter's Five Forces, Value Chain Analysis, Financial Analysis, Human Resource Analysis and Benchmarking Tools.Formal planning processes can strengthen and enhance planning skills in organisations, but poorly designed processes can be detrimental to effective planning. After criticizing other definitions of planning, Mintzberg (1993) concluded that planning is a formalized procedure to produce an articulated result, in the form of an integrated system of decisions. Hence it is inevitable for SMEs in the ZCI to pay particular attention to the external environment and consider various factors in formulating their strategy besides having a deliberate or formal strategy in place.

1.3 Strategic planning implementation

It is one thing to formulate a company strategic plan and another to implement no matter how brilliant it may be. The strategic plan describes and justifies the course of actions, on the other hand implementation addresses who, where, when, and how (My Strategic Plan, 2014) It takes critical actions to move a strategic plan from a document that sits on the shelf to actions that drive business growth and organisations to prosper. Importantly, a strategic plan to be effective they have to be owned by the ones implementing them (My Strategic Plan, 2014). Therefore, workers need to be empowered to carry out the plan, provide progress reports and recognition of progress. Hence, in order to effectively implement strategy, it is imperative that the company has the right people. This is critical especially for local Zambian SMCs who have been cited as having the problem of incompetent key personnel (NCC, 2005) and poor managerial skills (Sinyangwe, 2000). Further, the right people are those people with competencies and skills that are needed to support the plan. Apart from empowering workers a communication plan is critical, hence the need to have clear, open lines of communication with your employees. Both management and technology systems help track the progress of the plan and make it faster to adapt to changes (My Strategic Plan, 2014). As part of the system, it is also important to build milestones into the plan that must be achieved within a specific period. Overall, in order to optimize on the relationship between strategic planning and competitive advantage, SMCs should start by selecting the type of competitive advantage they want, in order to obtain and then develop the competencies needed (Clark, 2006). The competitive advantage could be in resources, value creation (Chiranni and Saberi, 2012), Profitability (Potter, 1987; Grant, 2004), technology and innovation and human resource (Cheng et al, 2011).

1.4 Basic strategic planning models

McNamara (n.d) identifies the following strategic planning models:

- *Model One - Vision-Based or Goals-Based Strategic Planning*: This is a very basic process normally carried out by top-level management and it is typically used by organisations that are extremely small, busy, and have not done strategic planning in the past.
- *Model Two - Issues-Based Plannin*g: This model is used for organisations that have very limited resources; several current, major issues; little success with achieving future-oriented goals; or very little buy-in to strategic planning
- *Model Three* **-** *Alignment Model*: The overall purpose of the model is to ensure strong alignment between the organisation's mission and its resources to effectively operate the organisation. This model is useful for organisations that need to fine-tune strategies or find out why they are not working
- *Model Four* **-** *Scenario Planning***:** This approach might be used in conjunction with other models to ensure planners truly undertake strategic thinking.
- *Model Five* **-** *"Organic" (or Self-Organising) Planning***:** Traditional strategic planning processes are sometimes considered mechanistic or linear. Another view of planning is similar to the development of an organism.
- *Model Six* **-** *Real-Time Planning***:** Many experts assert that conventional strategic planning has become rather outdated because the world is changing much more rapidly than before, to the extent that conventional (especially long-range) plans quickly become obsolete. These experts might assert that planning be done continuously, or in real time. Consequently, simulations and business modeling are fast becoming one of the hottest management tools in use today. Managers use simulations to test-drive new processes before they are implemented, identify the most impactful drivers of profitability, or to assess new go-to-market strategies and likely competitor responses.

1.5 Competitiveness and strategic planning

Competitiveness is the capability of the organisation to do its activity in a way that is different from what other competitors can (Kotler, 2000). In other words, competitiveness is the extent to which an organisation is able to create a defensible position over its competitors and the said position allows them to gain more profits than the competitors (Cheng et al., 2006). According to Analou and Karami (2003) competitiveness is a base for a good strategy and a good one creates competitive advantage. Competitive advantages are simply those factors that a firm needs to have in order to succeed in business (ibid). Gaining competitive advantage has become crucial for the Zambian SMCs due to the competitiveness of the sector. This is because the competition that has come with globalization in the construction industries of developing countries has the potential to destroy non-competitive contractors (Ofori, 2012). An estimate of about 70% of the construction market share goes to foreign contractors and consultants in the Southern African region (ibid) Zambia inclusive. Zulu and Chileshe (2008) affirms that the performance of Zambia contractors is apparently below expectation, and that it is common for local projects to be incomplete or significantly delayed. Some of the internal factors that lead to failures by local contractors include failure to employ competent and qualified key personnel (NCC, 2005). In addition, the majority of companies have no economic basis for bidding for the jobs they tender for resulting in contract bid being far below what it would take to professionally execute the works, let alone make a profit (NCC, 2005). Consequently, this leads to cutting corners, thus compromising the standards of workmanship or resorting to buying poor or substandard materials. This is not surprising as O'reagan and Ghobadian (2002) suggest that small and medium scale companies have a less structured approach to strategic planning deployment. Additionally, Papulova and Papulova, (2006) established that strategic planning practices in small firms have been found to be unstructured, irregular, and incomprehensive. They are best described as informal as they are almost never written down and are rarely communicated beyond the chief executive's closest associates (ibid). Besides, the strategic focus in small businesses takes on a more limited time horizon than in large organisations, usually covering periods of two years or less (ibid). Further, according to Mofokeng and Thwala (2012), most contractors in developing countries face the problems of incompetency and poor workmanship, which are mostly attributed to lack of personnel competency. Such a scenario can equally be related to the Zambian Construction where SMCs are faced with similar challenges. In addition, Zulu and Chileshe (2008) attributed failure by small-scale businesses in Zambia to poor management skills amongst other factors. These skills may include the lack of effective planning tools that are needed to identify the company's core competence, which is a basis fora sustainable competitive advantage. Hence it is therefore imperative to take a strategic approach by the local SMCs if they are to gain competitive advantage realizing the competition that has been created by globalization.

1.6 Methodology

The research approach used a questionnaire survey with a questionnaire that comprised of both open and closed questions resulting in qualitative and quantitative responses. The data were collected in a cross-sectional manner with the target group being small and medium scale contractors and regulators of the contractors, that is, National Council for Construction (NCC) and the National Association for Small and Medium Scale Contractors (NASMC). The Small and medium scale contractors in the building and civil category in Group 4-6 registered with NCC were targeted. Stratified sampling was used for contractors as the groups are homogeneous in nature (Saunders et al, 2012). A total of 66 questionnaires were distributed. 42 questionnaires were collected resulting in a response rate of 67%. The open ended questions were analysed interpretively while the quantitative data was analyses using descriptive statistics (means, frequency and modes).

1.7 Results and discussion

1.7.1 Use of strategic planning documents in place and how often are the strategic plans reviewed

The results show that the majority 56% do not have a strategic planning document while 44 % do have a planning document. The implication is that most firms if they do apply strategic planning do so informally as noted by other researchers among SMCs (Mofokeng and Thwala 2012). In addition, it was found that for those that have planning documents 20% rarely review the strategic plan, 15% review the plan after an event, 10% review it quarterly, 7% review it twice a year and 5% review it annually, 30 % do not review it at all while 10% indicted that the review is done frequently. Additionally, NCC described the type of planning employed by SMCs as being informal as it is not comprehensive. This is congruent with the findings of O'reagan and Ghobadian (2002) and Wang et al (2007). On the other hand, NASMC described it as being structured. The difference in observation between NCC and NASMC could be because NASMC is made up of the SMCs who view their planning as structured.

1.7.2 Focus areas of strategic plans of contractors

For the companies that have a strategic plan, a question was asked on what is actually included in the plan. The survey showed that a majority of contractors consider profit targets and output targets in their strategic plan (See Table 1). Product differentiation is not so much considered followed by cost leadership. Staff training is rarely considered.

Table 1: Focus areas of strategic plans in SMCs

Strategic Plan Focus Area	Percentage
Profit Targets	41%
Output Targets	38%
Business level objectives	38%
None	33%
Cost Leadership	13%
Product Differentiation	10%
Staff training	3%

The findings established that strategic planning in SMCs is incomprehensive, as it does not cover various aspects that matter as far as planning is concerned. The majority (72%) of the SMCs indicated that they have competence gaps in their organisation. Lack of comprehensive strategic planning justifies the reason why SMCs have competence gaps in their companies as there is no serious consideration of staff training in their planning as shown in table 1. The components of cost leadership, product differentiation and staff training are vital for a firm's competitive advantage (Cheng et al, 2011; Porter, 1985). However, the underutilization of these key components in SMCs' strategic plans substantiates the reason they are lacking managerial skills and are uncompetitive. To conclude, planning for SMCs used in the industry using McNamara (n.d) models one would place majority of rims at Model Two - Issues-Based Planning as organisations strategic planning seem un-formalised and resource deficient. This is what was established by Mofokeng and Thwala (2012).

1.7.3 Perceptions of SMCs towards strategic planning

A 5-point Likert scales with 1strongly disagree and 5strongly agree was used to determine the perceptions of SMCs. Table 2 shows the perceptions of the respondents.

Table 2: Perceptions that SMCs have towards of strategic planning

Item	Strongly Disagree	Disagree	Partially agree	Agree	Strongly agree	Mean score
Strategic planning makes it easier to manage business.			3	13	16	4
Planning in SMCs is mostly by intuition and business decisions are done as such.	4	6	11	8	3	3
Strategic planning creates bureaucracy.	3	7	15	5	2	3
Strategic planning is critical for the business success of SMCs.			1	26	5	4
SMCs spend time gathering industry information.	4	5	5	15	3	3
SMCs spend time analysing competitor strategies.	10	1	10	6	5	3
Lack of planning allows fast decision making.	9	10	3	6	4	2
SMCs know where they will be in 3 - 4 years' time.	1		4	15	12	4
Long term planning is redundant as the business environment changes fast	2	5	11	9	5	4

It was established that majority of contractors perceive that strategic planning makes it easier to manage a business and that it is critical for the success of a business yet few have strategic plans in place. Further, contractors submitted that planning in SMCs is mostly by intuition and that it creates bureaucracy. Contractors also claimed that they spend time gathering industry information and competitor information. It was acknowledged that SMCs lack of planning does not allow for fast decision-making, and that long term planning is redundant as the business environment changes too fast. Given the findings, it is evident that SMCs employ emergent planning approach as the majority of contractors agreed to the fact that planning is mostly by intuition and business decisions are done as such (Mintzberg, 1991). Long term planning is viewed as redundant as the business environment changes fast. Hence, in today's challenging business environment companies must proactively react to change or be left behind. In essence, SMCs must adopt a strategy that provides for both short term (rapid changes) and long term needs realizing that the construction industry is dynamic.

1.7.4 Strategic planning tools used by SMCs

In as much as there is a great appreciation of the significance of strategic planning in the success of contractors, its practical use leaves much to be desired, as most contractors' strategic planning tools are not utilized comprehensively in the ZCI.This is illustrated in table3which shows the planning tools used by SMCs. The most commonly used planning tools by contractors are; business plan (48%) followed by mission statement (46%). Then vision (44%) was 3rd which is followed by SWOT analysis (20%). The others such as PESTLE analysis, breakeven analysis and Scenario analysis are rarely used. Whilst 17% indicated that they have no strategic tool being used. The underutilization of planning tools has been mainly attributed to the lack of knowledge. This also substantiates the argument that planning in SMCs is mostly unstructured, incomprehensive, informal and that it is mostly intuitive because of the underutilization of planning tools (Odame, 2007). Further, this also explains why lack of managerial skills is the cause of failure of most small and medium scale businesses. This is so because these tools help a company to examine the industry structure and resource base of the company including identification of core competencies. Core competencies can help the company to build a sustainable competitive advantage that can ultimately facilitate the growth and longevity of a company.

1.7.5 Company strategy ownership

It has been argued that for a strategy to be effective it has to be understood by those implementing it (My Strategic Plan, 2014). The findings reveal that in most (44%) cases only management understands the goals, mission and objectives of the company this group is followed by both management and low-level employees at 31%. 25% indicated that the strategy is known by the company owner only. Given that not all are involved in the day-to-day activities of SMCs and understanding the company strategy, it is not surprising that its implementation comes with challenges.

1.7.6 Challenges faced by SMCs

Table 3 highlights challenges associated with strategy implementation. From Table 3, a number of contractors attributed the failure to realize the company strategy mostly to the failure to link the strategy and the budget (59%) and the least to, typical workers not understanding the company strategy (41%). It could be argued that the contractors may be to blame for typical workers not understanding the company strategy.

Table 3: Shows the challenges for not realizing strategy

Challenges	**Percentage**
Failure to link strategy and budget	59%
Failure to link employee incentives to strategy	56%
Less time spent discussing strategy	48%
Typical workers do not understand company strategy	41%

1.7.7 Factors limiting the SMCs competitive advantage

It was established that apart from capital, plant and equipment, and infrastructure; incompetent personnel, poor workmanship, poor managerial skills and untimely completion of projects are the major deterrents to SMCs competitiveness (see Table 4).

Table 4: Factors hindering the competitive advantage of SMCs

Factors	Percentage
Incompetent Personnel	71%
Poor workmanship	67%
Poor Management skills	59%
Untimely completion	49%

These findings are congruent with similar studies e.g. Mofokeng and Thwala (2012) who attributed lack of competiveness to poor workmanship and incompetent personnel while Sinyangwe (2000) attributes it to poor management skills.

2. Conclusion

Strategic planning is important for the survival of businesses more so for SMCs. In the Zambian Construction Industry, most SMCs do not have strategic plans in place in their organisations. This has made them less competitive as they do notapply strategic planning principles such as being a product/cost leader, innovation, etc. This is also worsened by those in the implementation ranks of the company not being able to understand the goals, vision and mission of the organisation. It has also been established that not many SME organisationsthe Zambian construction industry use strategic planning tools. Therefore, for the SMCs to be competitive they have to adopt strategic plans, use strategic tools and endeavour to differentiate their products by being innovative.The aforementioned are the contributed made by this research by clearly identifying areas needing improvement in SMCs for the improvement of their competitiveness.

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DII-2017-056

Obstacles to Risk Management Implementation in Construction Small and Medium Enterprises in South Africa

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Abstract

The implementation of risk management practices (IRMP) in construction projects is often affected by several obstacles which can endanger the achievement of project objectives. Regrettably, there is a paucity of empirical studies investigating these obstacles in the South African construction industry (SACI), especially in the small and medium enterprises (SMEs) sector. Hence, the current study sought to investigate the major obstacles hindering the IRMP at project level of SMEs. A structured questionnaire consisting of eighteen factors was used to collect data from SMEs who were conveniently sampled. The data was analysed using the Statistical Package for the Social Sciences (SPSS) version 23, computing descriptive statistics. The results indicated that: unsupportive organisation culture, lack of qualified personnel and inadequate training were the major obstacles hindering the IRMP. The results of the study will provide professionals in the CI with information on factors that hinder the IRMP in construction projects of SMEs. This will enable construction SMEs to conscientiously incorporate RM in their professional work and that would result in better project performance.

Keywords: construction, Gauteng, project success, risks, small and medium contractors, South Africa

1. Introduction

The risky and challenging nature of the SACI leads to its rather poor reputation in comparison to other industries (Shunmugam and Rwelamila, 2014). The rate of challenging projects in this industry is among the highest of all industries (Rounds and Segner, 2011). Shunmugam and Rwelamila (2014) indicated thatorganisations in the CI face major difficulties in meeting their projects' planned schedules in the most cost effective manner and at the desired quality. Many authors (Zhao et al. 2015; Beasley et al. 2010; Smit, 2012:137; Zou et al. 2006) have emphasised that in order to achieve the project objectives in terms of time, cost and quality, organisations have to implement and practice RM. Additionally, Skeen (2012) articulated that driving a culture of risk awareness and management adds value to the entire organisation resulting in overall improved project management ability. However, there is an assertion that although RM has been a topic of great interest, very little is actually practiced or carried out correctly (Laryea 2008; Taroun, 2012). A study by Chihuri and Pretorious (2010) found that in SA, RM was also not widely used in the engineering and construction environment, and there was a lack of actual adoption and IRMP. Cooke-Davies (2002) study established that project success is

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highly dependent upon the IRMP. Rounds and Segner (2011) described it as one of the most capable areas and critical procedures that help to complete projects successfully. In order to improve the performance of the CI, some studies indicate casual relationships between IRMP and project success (Funston, 2003). Therefore, it could be argued that awareness of and subsequent IRM could contribute to the enhanced project performance. Furthermore, empirical evidence has shown that some construction organisations in SA that do not implement RMP, often resulted in project exceeding budged cost and behind schedule (Shunmugam and Rwelamila, 2014; Chihuri and Pretorious, 2010). The Association for Project Management (APM) (2013) stated that resources to support RM implementation and its continued application are unrealistic for SMEs and beyond their capability and affordability. Previous studies have reported a number of obstacles hindering RM implementation in the SACI (Chihuri and Pretorius, 2010; Shunmugam and Rwelamila, 2014; Fischer, 2016). These studies were conducted among large contractors and did not consider small and medium contractors. Furthermore, a review of literature in SA indicates limited studies on SMEs pertaining to obstacles in implementing RM. Hence, the current study was undertaken to fill this gap by investigating the obstacles impeding RM implementation at project level of construction SMEs. The results of the study will boost the knowledge of industry practitioners on the obstacles impeding the implementation of RM. In addition, other construction firms can use the obstacles identified in this study to prepare their customised list of obstacles.

2. Literature Review

2.1 Challenges facing small and medium construction enterprises

Despite being the lifeblood of SA economy (Sayed and Sunjka, 2016), the South African SMEs sector is still inundated with several challenges which include lack of resources management and lack of trained professionals (Smit, 2012). These challenges have impacted the overall execution of and application of project management concepts and principles among the stakeholders. Although previous SA studies (Thwala and Phaladi, 2009; Abor and Quartey, 2010) have addressed project management challenges such as poor procurement systems, lack of management capacity and lack of available resources to equip managers to operate their businesses effectively, they have never addressed the factors hindering the IRMP directly. Furthermore, The Institute of Risk Management South Africa (IRMSA) Risk Report (2015) indicated that poor project management was one of the main causes of delays and disruptions in SA construction projects. These challenges could worsen the current state of poor project performance of SMEs globally.

2.2 Risk management status of the South African construction industry

Regardless of the initiatives deployed by the South African government to improve project management and quality performance, project overruns continue to occur in South Africa (Shunmugam and Rwelamila, 2014); for example, the Gautrain project which was only ready two years after its baseline completion date and cost R14 billion over budget (South African Politics, 2013). A further example is an R2.5 billion contract for a multi-product pipeline between Durban and Gauteng for Transnet was estimated to cost R23.4 billion and the completion date was almost 3 years late (Guern Le, 2013). The continuing ineffective project risk management of the CI in the form of cost and time overruns, poor quality achievement, project not meeting technical requirement, project not achieving user/client satisfaction, provided the catalyst for a new approach to RM in the form of consolidated construction RM and regulatory compliance legislation such as the Construction Regulations of 2003. This legislative framework required new multi-stakeholder interventions (Abor and Quartey, 2010). However, Taroun (2012) indicated that there was a very little commitment to conforming to basic requirements, let alone promoting a culture of RM. SMEs contractors could hardly maintain their RM tools and equipment and regarded RMP as costly activities. Improvement of the standard of RM performance of construction SMEs could inevitably be helped by continuous monitoring and review of their RM performance.

2.3 Obstacles hindering the IRMP

2.3.1 Theoretical review of literature

A study conducted by Fischer (2016) identified seven obstacles to RM implementation namely Lack of time, lack of knowledge, lack of potential benefits, project not large enough to warrant the use or RM tools and techniques, lack of funds, lack of joint risk management and competition amongst small construction companies. Fischer (2016) undertook a study on risk management and presented three significant barriers to effective risk management which included lack of a formal RM system, a lack of joint RM shortage of knowledge and or techniques.Furthermore, Chihuri and Pretorius studies (2010) listed the following obstacles in their study: lack of appreciation of the benefit associated with RM implementation, inadequate time to implement risk management effectively on fast paced projects, deficiency in project risk management knowledge, perception that project risk management is costly.

In this study, a total of eighteen (18) obstacles were identified, as shown in Table 1. Confronted with these obstacles, firms in various industries tend to find it difficult to fully implement RM practices and the percentage of companies adopting or implementing RM was not high (Zhao et al. 2015). According to Beasley et al. (2010), 46 percent of the global respondents had a formal RM process while only 11 percent of American respondents possessed a complete RM process.

Table 1: Obstacles to IRMP

Obstacles to risk management practices	**Source**
Insufficient resources (e.g. time, money, people.)	Smit (2012)
Lack of formalized risk management process	Smiechewicz (2001)
Lack of risk management techniques and tools	Kleffner et al. (2003)
Lack of internal knowledge, skills, and expertise	Schrøder (2006)
Lack of qualified personnel to implement risk management	Beasley et al. (2010); Zhao et al. (2015)
Lack of risk management information systems	Funston, 2003; Zhao et al. (2015)
Lack of a common risk language	Nielson et al. (2005)
Lack of risk management knowledge	Smit (2012)
Inadequate training on risk management	CIDB (2008); Smit (2012)
Lack of commitment of the board and senior management	Weinstein et al. (2003)
Lack of the board or senior management leadership	Smit (2012); Funston (2003)
Lack of a clear risk management implementation plan	DeLoach (2000); Smit (2012)
Employees’ reluctance to share risk information	Funston (2003); Nielson et al. (2005)
Difficulties in quantifying the risks	Zhao et al. (2015)
Low data quality	Weinstein et al. (2003); Schrøder (2006)
Lack of data	Zhao et al.(2015); Schrøder (2006)
Lack of risk awareness within the organisation	Smiechewicz (2001)
Unsupportive organisation culture	Funston (2003); Smit (2012)

A recent study conducted by Zhao et al. (2015) reported that none of the Singapore-based Chinese construction firms had high-level RM implementation. Likewise, a study conducted on SA contractors established that there was insufficient knowledge/understanding of the RM processes and a lack of adequate skills to carry out processes (Shunmugam and Rwelamila, 2014). These findings indicate the importance of investigating the hindrances faced by these firms to implement RMP.

Insufficient RM knowledge and the compromising attitude of personnel might be a significant obstacle to RM as it obstructs comprehensive and open risk discussions (Smit, 2012). The CIDB (2008) report in SA pointed out that small and emerging contractor encountered challenges in obtaining a formal education. The lack of formal education could hinder the IRMP. Management's priorities (Smit, 2012) and reluctance of management to discuss sensitive information in different firm units (Funston, 2003) were also identified as obstacles to RM implementation.

A further obstacle to RM activities originates from the uncertainty about how RM adds value to a firm (Kleffner et al. 2003). To overcome this, robust support for RM activities, along with clearly defined and communicated expectations of the value the firm aims to derive from the RM process, is important in establishing a strong risk culture (Schrøder, 2006).

A further requirement to RM success is that executive management of SMEs must assume primary responsibility for RM in its corresponding areas (DeLoach, 2000). Nonetheless, the complex nature of RM requires expertise that is best utilised if placed in one firm unit that is responsible for supervising the process. This will ensure continuity of RM actions, as well as consistency in application (Smit, 2012). In practice, this is hard to implement as specialized knowledge, skills and experience are required for such a unit, as well as a more active organisational role that goes beyond traditional consultation activities, which may be contrary to the existing firm culture (Schrøder, 2006). To be successful, RM should be aligned to the management teams in the different units as this alignment helps in enhancing their understanding of the business functions they support (Kleffner et al. 2003). Further key components for ensuring RM success is the alignment of the RM strategy with the firm's overall business strategy, and the integration of RM into the organisational processes, as risks, are the best managed as close as possible to the source of the risk (Smiechewicz, 2001).

The main obstacle in RM implementation is the lack of a common risk language, which should support discussions around risks, both holistically and departmentally, and RM methods (Nielson et al. 2005). Each employee interprets and understands business risks differently, which imposes the formulation of a common risk language to ensure that risk is seen in a consistent and comparable way by all parties in the organisation (Smiechewicz, 2001).

Barrese and Scordis (2003) and Schrøder (2006) indicated that RM concepts, applications, and capabilities must be embedded into the firm's corporate training curriculum. The importance of training and learning is stressed by Weinstein et al. (2003) who declared that firm and individual learning should support the RM process. Further obstacles highlighted were difficulties in quantifying the risks, the wide span of the risk universe and managers' inability to understand simple risk tools (Zhao et al. 2015).

The lack of quality data, limited access to data due to inadequate integration between systems, lack of data mapping and risk modelling tools, which some authors regard as the largest obstacles in effective RM application (Zhao et al. 2015). The segmental approach towards different types of risks that still prevails in firms (Schrøder, 2006).

2.3.2 Review of empirical research

Building on the perceptions detailed earlier, the trends from some other parts of the world on the factors hindering the IRMP are summarized below:

United Kingdom: Rostami et al. (2015), investigated the factors hindering the IRMP among SMEs. It was highlighted that none of the available RM standards explain the fundamental principle of applying RM to the situations that SMEs find themselves in. It was further established that lack of management skills and knowledge in the adoption of RM tools or techniques were the major factors hindering the IRMP among UK SMEs.

Singapore: A survey conducted by Hwang et al. (2013) established that lack of time; lack of budget; low-profit margin; and not economical were the most recurrent hindrances to RM implementation. Yet, RM was identified to be crucial for project success (Hwang et al., 2013).

Hong Kong: Tummala et al. (1997) study concluded that formal RM processes were used minimally. The time required and the difficulty in interpreting the results of RM processes; the lack of RM skill and resistance to change, were found to be the major barriers to RM implementation; yet the majority of the participants believed that RM could positively contribute to project success (Tummala et al. 1997).

Ghana: A study conducted by Buertey et al., (2012) established that the majority of professionals who participated in a survey related to RM in the construction industry had no knowledge regarding RM theories and techniques.

Tanzania: Chileshe and Kikwasi (2013) study found that awareness of risk management process, lack of experience and lack of information were the most significant barriers to implementing risk assessment and management practices by construction professionals.

A review of the previous studies by South African researchers on RM in the CI corroborates the results from the global studies. Makombo (2011) study found that the obstacles related to RM were found to be the skills gap amongst the professionals in dealing with such issues, poor scope management and a lack of focus on RM in the project initiation phase; hence, RM is almost always a ‘crisis-management’ endeavour. Most of the respondents stated that they had not planned RM activities, and there was no formal RM-structure in place. Similarly, a survey among over half of the South African organisation revealed that there was a lack of formal RM policies and procedures, and there was a lack of RM training (Visser and Joubert, 2008). These findings were also identified by Mbachu and Nkado (2007) in their earlier study.

From the foregoing review of the literature, it is apparent that project success is extremely reliant on the aptitude of the project team to deal with risks. Nonetheless, there is a dominant issue of insufficient skills, inadequate training in risk management, lack of risk-management knowledge, and lack of understanding of the RMP.

3. Research Methodology

3.1 Population and data collection

An extensive literature review was conducted in journal articles, conference proceedings, and relevant risk management books. A list of 18 obstacles was identified which were included in the structured questionnaire which was later pre-tested among construction SMEs drawn from the Construction Industry Development Board (CIDB) register of contractors. The respondents rated the obstacles on a four-point Likert scale (1=Very minimal obstacle and 4= a major obstacle), the extent to which each factor has been an obstacle to the implementation of risk management practices for their projects.

3.2 Sample and sampling method

Following the questionnaire pre-testing with SMEs personnel or those who were knowledgeable of RM practices in their organisations, the final refined version of the questionnaire was presented to 225 conveniently sampled SMEs using personal hand delivery and collect method of which 187 questionnaires were returned of which 6 were excluded from the study due to various ambiguity (questionnaire incorrectly answered, respondents' information missing and inadequate information provided).Consequently, the remaining 181questionnaires were deemed usable representing approximately 80% response rate.

3.3 Data analysis

The Statistical Package for Social Sciences (SPSS) version 23 was employed to analyse the data generated by the research questions. The following statistical methods were used: frequency analysis, percentage, means score, and standard deviation. Frequency and percentages were used to analyse the socio-demographic characteristics of the respondent and the information about the company. Mean and standard deviation values were used to respond to the research questions on the obstacles hindering the implementation of risk management practices. Review of the literatureindicates that such approaches have been adopted previously in survey related studies (Visser and Joubert, 2008; Rostami et al. 2015).

3.4 Validity and reliability

The measurement instrument was also tested for validity and internal consistency. Validity was ensured as a result of conducting an extensive literature review by consulting previous related studies, this was requisite to specify the variables. The questionnaire was reviewed and revised by experts (academics, researcher's promoter, and a professional statistician) before the pilot study took place. Internal consistency was assessed using Cronbach's Alpha. A generally agreed upon minimum limit for Cronbach alpha is 0.70 (Hair et al., 2006). However, a cut-off value of 0.60 is common for exploratory research and values closer to 1 suggest good reliability (Zaiontz, 2014).

4. Survey Results and Discussion

4.1 Respondents' information

Table 2 presents information on respondents. It is obvious that 87.56% of the respondents were either owners or managers of their enterprise, male (81.80%), African/Black (56.40%), had either Matriculation (22.70%) or a Certificate (20.40%), 43.10% of respondents had 10 years' or less experience in construction.

Table 2: Respondents' information

	Frequency	**Percentage**
Position		
Owner	56	30.90
Owner/Manager	40	22.10
Project Manager	31	17.10
Manager	28	15.50
Other	26	14.40
Total	181	100.00
Gender		
Male	148	81.80
Female	33	18.20
Total	181	100.00
Population group		
African/Black	102	56.40
White	47	26.00
Asian/Indian	18	9.90
Coloured	14	7.70
Total	181	100.00
Qualification		
Matric	41	22.70
Certificate	37	20.40
HND/Diploma	29	16.00
Honours/BTech/BSc	27	14.90
Basic schooling	26	14.40
Master's degree	11	6.10
No qualification	5	2.80
Doctorate degree	3	1.70
Missing	2	1.10
Total	181	100.00
Experience in construction (years)		
1-5	30	16.60
6-10	48	26.50
11-15	29	16.00
16-20	22	12.20
21-25	7	3.90
26-30	14	7.70
31-35	7	3.90
Over 36	9	5.00
Missing	15	8.30
Total	181	100.00

4.2 SMEs profile

Table 3 indicates that 37.60% of SMEs were subcontractors or general contractors (31.50%), working mostly in Johannesburg (41.40%) and Tshwane (30.90%) Metropolitan Municipality. Nevertheless, the subcontractors either operated for the main contractor or were sole trade contractors.

Table 3: SMEs profile

	Frequency	Percentage
Type of contractor		
Sub-contractor	68	37.60
General Contractor	57	31.50
Specialist contractor	32	17.70
Civil contractor	12	6.60
Home building contractor	9	5.00
Missing	3	1.70
Total	181	100.00
Municipality		
City of Johannesburg Metropolitan Municipality	75	41.40
City of Tshwane Metropolitan Municipality	56	30.90
Ekurhuleni Metropolitan Municipality	19	16.60
West Rand District Municipality	30	10.50
Missing	1	0.60
	181	100.00
Total		

4.3 Ranking of obstacles by respondents

This section reports on the obstacles which could hinder the IRMP in SMEs construction projects. These obstacles were tested for validityand internal consistency. The overall Cronbach's alpha of the factor was 0.765 and the one of each item ranged from 0.731 to 0.775 (Table 4). These values were all greater than the suggested value of 0.60, indicating good reliability (Zaiontz, 2014).

As indicated in Table 4, unsupportive organisation culture (M=3.44; SD=0.670), lack of qualified personnel to implement risk management (M=3.43; SD=0.643), inadequate training on risk management (M=3.41; SD=0.836), lack of internal knowledge, skills and expertise (M=3.32; SD=0.565), lack of risk management techniques and tools (M=3.30; SD=0.623) and insufficient resources (M=3.30; SD=0.931) were the major obstacles in the implementation of risk management practices. The standard deviation obtained suggested that the responses of the respondents were not mostly centered on the mean.

These findings indicated that the corporate culture of construction SMEs in Gauteng do not support RM implementation. Also, the behaviours directed by the corporate culture were not conductive to RM implementation. This finding was similar to the findings of Zhao et al., (2015), where unsupportive organisation culture was found as the major obstacle to RM implementation within construction companies operating in Singapore. The lack of qualified personnel as a hindrance to risk management practices is in line with the findings of Klemetti (2006) who established that lack of education was a significant obstacle to implementing RM in construction. The staff qualified to implement RM must possess the knowledge, skills, and experts relating to RM in order to be actively involved in RM implementation practices. Without these qualified staff, SMEs would face the difficulty in carrying RM. Under these circumstances, SMEs should employ external consultants to provide training programs for the relevant staff, or to help initiate RM.

Table 4: Obstacles to implementing risk management practices

Obstacles to RM implementation practices	Mean	SD	Cronbach' alpha (0.765)	Rank
Unsupportive organisation culture	3.44	0.670	0.775	1
Lack of qualified personnel to implement RM	3.43	0.643	0.742	2
Inadequate training on risk management	3.41	0.836	0.731	3
Lack of internal knowledge, skills, and expertise	3.32	0.565	0.745	4
Lack of risk management techniques and tools	3.30	0.623	0.757	5
Insufficient resources (e.g. time, money, people)	3.30	0.931	0.762	5
Employee's reluctance to share risk information	3.25	0.761	0.746	6
Lack of the board or senior management leadership	3.18	0.653	0.755	7
Lack of commitment of the board or senior management	3.17	0.695	0.747	8
Lack of risk management information systems	3.15	0.628	0.758	9
Lack of formalised risk management process	3.15	0.619	0.760	9
Lack of a clear risk management implementation plan	3.14	0.569	0.755	10
Lack of risk management knowledge	3.13	0.746	0.744	11
Lack of data	3.03	0.759	0.769	12
Lack of risk awareness within the organisation	3.01	0.601	0.760	13
Lack of a common risk language	3.00	0.650	0.749	14
Difficulty in quantifying the risks	2.86	0.684	0.768	15
Low data quality	2.85	0.792	0.762	16

SD: Standard deviation

The results of inadequate training on RM were consistent with those of Tam et al. (2004) who established that inadequate training posed difficulty in implementing RM in various industries. Without adequate training, the personnel would not clearly understand RM philosophy and policy. Furthermore, the application of RM techniques and tools, the potential benefits and risk-aware culture would not be built up across the firm, even if an RM program had been initiated. These results are also in accordance with the results of Karimi et al., (2010) who established that many construction firms in developing countries are small-to- medium construction enterprises and hence, do not have the facilities to provide fortraining. The current findings on lack of internal knowledge, skills, and expertise echoed the findings of Smiechewicz (2001) that reported the low-level of RM knowledge among Chines construction; these contractors were not likely to possess adequate internal knowledge, skills, and expertise relevant to RM and most of them obtained these resources from the parent companies.

5. Conclusions and Recommendations

The study sought to investigate the obstacles to implementing RMP among construction SMEs in SA. Findings indicated thatunsupportive organisation culture, lack of qualified personnel, inadequate training were deemed to be the major obstacles to the implementation of RMP at project level of SMEs. In order to raise the awareness of implementing RM benefits, there is a need for a 'cultural shift' in the mindset of senior management and relevant stakeholders within the SACI. In addition, the organisations should also be encouraged to engage or utilise internal auditors through the application of enterprise risk management (ERM) as part of the IRMP. To assist contractors with the training issues associated with RMI, the government could further focus on the development of vocational training and apprenticeships for its citizenry and relevant professionals. This would act as a source of skills for the majority of the SA employees. Findings of this study further reinforce the observation that, despite the quest of the SACI to remain competitive, it is faced with a number of challenges. These challenges undoubtedly have an impact of implementation of practices such as RM. This paper further sheds light and provides insights on the understanding of the obstacles hindering the implementation of RMP within the SACI, an area previously under-researched. Furthermore, this study makes a contribution to the body of knowledge on the subject within a previously unexplored context.

Regardless of the achievement of the study objectives, there were boundaries to the conclusions. The study was conducted in South Africa; however, it was delimited to the province of Gauteng. The surveyed respondents were small and medium enterprises in the CI; hence, the findings of this study may not be representative of the entire country.

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DII-2017-057

Investigating the Impact of Risk Factors on Project outcome of Small and Medium Contractors in South Africa

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Abstract

The delivery of construction project is often affected by several risks factors which can threaten the achievement of project outcome in terms of time, cost, quality and health and safety (H&S). Regrettably, there is a paucity of empirical studies investigating the impact of these risks on project outcome in the South African construction industry (SACI), especially in the small and medium enterprises (SMEs) sector. Hence, the current study sought to investigate the impact of these risk factors on project outcome of SMEs in the Gauteng province of South Africa. A structured questionnaire consisting of nineteen risk factors was used to collect data from SMEs who were conveniently sampled. The data was analysed using the Statistical Package for the Social Sciences (SPSS) version 23, computing descriptive statistics. Empirical findings revealed that time and cost were both impacted by variation by the client, design variation, incomplete approval and unsuitable construction program planning while incomplete or inaccurate cost estimates impacted highly on cost and quality objectives. Furthermore, accidents due to poor safety procedure, the absence of fire safety systems on site, equipment damage and labour injuries were deemed to have a high impact on project H&S outcome. The results of the study will boost the knowledge of industry practitioners on the risk factors affecting project outcome of SMEs.

Keywords: construction, Gauteng, project success, risks, small and medium contractors South Africa

1. Introduction

Despite growing uncertainty and seasonal swings, the SACI moves forwards. According to StatsSA (2016), the total employment in SA has risen from 14,2 million to 15,9 million between the period 2009 to 2015 and the CI is one of the eight industries that has contributed to this increase by creating 216 000 jobs over this period. Currently, the SACI contributes to around 9.7% of the country Gross Domestic Product (GDP) and accounts for 11% of total employment (Construction Industry Development Board (CIDB), 2016). Regardless of the social and economic value of the CI, cost and time overruns continue to occur especially at project level of SMEs (Chadhliwa, 2015). Research indicates that there have been a number of mega projects that have failed to meet baseline completion dates, costs and quality requirements in SA; for example, the Gautrain project which was only delivered two years following

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its initial completion date and cost R14 billion over budget (SA Politics, 2013). A further example is an R2.5 billion contract for a multi-product pipeline between Durban and Gauteng for Transnet was estimated to cost R23.4 billion and the completion date was almost 3 years late (Guern Le, 2013). Shunmugam and Rwelamila (2014) have stressed that in order to achieve the desired project outcome, organisations have to implement and practice risk management (RM). Many studies have been conducted to understand why small contractors keep failing despite the support being provided. Studies conducted, revealed that many SMEs fail due to the lack of access to finance (Boone and Kurtz, 2006; Ramlee and Bernma, 2013; Brown and Lee, 2015). However, the results of the study conducted by Rostami et al. (2015) revealed that 80% of SMEs failures are as a result of management failure. It was further indicated, that there is a necessity to enhance corporate governance and the link to RM. Smit (2012) confirmed that the risk of not delivering the project within its set target in SMEs was higher than in larger enterprises. Furthermore, Rostami et al. (2015) indicated that SMEs tend to experience more uncertainties than larger enterprises. Chihuri and Pretorious (2010) indicated that lack of RM knowledge and lack of knowledge of the risk factors which can impact the successful achievement of project outcome is one of the reasons of cost and time overruns in the construction project of SMEs.

A review of literature indicates that most of the studies conducted on risk factors in South Africa, identified holistically and categorised risk according to their nature (Wadiwalla, 2004; Chihuri and Pretorius, 2011; Mpakama, 2016; Renault et al. 2016) and that limited studies have been conducted to investigate project outcome (time, cost, quality and health and safety) related risk factors and their impact on project outcome. Therefore, the current study sought to fill this gap by identifying project outcome related risk factors and investigating their impact on each project outcome. The results of the study will boost the knowledge of industry practitioners on the risk factors affecting project outcome of SMEs but also they will provide information on specific risk factors that impact project outcome. In addition, other construction firms can use the risk factors identified in this study to prepare their customized list of project outcome related risk factors.

2. Review of Literature

Literature review is one of the key features of carrying out a study and also as a way to be aware of what has already been covered on the topic in order to establish the trends in the solutions that are being proceeded to resolve the various problems that face mankind (Heppner and Heppner (2004). Hence, it was compulsory to review literature related to Risk and RM in construction in order to establish project outcome related risk factors.

2.1 Project outcome

Over the years, numerous studies have been conducted on project outcome, and most of them have suggested various dimensions for measuring project outcome. Wang and Huang (2006) opined that project outcome is contrastingly viewed among researchers and practitioners. The conventional measures of time, cost, and quality known as the Iron triangle have been the leading success metrics in construction (Toor and Ogunlana, 2010). The Iron triangle is cited in nearly every study (Na Ranong and Phuenngam, 2009; Hinze et al. 2013; Chou and Pham, 2013) on project success. Contrariwise, Collins and Baccarini (2004) posited that project outcome should not be limited to just the Iron triangle and the project management community need to be informed about this. Toor and Ogunlana (2010) indicated that while other definitions of project outcome have emerged, the iron triangle is constantly cited in the unconventional definitions. In addition to the conventional measures, Ojiako et al. (2008)

supported that dimensions for project outcome should also encompass project psychosocial outcomes which involve the contentment of interpersonal relations with the project team. Individual dimensions such as participants' satisfaction level are referred to as soft dimensions. The incorporation of satisfaction as a success metric is recommended by Weninger et al. (2013). Berssaneti and Carvalho (2015) further suggested incorporating the absence of legal claims as a measure of project success. This indicates the importance of including safety as a success measure since it is logical to anticipate that if accidents materialise, both clients and contractors may be subject to financial loss, contract delay as well as legal claims. Ahadzie et al. (2010) assessed project outcome extensively based on five criteria namely; maintenance cost, construction cost, time, safety and flexibility to users. Lam et al. (2008) stated that it is problematic to evaluate whether the performance of a project is a success or a failure owing to the fact that the notion of success remains unclear amongst project participants. According to Roelen and Klompstra (2012), the project is a complete success if it attains the technical performance specifications to be executed, and if there is satisfaction regarding the project outcome among key users and project team members. In evaluating project outcome or project success, Chou and Pham (2013) included a range of criteria which included project meeting planned cost, time, quality of work, affability of the environment, transfer of technology, client and project manager's satisfaction, and health and safety. Chou and Yang (2012) defined project outcome based on four measures namely; achieving design goals, the value to the end user, the value to the organisation, the value of the technological infrastructure of the country and of organisations implicated in the development process. All these measures combined provide the inclusive evaluation of project outcome.

2.2 Project outcome related risk factors

Various studies have been conducted in the area of RM for construction projects, a notable outcome of which is the identification of many risks that may impact the project outcome. Chen et al.(2004) identified fifteen risks associated with project cost and grouped them into resource, parent and management groups. Furthermore, they found that price escalation of material was associated with the resource group; inaccurate cost budget and supplier or subcontractors' default pertained to management group, and excessive interface on project management was associated with the parent factors. Tam et al.(2004) established that the leading factors impacting safety performance included lack of training, poor safety awareness of top management, poor safety awareness of project managers, reckless operation and reluctance to input resources to safety.

Klemetti (2006) stated that construction risks can be classified based not only on their impact on the project objectives but also the source of the risk, while Karimi et al. (2010) indicated that risks are mainly grouped into two groups according to their source namely, internal and external. Oztas and Okmen (2004) included management of project risk into the design risks which comprised but were not limited to "difficulty in capturing and specifying the user requirements", "difficulty of estimating the time and resources required to complete the design", "difficulty of measuring progress during the development of the design". In assessing the significance of risks in construction projects in Gaza, Abu Mousa (2005) identified forty-four risk factors which were further divided into nine (9) groups of physical, design, logistics, environmental, financial, political, legal, construction and management.

Similarly, Kishan et al. (2014) identified forty-four risk factors for building construction which was further categorised in ten groups of physical, logistics, design, environmental, legal, financial, management, cultural, construction and political. Of the identified factors, design changes, poor communication and delayed payment on contracts were found as the major causes of project delay. In

Addition, Abu Mousa (2005); Ahmed et al. (1999); National Audit office (2001); Okeyo et al. (2015) found that delayed payment of the contractor affected the project by causing loss of productivity, inefficiency, and increase in time-related costs. Regardless of these various classifications, risks are meant to attain a common objective, that is, they are an important aid in RM and assist in forming risk lists that are used when detecting a risk (Wong and Hui 2006; Klemetti, 2006).

Based on the reviewed literature and the opinion of practitioners and experts in the field of construction and RM, several risk factors that affect project outcome were identified and studied. For the purpose of this research, risks were categorised based on their impacts on project outcome in terms of time, cost, quality as well as health and safety. The detail of each category of project outcome related risk factors is outlined in Table 1.

Table 1: Project outcome related risks (adapted from Zou et al. 2005; Olamiwale, 2014)

Risk Type	**Description**
Time-related risks	Design variations, high performance, variations by the client, incomplete approval, and other documents, unsuitable construction program planning, bureaucracy of government, inadequate program scheduling, pressure from high performance or quality expectations and variation of construction programs.
Cost related risks	Variations by the client, occurrence of dispute, unsuitable construction program planning, price inflation of construction materials, incomplete or inaccurate cost estimates, incomplete approval, inadequate program scheduling, and design variations.
Quality related risks	Unsuitable construction program planning, inadequate program scheduling, incomplete or inaccurate cost estimates , pressure from high performance or quality expectations, low management competency of subcontractors, variations of construction programs, design variations, lack of coordination between project participants, unavailability of sufficient amount of skilled labour
H&S related risks	Accidents due to poor safety procedures, labour injuries, equipment damage, materials or property damage, absence of fire safety systems on site.

3. Research Methodology

This section reports on the methodology used to conduct this study. The target population, method to collect data and the sample used are described. The tool used to analyse data as well as issues pertaining to validity and internal consistency of the measurement instrument were also described.

3.1 Population and data collection

An extensive review of literature was conducted in conference proceedings, journal articles and relevant risk management books. A list of 18 obstacles was identified which were included in the structured questionnaire which was later pre-tested among construction SMEs drawn from the CIDB register of contractors. The respondents rated the risk factors on a five- point Likert scale where: 1=Very low impact (VLI), 2=Low impact (LI); 3=Moderate impact (MI); 4=high impact (HI) and 5=very high impact (VHI). In order to present the outcomes appropriately, a number of range were established, that is; VLI=1.00-1.80, LI=1.81-2.60, MI=2.61-3.40, HI=3.41-4.20, VHI=4.21-5.00.

3.2 Sample and sampling method

Following the questionnaire pre-testing, the final refined version of the questionnaire was distributed to 225 conveniently sampled SMEs using personal hand delivery and collect method. Of the 225 questionnaires distributed, 187 were returned of which 6 were excluded from the study due to various ambiguities (questionnaire incorrectly answered, respondents' information missing and inadequate information provided). Consequently, the remaining 181 questionnaires were deemed usable representing approximately 80% response rate.

3.3 Data analysis

SPSS version 23 was employed to analyse the data generated by the research questions. The following statistical methods were used: frequency analysis, percentage, means score, and standard deviation. Frequency and percentages were employed to analyse the socio-demographic characteristics of the respondent and the information about the company. Mean and standard deviation values were used to respond to the research questions on the risk factors impacting project outcome. Review of the literature indicates that such approaches have been adopted previously in survey related studies (Visser and Joubert, 2008; Rostami et al., 2015).

3.4 Validity and reliability

The measurement instrument was also tested for validity and internal consistency. Validity was ensured as a result of conducting an extensive literature review by consulting previous related studies, this was requisite to specify the variables. The questionnaire was reviewed and revised by experts (academics, researcher's promoter, and a professional statistician) before the pilot study took place. Internal consistency was tested using Cronbach's Alpha. A generally agreed upon minimum limit for Cronbach alpha is 0.70 (Hair et al. 2006). However, a cut-off value of 0.60 is common for exploratory research and values closer to 1 suggest good reliability (Zaiontz, 2014).

4. Findings and Discussion

This section presents and discusses the findings obtained from the questionnaire survey. Demographic and findings on project risk impact are discussed.

4.1 Demographic findings

This sub-section reports on the profile of the respondents and the company. Results revealed that among the respondents, 81.80% was male while 18.20% was female, 87.56% were either owners or manager of their enterprise, 56.40% were African/Black, had either matriculation (22.70%) or a certificate (20.40%), 43.10% of respondents had 10 years' or less experience in construction. Furthermore, it was found that 37.60% of SMEs were subcontractors or general contractors (31.50%), working mostly in Johannesburg (41.40%) and Tshwane (30.90%) Metropolitan Municipalities. Nevertheless, the subcontractors either operated for the main contractor or were sole trade contractors.

4.2 Findings on risk factors' impact on project outcome

Table 2 presents the impact of risk factors on project outcomes i.e. time, cost, quality and H&S as rated by respondents. A total of nineteen risk factors were identified, among which, eight were related to time, eight were related to cost and nine were related to quality outcome. Five risk factors were related to H&S outcome. These risk factors were tested for validity and internal consistency. The overall Cronbach's alpha of each risk category (time, cost, quality, and H&S), as well as the Cronbach's alpha values (see Table 2) of the individual risk factor, were all above the cut-off value of 0.60. These results indicated the good reliability of the variables. The results are discussed in terms of the impact of risk on each project outcome.

It was revealed that of the eight-time related risk factors, variation by the client (M=3.83; SD=0.406), design variations (M=3.72; SD=0.463) and incomplete approval (M=3.67; SD=1.028) were rated by the respondents to have high impact in inhibiting the SMEs in achieving the project time.

It was further indicated that under cost related risk factors' category, design variations (M=3.98; SD=0.788), and variations by the client (M=3.97; SD=0.690) had high impact in slowing down the SMEs to achieve their project cost. Furthermore, dispute occurrence (M=3.23; SD=1.076), incomplete/inaccurate cost estimates (M=3.20; SD=1.259), inadequate programme scheduling (M=3.04; SD=1.272) and unsuitable construction programme planning (M=3.03; SD=0.922) were deemed to have a moderate impact in achieving the project outcome of cost.

Likewise, lack of coordination between project participants (M=3.42; SD=1.136), had a high impact in the SMEs not achieving the quality of the project, whereas low management competency of subcontractors (M=3.38; SD=1.001), design variations (M=3.37; SD=0.844), incomplete/inaccurate cost estimates (M=3.29; SD=1.232), inadequate programme scheduling (M=3.10; SD=0.937) and unavailability of sufficient amount of skilled labour (M=2.94; SD=1.001) were deemed to have a moderate impact in hindering the SMEs from achieving the quality of their project.

Results of the H&S related risk factors evinced that accidents due to poor safety procedures (M=3.56; SD=1.226) were rated by respondents to have high impact in achieving the project H&S outcome. Moreover, the absence of fire safety systems on site (M=3.29; SD=1.272), equipment damage (M=3.27; SD=1.172), labour injuries (M=3.17; SD=0.853) and property and material damage (M=3.04; SD=0.942) were deemed to have a moderate impact in inhibiting the SMEs in achieving the H&S project outcome.

4.3 Discussions on risk factors' impact on project outcome

4.3.1 Time-related risk factors

The results indicated that variation by the client, design variations, and incomplete approval had a high impact on project time not being achieved. These results are in accord with the results of Zou et al. (2005); Wang and Huang (2006), who observed that variations by the client can engender variations in the planning, design, and construction. Wang and Huang (2006) further added that variations probably emanate because of three reasons namely; change of mind by the clients and misconception of the clients' needs. This situation, for example, can be avoided if the client does not interfere with the process of the project.

Table 2: Risk factors' impact on project outcome

Risk category	**Mean**	**SD**	**Cronbach's alpha**	**Rank**
Time related risks			0.856	
Variations by the client	3.83	0.406	0.864	1
Design variations	3.72	0.463	0.883	2
Incomplete approval	3.67	1.028	0.825	3
Inadequate program scheduling	3.29	1.348	0.820	4
Unsuitable construction program planning	3.07	0.987	0.815	5
Variation of construction programs	3.02	1.174	0.828	6
Pressure from high performance or quality expectations	2.88	1.097	0.827	7
Bureaucracy of government	2.63	0.913	0.822	8
Cost related risks			0.912	
Design variations	3.98	0.788	0.910	1
Variations by the client	3.97	0.690	0.916	2
Occurrence of dispute	3.23	1.076	0.891	3
Incomplete or inaccurate cost estimates	3.20	1.259	0.898	4
Inadequate program scheduling	3.04	1.272	0.886	5
Unsuitable construction program planning	3.03	0.922	0.903	6
Incomplete approval	3.02	1.186	0.887	7
Price inflation of construction materials	2.96	1.082	0.904	8
Quality related risks			0.862	
Lack of coordination between project participants	3.42	1.136	0.833	1
Low management competency of subcontractors	3.38	1.001	0.877	2
Design variations	3.37	0.844	0.855	3
Incomplete or inaccurate cost estimates	3.29	1.232	0.845	4
Inadequate program scheduling	3.10	0.937	0.841	5
Unavailability of sufficient amount of skilled labour	2.94	1.001	0.835	6
Pressure from high performance or quality expectations	2.90	0.975	0.838	7
Variation of construction programs	2.86	0.922	0.835	8
Unsuitable construction program planning	2.80	0.957	0.860	9
Health and Safety related risks			0.909	
Accidents due to poor safety procedures	3.56	1.226	0.892	1
Absence of fire safety systems on site	3.29	1.272	0.883	2
Equipment damage	3.27	1.172	0.881	3
Labour injuries	3.17	0.853	0.902	4
Property and materials damage	3.04	0.942	0.884	5

Values in bold representthe overall Cronbach's alpha of each risk category.

Furthermore, inadequate program scheduling was deemed to have a high impact on project time not being achieved. This result corresponds with the findings Zou et al. (2005) who concluded that inadequate program scheduling had a high impact on project time objective. They further indicated that program scheduling frequently appears in projects with a tight schedule when some programs need to be reduced to achieve the project timeline. However, the high impact of pressure from high performance and bureaucracy of government were contrary to the finding of Zou et al. (2005) where high performance was identified as a risk with a major impact on project time outcome.

4.3.2 Cost related risk factors

Design variation, variations by the clients, the occurrence of dispute and incomplete or inaccurate cost estimates were deemed to have a highimpact on project cost not being achieved. These results suggested that design variation usually arises in the design phase of a project and may derive from matters such as variations by the client and faulty design. These results concur with the results of the study conducted by Probhakar (2008) where design variations and variations by the client were both considered as the major cause of construction project cost overruns. The high impact of occurrence of dispute indicates the concern of communication between project participants. The occurrence of the dispute is frequent in construction, due to inconsistency and changes in the design and construction (Probhakar, 2008). Contractors should constantly communicate with the project team and initiate negotiations with the project manager (particularly the representative of clients) about prospective variations in the documentation and record the resulted delay of progress in construction log. This finding agrees with the finding of Enshassi et al. (2008) where the occurrence of legal disputes between project participants during the life of a project was identified as a major cause of project delay. Incomplete or inaccurate cost estimates seems to be directly correlated with the designers/consultants' knowledge and attitude towards work.

Many unpredicted factors comprise construction activities, which often deviates the estimated cost from the real cost. Hence, choosing skilled and qualified designers and involving the contractor or subcontractor early can help minimize the incorrectness. These results concur with those reported by de Bakker et al. (2011) where inaccurate material estimates were identified as the major causes of construction project cost and schedule overruns. The other cost-related risks were considered by the contractor to have a moderate impact on project cost outcome.

4.3.3 Quality related risk factors

Lack of coordination between project participants was deemed to have a high impact on project quality not being achieved. This result indicated that lack of coordination between project participants may lead to chaos in the management of construction team and programs. A general contractor or project manager who is skillful in the team and program coordination should be engaged. On the other hand, strengthening the participant's perception of cooperation and communication is also of importance for improving construction quality and efficiency. This finding was in line with the empirical findings of Enshassi et al. (2008) who established that lack or poor communication between parties had a high impact on the quality of the end product. This result raises the importance of management topics for contractors and the existence of the type of risk, which need high-level management skills.

Furthermore, low management competency of subcontractors had a high impact on project quality not being achieved. This is probably the only recognised key risk related to subcontractors. Unlike a general contractor who constantly manages a construction site for a long period, subcontractors normally allocate their manpower and other resources to different projects in order to achieve a maximum profit of their own business. Without competent management skills, subcontractors cannot successfully manage their resources to meet the needs from several concurrent construction sites. Accordingly, in addition to specialist abilities, the management competency should be considered as one of the key criteria for appointing subcontractors. These results were in general agreement with the study of Abu Mousa (2005) who also identified low management competency as one of the causes of construction project delay. The rest of factors namely: pressure from high performance or quality expectations; unavailability of enough skilled labour, variation of construction programs and unsuitable construction program planning were considered as risk with a moderate impact on project quality outcome. However, these results were contrary to the empirical results of Kishan et al. (2014); Mahendra et al. (2013) that identified these factors as factors with high impact on project quality outcome.

4.3.4 Health and safety related risk factors

The H&S success was negatively impacted by poor safety procedure, the absence of fire safety systems on site, equipment damage and labour injuries. This result is accordance of those of Ahmed et al. (1999); the National Audit Office (2001), which established the risks of defective materials and safety measures as very important risks. However, they are contrary to the findings ofPhoya (2012); Oztas and Okmen (2004) which identified accidents are caused by poor safety measures, labour injuries, and damage to materials and equipment as risks with a moderate impact on H&S objectives. However, in order to overcome some of these risk factors that exacerbated poor H&S performance among construction SMEs, Agumba (2013) found that upper management commitment and involvement in H&S, H&S resources and training and project performance supervision improved the H&S performance.

5. Conclusion

The study sought to investigate the impact of risk factors on project outcome of SMEs in the Gauteng province of South Africa. Nineteen risk factors were identified and categorised into time, cost, quality, and H&S related risk factors. Empirical findings established that variations by the client, design variations, incomplete approval and inadequate program scheduling were deemed to have a high impact on project time outcome. It was further revealed that design variations had a high impact on project cost outcome followed by variations by the client, occurrence of dispute and incomplete or inaccurate cost estimates. Furthermore, project quality outcome was highly impacted by the lack of coordination between project participants, low management competency of subcontractors, design variations, and incomplete or inaccurate cost estimates. In addition, accidents due to poor safety procedure, the absence of fire safety systems on site, equipment damage and labour injuries were deemed to have a high impact on project health and safety outcome. Further exploration of the empirical findings revealed that variation by the client, design variation, incomplete approval, and unsuitable construction program planning can negatively impact both project time and cost outcomes. Similarly, inadequate program scheduling impacted simultaneously the three project outcomes namely; time, cost and quality objectives, while incomplete or inaccurate cost estimates impacted highly on cost and quality objectives. To reduce chances of project failure, the risk factors as revealed in this study should be properly handled in managing the risks. This paper further sheds light and provides insights on the understanding of the risk factors impacting construction project, an area previously under-researched. Furthermore, this study makes a contribution to the body of knowledge on the subject within a previously unexplored context. Regardless of the achievement of the study objectives, there were boundaries to the conclusions. The study was conducted in South Africa; however, it was delimited to the province of Gauteng. The surveyed respondents were SMEs in the CI; hence, the findings of this study may not be representative of the entire country

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ICT and Innovation in Infrastructure development

DII 2017-018

Exploring the Efficacy of Innovative Urban Public Transport Infrastructural Systems on Economic Transformation: Case of Gautrain and Are Yeng in the City of Tshwane

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Abstract

There is generally interconnectedness among the complex urban challenges that are being experienced in most developing countries. Of particular note are the spatial fragmentation and inefficient and ineffective transport systems that characterize South African cities. In response, innovative urban public transport systems that seek to improve mobility and encourage mixed land use development have emerged. The innovations also seek to resolve the three apartheid vices that are unemployment, poverty and inequality thus enhancing economic growth and development within South African cities. This paper therefore examined the role of innovations in urban public transport systems to the creation and improvement of business operations and employment opportunities within the City of Tshwane. Both qualitative and quantitative research approaches were adopted and applied to gather from key informants and users of the transport services using interviews and questionnaires. Study findings revealed that the innovations have resulted in some commendable developments within the city of Tshwane however, the poor and previously disadvantaged citizens are yet to benefit meaningfully. The economic transformation agenda still needs to deliberately facilitate the inclusion of the poor in line with the massive transport infrastructure investments that have been made. Accordingly, the study recommends an integrated approach to economic transformation and innovative urban transport system. Human capacity development anchored through investment in education, skills development and human rehabilitation for self-help projects and Small, Medium and Micro Enterprises (SMME's) is highly recommended. Major investment opportunities should prioritize the urban poor instead of mainly improving the lives of that are already part of the formal economy. As a result, the study concludes by developing a model on Integrated Approach to innovative urban transport planning and economic transformation.

Keywords: economic transformation, Gautrain, sustainable development, transport infrastructure

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1. Introduction

Urban public transport innovations have emerged as an important component of economic growth and development (Rode and Floater, 2014). This has been evident through the global focus on sustainable transport planning systems. Consequently, concepts such as smart and compact cities have come to the fore with the aim of ensuring efficient, effective public transport systems (Wilkinson, 2006). Subsequent to these developments, massive infrastructure investments that have strong focus on transport infrastructure for connectivity, accessibility and affordability for the purposes of trade facilitation across developed, transitional and developing countries have been witnessed (Jouanjean, Gachassin and te Velde, 2015).

Development planning challenges that are encountered each day are interrelated. If not planned for accordingly, spatial fragmentation and lack of integration becomes the order of the day which ultimately hinders economic transformation. This is more so in previously disadvantaged communities that should be planned and developed to enhance transformation, economically and spatially. In response to this, sustainable transport planning focusing on innovative urban public transport systems, integration and smart mobility has emerged as the focal point of discussion worldwide (Moody, 2012). Emerging from such discussions is the call for innovative urban transport systems which encourage mixed-use development to respond to challenges of inequality, poverty and unemployment. Notable, integrated transport planning forms an integral part of development planning and economic transformation at global level (Byiers, and Vanheukelom, 2014).

The common trend has been the emphasis on the functionality of the linkages between major economic nodes which also saw the rise of corridor development and multi-modal transport planning initiatives (Marrian, 2001). At international level, countries such as England, Austria, China and Brazil have made commendable progress in implementing innovative urban public transport while addressing socio-economic challenges faced by their citizens/residents (Babinard, 2012; Jones, Turner and Heydecker, 2014). In contrast, Pardo, Jiemian, Hongyuan and Mohanty (2010) observe that there is a common trend in the developing countries where urban public transport systems are not as efficient compared to the developed world. They further argue that this has negatively affected Growth Domestic Product (GDP) in developing countries.

In light of the above, innovative urban public transport systems are geared towards achieving the principles of efficiency, liveability, safety, reliability, viability, convenience, accessibility and cost effective transport options (Toth-Szabo and Varhelyi, 2012).The stated principles are used as indicators to monitor sustainability of transport planning and development. Given the diverse nature of role players in transport planning and development, all integrated transport planning initiatives should be accompanied by deliberate planning initiatives and policy instruments to build integrated and sustainable transport network systems that yield positive economic spinoffs.

2. Innovative Urban Public Transport Systems Role in Integrated Development Planning

Innovative urban transport systems can be defined as practices that are new and provide better solutions to existing challenges and traditional measures in urban transport planning and mobility (Polis, 2015). Most common examples of these innovative transport systems include technologically advanced trains, Bus Rapid Transit (BRT) systems, etc. Through an efficient innovative urban public transport system where access to goods and services as well as people is well facilitated, there are prospects for better economic benefits through economies of scale and integrations effects. Cities with well-coordinated integrated transport systems are most likely to have an improved Gross Domestic Product (GDP) accompanied by higher levels of productivity (Rode and Floater, 2014).

Subsequently, transport planning has been identified as an integral part of economic transformation and improved access to economic opportunities (Pojani, and Stead, 2015). Thus this has encouraged development of innovative strategies or approaches to mobility and transport planning in general (Transport Research and Innovation Portal, 2013). Given the sustainable development agenda and the need for creation of efficient transport systems, integration has formed the core of urban public transport systems (Albalate and Bel, 2009; Preston, 2012). These include taking into account the socio-economic needs of the people served by the network as well as careful consideration of environmental constraints.

International experiences reveal that innovative urban transport systems like the BRT systems have led to improved access to economic opportunities by the urban poor in cities like Bogotá (Colombia), Rio de Janerio (Brazil) as well as the Chinese towns of Guangzhou and Lanzhou (Babinard, 2012; Bocarejo and Tafur, 2013). The common trend amongst these cities is integration and creation of cost-effective and efficient urban public transport systems given local context focusing on addressing socio-economic challenges. Where there is an efficient, effective public transport system, economic growth and development is enhanced (Pardo et al., 2010).

It is now evident that innovative urban public transport systems have since became one of the major investment pillars for most governments' institutions both at local and international level. The major investments associated with these innovations are understood as key drivers of economic growth and development. The separation of service providers combined with segmented travel market necessitates for integration and interchanges in urban public transport system. Lack of integration and cooperation amongst service providers constitute increased travel times and costs as they use different billing systems and service patterns, some with distinct technological tools which complicate things for the commuters (Guo, 2008).

As such, innovative urban public transport systems are geared towards creating sustainable, efficient and cost-effective urban public transport systems (Hrelja, Hansson, Richardson, Svensson, Lissandrello, Næss, Tennøy, and Longva, 2013). This is observed while there is a strong emphasis on the role of urban transport system as a critical tool to integrate all sectors of the economy and society while contributing to economic transformation (Pojani, and Stead, 2015). This can be achieved through an integrated approach where all relevant stakeholders play their role and contribute positively towards economic growth and development where a functional, efficient public transport system is created to strengthen the competitiveness and the growth of business in a city or region (Rosenberg and Weiste, 2007). The need for innovative approaches to transport planning has been recognised and more focused attention must be given to the improvement of the transport systems to ensure sustainable, integrated growth and development.

In an attempt to define transport integration one cannot neglect social, economic and environmental considerations (Potter, Stephen and Skinner, Martin, 2000). In the same vein, Louw (2003) argues that integrated planning looks beyond the dynamics of a well-coordinated transport system. This implies that if a transport system is well coordinated it can still be disintegrated if it neglects the social, economic and environmental considerations. Preston (2012) define transport integration as "the organisational process through which the planning and delivery of elements of the transport system are brought together, across modes, sectors, operators and institutions, with the aim of increasing net social benefits". This is also in line with Louw's definition which looks at integrated transport planning as an integrated approach that focuses on finding the right balances of all sectors and aspects of transport planning through identification of desired outcomes and common goals to promote economic growth.

3. International Experiences

There is a global shift from an old paradigm perspective on public transport which was based on physical travel (mobility) to more comprehensive innovative urban public transport systems that takes into account the socio-economic as well as environmental impact of urban public transport systems (Litman, 2014). It has been evident that where there is a healthy working relationship between the state as the regulatory and enabling authority, the public transport operators and the general public, a comprehensive innovative urban public transport network is possible (UNDESA, 2012).

Congestion during peak hours associated with rapid public transport in major cities globally has been a common trend in developed, transitional and developing countries (Gwee and Currie, 2013). Despite the complexities and challenges associated with urban public transport planning, it is important to priorities mass passenger transport options for the public. Regulatory frameworks and approaches to transport planning and delegation of powers differ from country to country. This is dependent on administrative structures, distribution of resources and capacity to provide a public transport system in line with peoples' socio-economic needs.

3.1 Developed countries

The developed world is at an advanced stage with their transport planning systems and operations providing more efficient and accessible transportation options and networks (Gould, and Schmalbruch, 2015). However, there are still challenges and issues that still needs to be planned for and attended to though innovative urban public transport systems are fully functional in major and most populated cities. For the purposes of this study, lessons were drawn from London (United Kingdom) as well as City of Linz (Austria) to inform some of the urban public transport planning strategies in the Global South given the South African context.

From the lessons learned, it is clear that planning and implementation of urban public transport systems in the developed world is already incorporating economic growth, improved business operations and employment creation as trickle down effects from transport infrastructure investments. The sampled cities of Linz and London represent comprehensive, fully functional and well planned innovative urban public transport systems. This is more so in the City of Linz where the railway station was transformed to a place of economic opportunities and social interaction promoting improved business operation and social cohesion (Klementschitz and Stark, 2009). On the other hand, the London innovative urban public systems may have few standards to adhere to before being completely sustainable, though it is also economically viable, efficient and accessible by all members of the public (Banisterand Finch, 2013).

The integration of different modes of urban public transport is also a predominant feature of innovative urban public transport systems in the developed world. The integration of rail transport to bus services and the availability of cycling options at the connector points has proven to be comprehensive and providing an efficient service for the commuters. Even those who are not working in close proximity to the main stations can still use the cycling option from the main stations to their respective work places while there are also safe pedestrian routes for those working and living in close proximity to the main stations or connector points.

3.2 Transitional countries

The Transitional Countries refer to those countries that can be regarded to be between the developed world the developing world as they contain characteristics of both. Although they have the infrastructure and economic productivity that can compare to that of developed countries, they still face some setbacks in terms of certain challenges facing the developing world. These countries can be considered as developmental states or emerging markets. BRICS (Brazil, Russia, India, China, South Africa) countries (which South Africa is part of) forms part of the transitional market countries. For the purposes of this study, China (Cities of Guangzhou and Lanzhou) and Brazil (Rio de Janeiro) were looked at from the Transitional Countries and key lessons were learned.

The transitional countries are characterised by rapid population growth and a demand for a fully functional, comprehensive urban public transport system that is accessible and affordable by all, including the urban poor. The progress made by China and Brazil brings hope to the rest of the transitional countries though there is still room for improvement in China and Brazil as well. The substantial progress can be a lesson on what are the critical aspects to attend to in order to attain a fully functional, comprehensive innovative urban public transport system against the challenges of rapid population growth, poverty and unemployment in transitional market countries.

The critical aspects observed in the cases of China and Brazil suggest that the State is a key role player in regulating all forms or modes of urban public transport while creating an enabling environment that encourages all relevant stakeholders to collaboratively work together. The integrated billing system and easy access to economic opportunities, heath facilities, social facilities and education facilities facilitated through integrated transport system also proved the be critical and essential given the for the transitional markets countries given the case of Rio de Janeiro, Brazil.

3.3 Developing countries

Developing countries are often associated with high level of socio-economic challenges and inadequate public transport systems to cater for the needs of the people, especially the poor (Gebeyehu and Takano, 2007). For the purposes of this study, lessons were drawn from the urban public transport system in Ethiopia (Addis Ababa) and Kenya (Nairobi). The urban public transport system can be seen as one of the essential transformation tools in these countries.

The common challenges facing the developing countries are the minimal State involvement in the urban public transport systems operations. Thus, common challenges faced by the developing countries are embedded on poor coordination of urban public transport systems, traffic congestion, increase non-regulated privately owned public systems or taxi industry, lack pedestrian friendly transport systems resulting in conflicting sharing of public roads between motorists and pedestrians and congestion with minimal parking space in support of urban uses (Marrian, 2001). The state of urban public transport system in the developing countries is such that there is high demand for urban public transport with limited supply resulting in uncoordinated informal public transport network that share the roads with a high volume of pedestrians raising safety concerns (Demdime, 2012).

The state of urban public transport systems in the developing world appears to be far from being ideal and a lot of work still needs to be done to cater for the needs of the people. It is evident that a form of urban public transport is existing in the developing countries and that the desire to improve the state of affairs in urban public transport is there. However, it remains to be seen whether the comprehensive visions for urban public transport can be translated into meaningful progress. There is no proper coordination and management of different modes of transport and challenges of limited access and unaffordability persist and co-exist in the developing world.

4. South African Urban Public Transport System

The South African public transport system is renowned for its distinct formal and informal public operators (Ahmed, 2004). The formal public transport system constitutes the government subsidised public transport systems in form buses and trains while the informal public transport network is predominantly the taxi industry which is recognised by government but is not a government subsidised operation (Venter, 2013). Government has little say on the taxi industry which is said to be responsible for at least 65% of the public transport commuters in South Africa (Ahmed, 2004).

Since 1994, the South African government has embarked on the journey of transforming the country’s public transport network and operations through legislative and other initiatives (van Ryneveld, 2008). Central to this has been the formalization and transformation of the taxi industry with minimal progress which has later been followed by the introduction of the innovative urban public transport systems (Venter, 2013).

The taxi industry has play a critical role in the country’s public transport arena especially where the formal public transport operations like buses and trains cannot cater for the needs of the previously disadvantaged (Ahmed, 2004). However, there are also many inadequacies with the taxi industry operations often associated with violence hence the need to create a safer and convenient public transport system through integrated, innovative urban public transport network and system (Venter, 2013). Since 2005, Innovative Urban Public Transport Systems were brought in as a strategy to accelerate transformation under the national government led initiative known as the Integrated Rapid Public Transport Networks which saw the introduction of the Gautrain and Bus Rapid Transit (Ahmed, 2004). To date implementation of such initiatives has been slow despite massive investments.

Dawood and Mokonyama (2015) observe that the South African public transport challenges have been persistent despite various transformation and formalization initiatives since 1996. Even after the promulgation of the National Land Transport Act in year 2000 which was soon followed by attempts to recapitalize minibus taxis and restructuring of bus operations contracts under the accelerated modal upgrade programme (van Ryneveld, 2008).

The accelerated modal upgrade initiative has slowly subsided with minimal positive outcomes and has been overtaken by innovative urban transport initiatives implementation which seeks to produce a competitive and integrated urban public transport network (Department of Transport, 2007). The Gautrain and Bus Rapid Transit (BRT) are at the centre of Innovative Urban Public Transport Systems towards an integrated urban public transport network in South Africa. The economic benefits from these innovative transport systems to the urban poor and the previously disadvantaged leaves much to be desired.

The South African Urban Public Transport is characterized by poor coordination with multiple stakeholders and service providers responsible for providing public transport services for the commuters (Mashiri, Mokonyama, Mpondo, Jakhwizara and Mdunge, 2014). These ranges from formalized municipal buses in major cities, private owned bus companies, rail transport as well as a non-regulated, informal public transport in form of taxis which is arguably transporting most of the countries passengers in urban areas. In an attempt to deal with the ills of the past, South Africa developed strategies towards an Integrated Mass Rapid Public Transport Networks (van Ryneveld, 2008). It is from this initiative that innovative transport system like A Re Yeng and Gautrain implemented in the City of Tshwane emanated.

Given the South African context, public transport is the priority and there should be a transport network of high frequency/volume corridors with the aim of shortening the time for travel tips and improved access to economic opportunities (Patel, Freeman and Mitchell, 2001). The achievements of the country in urban public transport planning and implementation has been disappointing despite good policy instruments and legislation informed by good principles which are based on the 1996 White Paper which is in line with international standards

The apartheid system of governance has contributed to the current land use pattern which perpetuates long travel distances with location of townships far from major economic nodes (Patel et al., 2001). The apartheid system has also contributed to the availability of cheap land for housing development far from the major economic nodes mainly linked through mass public transport rail network which constitute a fragmented spatial form. Transit-orientated development (TOD) and smart growth shape the urban form as core component under infrastructure development (Todes, 2012). While there is a drive towards improved access to opportunities by all, the subsidised housing for the urban poor have been planned implemented in a manner that it works against access to opportunities by all.

The need for stakeholder cooperation has been identified as a lacking crucial component despite continued massive investments for public transport infrastructure and services by government (Van Ryneveld, 2008). There is a need to strengthen the public sector human resource to carefully analyse and understand public transport markets trends in order to influence the country towards a comprehensive urban public transport network through efficient implementation of policy and legislation.

Given the significance of mobility in the urban areas, one cannot overlook the importance of improving access and promoting affordability which will allow people to participate actively in the economy. Mashiri, Maphakela, Chakwizira and Mpondo, (2013) note that “the transportation burden faced by developing rural and urban communities on a daily basis in South Africa is real and substantial.”This is noted while massive transport infrastructure grants are made available each year which makes it not a question of availability of funds rather the manner in which transport planning and implementation is facilitated with limited research guiding practice.

It is evident that the South African Government has prioritized improved public transport system with the support provided through mega investments and strategic policy instruments. Van Ryneveld (2008) observes that South African urban public transport system has reached a critical stage with major cities (supported by national and provincial governments) already geared up to implement innovative urban public transport systems. Metropolitan cities seem to be the ones driving the innovative urban public transport systems initiatives while other cities and towns are lagging behind. This is understandable given the population concentration and major economic activities in these metropolitan areas.

The 1996 White Paper on national public transport policy is perceived as the key building block that formed the basis of urban public transport systems transformation in the democratic era (Dawood and Mokonyama, 2015). There has been a significant shift in terms of policy instruments since the White Paper that was published in 1996 but there is still a need for a pro-active approach to deal with the prevailing circumstances and ever rising challenges facing the country. The White Paper was then followed by the Integrated Rapid Public Transport Networks initiate which is a more sophisticated initiative towards an innovative urban public transport system. From this initiative innovative urban public transport systems like the Gautrain and Bus Rapid Transit (BRT) were introduced with the BRT as the common adopted form of innovative public transport across major cities in the country.

With the promulgation of the Infrastructure Act, Act 23 of 2014, South Africa has recognised the need to carefully manage and invests in infrastructure development, including transport infrastructure. Many discussions are taking place around spatial restructuring through integration and building good infrastructure to support the economy. Despite various initiatives and investments in transport infrastructure development, the poor planning for this growth has led to failure symptoms such as severe traffic congestion, conflicting vehicle-pedestrian movements, increased number of uncoordinated small-scale freight vehicles and severe parking shortages (Marrian, 2001).

5. Socio-economic implications of prevailing circumstances in South Africa

Social and economic transformation has been arguably the core of South Africa’s post-apartheid economic growth and development agenda (Leibbrandt, Woolard, McEwen and Koep, 2010). Spatial structures and forms inherited from the apartheid planning system have hindered and frustrated the social and economic transformation in most parts of the country (Turok, 2013). Pre-1994, the South African economy used to be that of a polarised labour market where benefits of most skilled jobs were accessible mainly by the minority or whites and the native people occupied the low income jobs in the unskilled or semi-skilled labour market (Leibbrandt et al., 2010). These necessitated that economic transformation becomes South Africa’s top priority hence numerous transformation orientated policies were developed. Most of these policies can be deemed to have made little or no difference given the prevailing circumstances on the socio-economic challenges that South Africa is constantly battling with.

Long-term unemployment is the most prolific, unprecedented negative consequence born of the country’s history of skewed distribution of economic opportunities (Van Der Westhuizen, 2012). Over the past two decades little or no progress has been witnessed in equal distribution strategies which are crucial for economic empowerment, land reform and access to urban amenities despite having proliferation of micro-financing and institutional transformation (Baruah, 2009).

The income disparities in South Africa are by far a reflection of the historical imbalances manifested though a racial footprint and geographic location (Leibbrand et al., 2010). It is not surprising that even the educated workforce from the previously disadvantaged communities and racial groups are subject to ever increasing unemployment in the country. Travel costs and lack of access to economic opportunities has been the predominant challenges for most people of South Africa with the urban poor having to spend more than a third of their income in travelling cost while also travelling long distances (Patel et al, 2001). Government subsidy has only been offered for the bus system and rail network which excludes the taxi industry which is arguable the biggest transporter of the urban poor segment of the population (Dawood and Mokonyama, 2015). Thus, this has contributed to lack of economic integration of the urban poor.

Limited access to economic opportunities by the urban poor where the geographic location of some residents means that they are far from work places and as a result the cost for transport is increased as they have to use more than one mode of public transport for a single trip (Franklin, 2014). This also results in increased travelling times which negatively affect productivity in the work place and end up discouraging some residents from working, some even give up their jobs due to high travelling costs and long travel distances (Mackie, Laird and Johnson, 2012). Entry into the formal economy is arguable the most challenging for the previously disadvantaged. In light of this note, one would expect South Africa to have a large informal economy but surprisingly it is relatively small and even those involved in informal trading often times find themselves victims of state bureaucracy through the public policing system. There is a need to encourage informal economy through legislative and other interventions.

The status quo of the complex and interconnected South African Socio-economic challenges can be attributed to apartheid and colonialism. Even the history of South African labour market and distribution of economic opportunities is that of an unequal society where access to economic opportunities set on the bases of discrimination for decades during the apartheid era prevail. With the birth of the democratic dispensation in 1994, there has to be a shift in mind set and policy frameworks. However, South Africa still has a huge mountain to climb to redress ills and imbalances of the past, especially on the labour market polarisations and access to economic opportunities and spatial fragmented society.

The democratic government of South Africa have emphasized on economic transformation, widely supported by the developed policies and strategies to alleviate poverty, reduce unemployment and address challenges of inequality given the ills of the past. This is through a number of policies and programmes have been put in place by the South African government (Gumede, 2013).Despite the efforts, statistics suggest that there has been little or no progress if any in bridging the inequality gap and alleviating poverty. This is observed as the State continues to produce policies and plans that looks good on paper but with limited or no significant impact in improving people's lives (Cilliers and Camp, 2013).

The policy frameworks and all other forms of interventions that have been commissioned since 1994 were centred on the premises of transforming and addressing the past development imbalances. Twenty-two years into democracy, all spheres of states are now mandated through the Spatial Planning and Land Use Management Act, (Act 16 of 2013) to economically integrate the previously disadvantaged areas and promote spatial justice and sustainability. The National Development Plan as well as the New Growth Path also supports the notion of on economic transformation addressing the imbalances of the past while fostering spatial integration.

Since the 1994 transition to democracy South Africa has recorded steady economic growth per annum (although has significantly dropped recently) but socio-economic challenges like poverty and inequality continue to persist despite the increased governmental redistribution initiatives (Van Der Westhuizen, 2012). As already highlighted, there have been various attempts by the democratic government to improve the social and economic status of the people and build sustainable communities situations on the ground suggest otherwise. From the Reconstruction Development Programme (RDP) to the 1996 Growth Employment and Redistribution (GEAR); Urban Renewal Programme of 2000; Accelerated and Shared Growth Initiative – South Africa (ASGISA); the New Growth Path of 2010 and now the National Development Plan Vision 2030, the impact on the day to day lives of the residents leave much to be desired.

In contrast, questions are now raised on whether or not has the state created a dependency culture where people are solely dependent on government to provide their needs. Though poverty has been debated as the increasing source of income for people's survival, however this should not overshadow the role of social grants in the countries poor segments of population. In the public dialogues, service delivery protests and economic disparities have been the focus point of the discussion where the inclusive nature of government policy initiatives and service delivery is questioned. The defining feature agreed upon in all these dialogues has been the notion that issues of economic disparities and labour market polarization persist and coexist with the previously disadvantage continuously being marginalized.

6. Urban Public Transport Systems and Economic Transformation in the City of Tshwane

The City of Tshwane is the administrative capital city of South Africa and the 5th largest metropolitan municipality in the country. It is located in Gauteng province which is known as the economic hub of South Africa. As a result, the innovative urban public transport systems for the province's three metropolitan cities (including the City of Tshwane) are critical not only for the province's economic growth and development but also the South Africa as well. Urban communities in South Africa face substantial and real challenges and burdens with regards to transportation and access to economic opportunities (Mashiri, Maphakela, Chakwizira and Mpondo, 2013). This is still being observed despite massive transport infrastructure investments in the country during the democratic era.

In this regard, an effective and efficient transport system becomes the core component of spatial integration and economic transformation in Tshwane. Hence innovative urban transport systems focal point of discussion. Mulenga (2013) argues that transport corridors have a critical role to play in integration and development at large. With major investments on rail and road transport in Gauteng province, the expectation is that such investments should translate to spatial integration and economic transformation.

It is essential that both soft and hard infrastructure is taken in to cognizance in development processes and policy formulations (Mulenga, 2013). The hard infrastructure relates to the railway lines and highways or BRT routes whereas soft infrastructure speaks to the socio-economic programs and institutional or market orientated development secondary to hard infrastructure (Fung, García-Herrero, Iizaka, and Siu, 2006). These observations are also acknowledged in the Gauteng 25-Year integrated transport master plan of 2013 focusing on intelligent transport systems. This plan outlines the Province's envisaged plans to develop sustainable transport system that will anchor the economic, social or cultural and environmental objectives of Gauteng (Department of Roads and Transport, 2012).

Consequently, the need and search for innovative approaches to economic transformation and development planning has been identified. In this regard, transport planning has been identified as a key sector in facilitating economic integration and transformation. While this has been said, it is also important to note that places are unique and area specific issues should be studied, analysed understood in order come with relevant solutions or recommendations. South Africa prevailing economic disparities and uniqueness of different areas within the country should be noted and attended to (Todes, 2012). Hence questions remain on what hinders economic transformation in the City of Tshwane, Gauteng province and South Africa at large despite various initiatives and major investments to enhance economic growth and development.

The current political administration of Gauteng provincial government has outlined their plans and intentions to transform the economic space of Gauteng province in the next 10 to 15 years (Makhura, 2015). This was through the pronouncement of the multi-pillar programme of radical transformation, modernization and reindustrialization of Gauteng geared towards social cohesion and economic inclusion. Taking note of the afore mentioned, it is important that questions are probed and new innovative approaches are researched and adopted to prevent repetition of major policy interventions and investments with limited progress in terms of economic transformation.

The City of Tshwane serves as South Africa's administrative capital city and amongst Gauteng's three metropolitan cities, and therefore the city has a significant role to play in shaping the direction of growth and development in the region. In light of this, it is important to commend initiatives to improve Tshwane's innovative urban public transport system through the A Re Yeng Bus Rapid Transit (BRT) system. It is also important to note that the Gautrain is an initiative driven and implemented by provincial government and not the Municipality. Currently the BRT system runs mostly between Pretoria CBD and Hatfield with connector points in between while the Gautrain within the City of Tshwane has three stations namely Bosman, Centurion as well as Hatfield station with the intentions to expand in the near future. The Gautrain Route also runs between Pretoria CBD and Hatfield with only two stations namely Bosman (Pretoria CBD) and Hatfield. Although the Gautrain also has another station in Centurion that is fully operational, for the purposes of this study only the Bosman – Hatfield route was the focus of the study since only these two major nodes also have the BRT system.

7. Findings and Discussion

Long distance between residential area (for the urban poor) and economic opportunities, extended travel times and high travel costs have a negative impact on the productivity of workers and in some cases may lead to low income earners giving up their jobs or discourage them from looking for employment opportunities completely (Pettinger, 2011). This suggest that there is a serious need to create affordable public transport options. The study findings reveal that the Gautrain is by far not affordable by the urban poor (who constitute majority of the City's population). The low-income group still prefer the taxi industry siting reliability and affordability while the middle-income group is keen on using the innovative urban public transport systems and the high-income groups are mostly using the Gautrain or private transport. The A Re Yeng BRT system proved to be the only option for the urban poor. The Gautrain is said to be serving the rich and the upper market class of the Tshwane community (which is in minority). Given the local context, the BRT system should take priority in terms of budgeting and implementation as it caters for the wider community and affordable by all. On the other hand, the Gautrain can be used mostly for linking major economic nodes for those making business trips.

Field observations and general consensus by the respondents were such that, in some instances public transport does not take commuters directly to their respective place of work or residence and therefore necessitating commuters to use two or more modes of public transport. This therefore makes connector points between residential areas and major economic nodes including linkages to work places and residential areas a critical component for innovative urban public transport systems. This will require cooperation and integration of different public transport providers, both public and private. Such was successfully implemented and achieved in Rio de Janerio. This was through the introduction of one travel card, i.e. Bilhete Único Integrado (BUI) or Integrated Ticket Fare launched in 2010 for different of modes of public transport in Rio de Janerio (Brazil) which helped reduce travel time and cost (Babinard, 2012).

This depicts effective planning and integration in urban public transport system where the poor and those living in the outskirts of the urban area benefited through the reduced travel costs and time. One of the respondents from the Municipality during the key informant interviews argued that the success of the Rio de Janerio innovative urban public transport system can be attributed to local context based solutions without directly copying a system that works in another city or country which may result in neglecting local specific issues and challenges. As already highlighted earlier, places are unique and should be treated as such. This does not dispute taking lessons from successful case studies but encourages that while drawing lessons externally, local complexities should not be neglected.

It is now evident that transport planning is evolving from a more traditional approach to transport planning towards a rational, comprehensive integrated approach that takes into account all modes of transport (Litman, 2013) while also fostering investments returns and positive spinoffs in economic growth and development (Mackie et al., 2012).To achieve these, innovative urban public transport system must be coordinating through an integrated approach to decision making and operations management to achieve economically viable and sustainable transport systems (Pardo et al., 2010). Mechanisms must be developed to ensure that transport planning investments and decision does not compromise the value of social, economic and environmental aspects of development focusing on realistic solutions to community problems. Through innovative urban public transport systems with strong focus on integration, cities will become hotbeds for innovation where trade, tourism, commerce, services and education will be improved and prosperous.

The genesis of an integrated approach to transport planning can be traced back to European during the 20th century (Pojani and Stead, 2015) from which the rest of the world followed suit. Arguable, integration is measured through best practices where various analytical methods are applied to optimize an efficient transport network with improved consumer experience and accelerated economic growth and development (Preston, 2012). Integration encompasses a number of factors which when facilitated and coordinated accordingly, best practices that contribute to economic transformation is inevitable (Potter et al., 2000). This can be evident easy access to economic opportunities, improved business opportunities, affordable transport options and fully functional, efficient and integrated urban public transport network characterised by reduced travel costs and improved productivity in work places while eliminating the element of discouraged unemployed residents.

Land use patterns of a city or town also influences the travel pattern transport network (Cervero, 2001). This makes coordination of land use planning and transport planning a critical component in towards sustainable development and creation of functional cities and urban centres that caters for the needs of the people. Evident in the City of Tshwane case is the involvement of the town and regional planning department in the innovative urban public transport where there focus on densification along BRT corridors. Through this initiative, the City of Tshwane is developing regional spatial development frameworks which intend to ensure that people leave closer to the BRT corridors and therefore promoting easy access. However, it is important to note that during the key informant interviews it was evident that accommodating development for low income earners will be a challenge since most developers are more interested in making profit. This leaves a responsibility to find ways in which the Municipality can secure land for developing a variety of housing options and create subsidy schemes to ensure low income earners and urban poor are not excluded but accommodated in the densification initiatives along the BRT corridors.

8. Conclusion and Recommendations

Since 1994 various policies and programmes have been commissioned to better peoples' lives and facilitate social and economic transformation towards sustainable livelihoods but the prevailing circumstances leaves much to be desired. Problems of poverty and inequality persist and coexist despite numerous programmes and investments that have been put in place over the past 22 years. Central to this are the ever increasing problems of unemployment, labour market polarization, informal settlements low literacy skills, lack of access to basic amenities in most rural communities of the country.

The economic transformation agenda still needs to deliberately facilitate the inclusion of the poor in line with the massive transport infrastructure investments that have been made. The urban poor and previously disadvantaged citizens are yet to meaningfully benefit from innovative urban public transport systems investments. Their economic constrains need to be at the fore front in order to access employment opportunities and get the necessary exposure for entrepreneurship and improved business opportunities that come with innovative urban transport systems.

Major investments opportunities should prioritise the urban poor instead of mainly improving the lives of that are already part of the formal economy. As already indicated in the findings and discussion section, the Gautrain is not a mode of urban public transport that can cater for the needs of the urban poor as it is by far not affordable. The BRT system (which has proven to cost less than half price of a single trip in the Gautrain) therefore becomes the appropriate option given the socio-economic needs of the urban poor. However, evidence on the ground suggest that places where the urban poor reside are most likely going be the last to receive the BRT system since the project already started by prioritising major economic nodes and not necessarily places where the urban poor reside. On the other hand, they cannot afford living expenses in place that take priority in the Municipal Plan's implementation of the BRT system.

Accordingly, the study advocates for an integrated approach to economic transformation and innovative urban transport system. Human capacity development anchored through investment in education, skills development and human rehabilitation for self-help projects and Small, Medium and Micro Enterprises (SMME's) is highly recommended. To foster economic transformation in South Africa, attention must not only be given to creating opportunities but also preparing citizens and the previously disadvantaged to use those opportunities effectively and benefit from them economically.

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DII-2017-031

Performance Indicators for Lean Construction in South Africa: Lessons from the Port Elizabeth province

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Abstract

This study sought to identify the Key Performance Indicators (KPIs) for monitoring the implementation performance of lean construction (LC) practices in South Africa. Given the limited penetration of the LC concepts and its associated tools in South Africa, an identification of how to measure progress among general contractors who are embracing practices akin to LC has become imperative. Relevant KPIs were extracted from conference proceedings published between 1996 and 2016 on the International Group for Lean Construction (IGLC) website using content analysis. Subsequently, a group of contractors, purposively selected as interviewees, were asked to identify KPIs being utilized by their organisations. Notable KPIs highlighted comprised mainly of the conventional ones like cost, time, quality, client satisfaction, minimal environment impact and improved value. It is worth noting that lean-specific KPIs were not observed from the thematically analyzed data. This realization reinforces the perception that LC practices are yet to make sufficientinroads into South Africa, andconventional KPIs are not adequate to indicate otherwise.

Keywords: performance indicator, lean construction, South Africa

1. Introduction

Construction project failures are being increasingly reported around the world. Instances of such failures appear to be prevalent in the developing countries, particularly in Africa. Countries within the continent are continually relying on the efficiency and effectiveness of the construction industry to deliver on its stride towards bridging the infrastructural deficit experienced within the continent. Furthermore, the attainment of construction project success not only within the continent but also across the globe has become difficult as a result of industry peculiarities such as its fragmented nature, etc. These peculiarities often lead to the occurrence of various types of waste. Accordingly, construction projects can be described as being vulnerable to wastes, hence denying clients the much sought after improvement of value (Al-Aomar, 2012). Suffice to say that construction activities across the globe have become synonymous with high levels of waste and Lean Construction has been identified a potent philosophy for curbing such wastes and resulting in optimal value creation for stakeholders (Bolviken and Koskela 2016). According to Arbulu and Zabelle (2006), considerable attention has been devoted

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by construction organisations towards the attainment of the benefits accruable from lean construction practices if properly adopted and implemented. Several case studies abound which attest to some of the proven benefits and pockets of excellence experienced within contexts where lean construction principles have been adopted either holistically or partially and implemented likewise (Alarcon et al., 2002; Swain and Mossman, 2003; Wu and Low, 2011; Andersen et al., 2012; Keiser, 2012).The lean philosophy appears not to have attracted all-round accolades as some unsuccessful projects have also been reported, the integration of lean practices, notwithstanding (Olatunji, 2008; Senaratne and Wijesiri, 2008; Abdullah et al., 2009; Mossman, 2009a).

Lean construction has been described as a management philosophy which seeks to be defined according to its pursuit of ideals such as waste elimination, cost reduction, mainstreaming of innovative practices, engagement of right skills mix and effective organisation within the workplace as well as methods utilised in the attainment of these ideals (Ballard, 2015). Significant advances have been recorded in the field of LC over the past decades. Challenges have been posed to extant production and project management theories resulting in the development and dissemination of new tools of lean construction to relevant stakeholders in the construction industry (Ballard 2000a; Ballard 2000b; Howell 1999; Koskela 2000). To buttress the growth of the LC literature, a substantial body of literature now exists especially from the archives of the International Group for Lean Construction (IGLC), a special interest group of academics and practitioners with interest in Lean Construction.

Despite the acknowledgment of successful implementation of LC practices in developed and emerging economies such as USA, UK, Australia, Brazil, Chile, Finland, Singapore, Peru, Ecuador, Indonesia and Columbia (Ballard and Howell, 2003), African countries seem not to have made appreciable progress in this wise. The case of South Africa is even more pertinent. A recent study conducted within the South African context reveal a low rate of LC awareness among industry stakeholders (Emuze and Ungerer, 2014). The inability of interested parties within the construction sector, in South Africa as well as the rest of the developing world, to measure the improvements brought about by the integration of LC practices remains a major obstacle to its adoption by these stakeholders. Accordingly, it becomes difficult to attract converts to this innovative approach in the absence of widely accepted performance indicators. This is partly due to the perception of relevant stakeholders of LC being largely conceptual. Questions about its meaning, processes for identifying where it has been applied, whether it implies achieving more with less as well as how much less actually qualifies as lean are continually being asked by interested parties. Obviously the construction industry in these climes requires an articulation of LC in a way that can easily be understood hence engendering its successful application (Ward 2015). Such an articulation would require the identification of widely accepted lean-centric KPIs for different stakeholders within the South African construction industry.

KPIs have been described as a means of improving the effectiveness and efficiency of construction projects. According to Yong and Mustaffa (2012), KPIs represent indicators which are "critical" to the success of the performance of a sector or organisation. They differ from organisation to organisation depending on contextual peculiarities such as their respective operation environment, policies and legal restrictions. But the most common KPIs available revolve around the generic items of cost, time and quality. However, concerning KPIs for LC implementation, Leigard and Personen (2010) observe that many case studies on LC implementation addressed implementation issues for a single project and not in a more holistic manner. This signals an inadequacy of extant KPIs for measuring effective LC implementation across a plethora of construction projects. This implies the elusive nature of the search for KPIs in the implementation of LC in construction project (Netland, 2015).

This is the gap which this study seeks to contribute towards bridging. However, the scope of this study will be limited to the contractors within the Port Elizabeth municipality of the Eastern Cape province of South Africa. The choice of contractors was premised on the centrality of their role to the attainment of project success or failure. This study stems from a proposition that an increased uptake of lean construction practices amongst contractors would lead to better project delivery outcomes. Admittedly, the identification of KPIs from the worldviews of these contractors would contribute to the development of a widely acceptable set of KPIs for LC implementation performance management within the South African Construction industry.

To achieve this salient objective, subsequent parts of this study will consist of: a brief review of the literature on performance measurement in construction and the integral nature of the KPIs therein; a justification of the research methodology adopted in the conduct of the study, a presentation and discussion of the findings, and the concluding remarks.

2. Performance Measurement in the Construction Industry

Performance is described as the valued productivity output of a system in the form of goods and services (reference is needed). The term 'performance' denotes the degree to which an organisation fulfills primary measures in order to meet the needs of its customers (reference is needed). Al-Aomar (2012) defines performance in competency terms as the behaviouralcompetencies deemed critical to the attainment of goals within project-based organisations. Franco-Santo, Lucianetti, and Bourne (2012) extend this definition by introducing the contemporary performance measurement system, which, for instance, consists of balance scorecards (BSC) and KPIs among others

An effective approach to selecting performance measures is the identification of the minimum set of measures which can enable effective judgments on the standards and extents of a particular process. The selection of performance measures should consider actions that reinforce the activities that are in the best interests of the organisation (Cha and Kim, 2011). Construction organisations should align the reasons for implementing a performance measurement system with the need to improve the overall effectiveness of its business processes. Accordingly, performance measurement can be described as involving the identification of a balanced set of measures for measuring what matters to service users and other stakeholders, involving staff in the determination of the measures and making sure that both perception measures and quantifiable performance indicators are included (Ofori, Teo and Tjandra, 2012).

2.1 Key performance indicators

According to Parmenter (2010), KPIs represent a set of measures focusing on those aspects of organisational performance that are most critical for the current and future success of the organisation. The KPIs reflect a balance between cost, quality and time. These indicators must be the critical and should be able to alert managers immediately if something goes wrong so that they can react to it. (Marx, 2013).

KPIs as applied in construction industry enables contractors to:(1) overcome uncertainty in contractor selection processes; (2) unify and standardize data collection processes surrounding KPIs; (3) enable greater clarity in contractor evaluation; (4) increase the quality of measurement and benchmarking processes; (5) provide essential pre-qualification measures for small to medium construction organisation; (6) improve contractors' competitiveness, (7) improve the quality and performance of construction process; (8) increase levels of customer satisfaction; and (9) improve project management capabilities (Alkilani, Jupp and Sawhney, 2012).

3. Research Methodology

This study adopts a qualitative case study research design with emphasis on the collection of data in two distinct yet interrelated phases. A review of the conference and journal article publications spanning a 20-year period on databases of the International Group of Lean Construction (IGLC), Lean Construction Journal, Emerald, Taylor and Francis, Sage, Scopus, and Ebscohost was conducted, initially. The keywords/search terms utilized in searching for relevant studies across these databases consisted of the following; 'lean indicators, lean performance indicators, lean key performance indicators'. Searches were conducted between the 1st day of March, 2017 to the 24th day of March, 2017 by the authors. These databases were selected as a result of their proclivity towards hosting journal publications on innovations in the construction industry such as LC. After a thorough search across these databases, 45 articles and conference papers were extracted using content analysis based on the search terms used. It must be noted that due to the inability of the authors to gain full unrestricted access to the publications available on these databases contributed to the meagre number of publications obtained. This posed a major constraint to the authors. The authors then perused through these articles to identify the lean KPIs mentioned therein.

The second phase of the data collection exercise consisted of the conduct of interview sessions with a purposively selected group of contractors within Port Elizabeth. Port Elizabeth was chosen for this study due to convenience purposes. Interviews have been described as capable of letting the interviewer into the worldviews of interviewees. Also, the adoption of semi-structured interviews as a data elicitation technique for this study provided the researchers with the flexibility needed to alter the questioning patterns to suit the particular interviewee. In consideration of the need to explore the perceptions of contractors concerning KPIs for measuring LC implementation performance in construction projects, 12 CIDB grade 5 contracts managers were selected as interviewees. Leedy and Ormrod (2010:141) recognise that "a typical sample size ranges from between 5 to 25 individuals". These respondents were sent invitations to participate in the study and asked to signal their intention to participate in the study to the authors. Seven interviewees replied in the affirmative and were subsequently recruited. Reminders sent out to the remaining five prospective interviewees were not replied within the timeline provided.

Having relied on a review of the lean KPI related articles sourced from the abovementioned databases and content analysis, the authors had developed an understanding of what these lean-centric KPIs were. Armed with this knowledge, they proceeded to ascertain from the interviewees, the manner of KPIs they applied in the measurement of LC implementation performance on their projects. Interview sessions lasted for an average of 30 minutes each. With the permission of the interviewees, the interview sessions were recorded with the aid of a tape recorder and subsequently transcribed. The transcripts were then read severally in the bid to establish any patterns worthy of note. These transcripts were thematically analysed in accordance to the pre-set theme selected by the authors prior to the commencement of the interview sessions proper.

4. Presentation of Findings and Discussion

Based on the review of 45 articles and conference papers sourced from various databases, nine (9) broad KPIs for lean construction implementation were extracted using content analysis. The nine KPIs are presented in Table 1 below.

Table 2: Identified KPI's for lean implementation

	KPI	A brief description of the KPI	Source
1	Time	Construction time, the speed of construction and time variation.	Leong, Zakuan and Samon (2014); Marx (2013); Parmenter, 2010.
2	Cost	Tender sum, construction costs, costs due to variations and modifications.	Leong et al. (2014); Parmenter, (2010); Marx (2013).
3	Quality	The ability of the project to adhere to the setup specifications.	Leong et al. (2014); Parmenter, (2010); Marx (2013).
4	Health and safety	Fatalities, accidents and injuries	Marx (2013); Parmenter, (2010).
5	Client satisfaction	Completion on time	Al-Aomar (2012); Parmenter, (2010).
6	Environmental impact	Air emissions, noise, solid waste and water discharge.	Marx (2013); Al-Aomar (2012); Parmenter(2010)
7	Waste	Number of defects, rework, errors, and omissions, the number of change orders, safety costs, excess consumption.	Al-Aomar (2012); Parmenter, (2010).
8	Speed	Quick delivery, speedy construction.	Al-Aomar (2012); Parmenter, (2010)
9	Value	Added value, profit, financial achievement, owner satisfaction	Al-Aomar 2012

The identification of these KPIs for LC implementation performance provided the authors with an in-depth understanding of what such KPIs were. This understanding was imperative considering the novel nature of the concept within the South African construction industry context where the selected interviewees were integral players. Excerpts emanating from the interview transcripts were presented according to the pre-set themes selected by the authors at the outset of the data collection exercise. These pre-set themes consist of the following, namely: awareness of LC among the contractors; knowledge of performance measurement indices in construction; KPIs for Lean construction implementation performance.

The discussion of the findings from the interviews will be presented in line to these above-mentioned themes.

4.1 Awareness of lean construction

Undoubtedly, with reagard to awareness of LC concepts or practices among contractors, it can be stated that without any awareness of such concepts, contractors would not be interested in implementing them within their projects and as such, will not be able to provide any LC based KPIs. This notion prompted the interviewer in this instance to commence the interview sessions with questions relating to the level of awareness of the interviewees concerning LC practices in construction. Five of the interviewees indicated that they were not aware of LC and proceeded to request for a brief explanation of the concept. Conversely, whereas two of the interviewees posited that they were aware of the LC concept, such awareness did not readily translate to adequate knowledge of the concept and the associated techniques for its application. Buttressing their level of awareness, they requested a brief explanation of the concept of lean construction and how it works. This request was acquiesced by the interviewer who carefully explained it to them. Following from the findings in this instance, it can be averred that there is a low rate of awareness among contractors in Port Elizabeth, South Africa, hence affirming the findings made by Emuze and Ungerer (2014) concerning the low level of awareness and uptake of the LC concept among relevant stakeholders within the South African construction industry. There is need for an improvement in the level of awareness regarding LC concepts in South Africa as such understanding/awareness has been on the rise in other parts of the world, developing and develop, alike (Raghvan, Kalidindi and Koshy, 2014). In furtherance to this, it was observed that the actual implementation of the lean concept in projects had not taken place in any significant manner in Port Elizabeth, South Africa (Cerveró-Romero, Napolitano, Reyes and Teran, 2013).

4.2 Identifying KPIs

During the interview sessions, the interviewees were asked to identify the key performance indicators / KPIs used for measuring lean implementation performance in construction projects. Since all contractors did not implement lean, they could not identify KPIs for lean construction in their projects and organisation. The contractors had some idea of what the KPIs were but still required a brief explanation about the KPIs being sought for by the interviewer. There was a consensus among the interviewees on the nature of cost, time and quality and health and safety (H&S) as KPIs which they adopt during project implementation for measuring implementation performance. Four contractors mentioned health and safety and the environmental impact as KPIs. These findings correspond with those emanating from studies carried out by Marx (2013); Chan and Ada (2004) and Enshassi et al. (2012). These scholars posit that cost, time and quality are the three basic and most important performance indicators in construction projects, followed by others such as safety and client satisfaction. The study reflects that most of the KPIs in the selected organisations are adopted as a policy matter and not based on benefits or gains. Those practices which are being stipulated under some policy guidelines are being practised whereas those practices which are not specified to be implemented are mostly left to the choice of practitioner. This showed that even though contractors used KPIs, they were not aware of its impact on the performance management system.

5. Conclusion

The adoption of LC practices in the delivery of construction projects has been described severally as a panacea for curbing the imbroglio of project failure across the globe. A plethora of evidence abounds to attest to this notion. South Africa has continued to grapple with the increasing incidences of failed construction projects, signalling the need for a change in the contemporary mode of project delivery in the country. Proponents of LC have continued to advocate for its adoption and integration within the local construction industry, highlighting as it were the immense benefits accruable from the proper application of the concept especially as it pertains to waste elimination, cost reduction, timely delivery and superb quality which conforms to the tenets of sustainable development.

The inability of relevant stakeholders to develop and maintain KPIs for the measurement of LC implementation performance on projects has been identified as a challenge to the holistic adoption of the principle in several construction industries like South Africa. The absence of a widely accepted set of LC based KPIs within the context further exacerbates this imbroglio and thus, has prompted this study. The study sought to identify the KPIs for LC implementation performance which are peculiar to the South African Construction industry context. It relied on the use of relevant publication databases and semi-structured interviews. However, the bid to make a significant contribution to the on-going discourse over the mainstreaming of LC practices into every facet of the construction project was controverted by the low level of awareness among contractors in the study area concerning LC practices. As a result of this, contractors interviewed were not able to distinguish between the conventional KPIs for measuring project performance and KPIs for measuring LC implementation performance. This observation highlights the need for more awareness to be created by stakeholders in bringing about such change.

Summarily, it is expected that findings from this study will contribute to the emerging discourse on KPIs for LC implementation performance in the South African construction industry as well draw attention of government-the major client- to improve the level of awareness pertaining to LC integration.

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DII-2017-032

E-Waste Mining, an Alternative to Traditional Mining in Africa: A Review

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Abstract

Globally, e-waste is the biggest source of waste and has the highest growth rate per annum. Africa is the continent that generates the least amount of e-waste. However, countries like Ghana and Nigeria have become major dumping sites. The objective of this study is to examine the socioeconomic and environmental impact of e-wastes and exploring e-mining as a viable solution to mitigate its negative impact while proposing it also as an alternative to small scale and traditional mining in Africa with a focus on Ghana. A juxtaposition of the socio-economic and environmental impact of small-scale mining in Africa to e-mining benefits are examined. The environmental implications of open air burning of e-waste at the Agbogbloshie e-waste dumping site in Ghana are presented with findings revealing that surface soils and blood and urine samples from workers at the site were contaminated. A thorough review of the different e-mining routes available such as pyrometallurgy, hydrometallurgy and biometallurgywas conducted. The most economical and environmentally friendly routes were hydrometallurgical and bio-metallurgical channels.

Keywords: bio-metallurgy, cyanide, e-mining, e-waste, hydrometallurgy, leaching, pyrometallurgy, recycling

1. Introduction

The "Solving the E-waste Problem" (StEP) Initiative, defines electronic waste (e-waste) as "a term used to cover items of all types of electrical and electronic equipment (EEE) and its part that have been discarded by the owner as waste without intention of re-use" (StEP Initiative, 2013). Globally, e-waste is the biggest source of waste and has the highest growth rate per annum estimated at 3 – 5% (Cucchiella et al., 2015). Blade et al. (2015) reported that in 2014, the global e-waste generated could be estimated at 41.8 million tonnes, however, this value is expected to increase to 50 million tonnes by 2018. The study by Blade et al. indicated that developed nations generated the majority of e-waste. In 2014 e-waste was valued at 48 billion euro. The combined effects of the advancement towards automation, miniaturisation and shorter life span of EEEs has contributed to a higher disposal rate and consequently an increase in e-wastes globally (Blade et al., 2015). The vast varieties of e-waste make its management complex and challenging. On the average, the estimated life span of most electrical and electronic equipment is seven (7) years. Africa only generates 1.9 million tonnes of e-waste, but countries such as Ghana and Nigeria have become major dumping sites (Blade et al., 2015). In Ghana and many West African countries, the informal recycling of e-waste involves four main steps namely dealing, sorting,

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dismantling and burning (Srigboh et al., 2016). This form of recycling significantly impacts the environment and human health negatively (Heacock et al., 2016).

The main aim of this study is to examine the socioeconomic and environmental impact of e-waste and e-mining as a solution while exploring its possible influence on Small scale and traditional mining in Africa with Ghana as the case study. A thorough review of the e-waste management problems in Africa and available technologies and techniques are reported. This study is significant because a case for adopting e-mining is presented as a viable option for dealing with the problem of e-wastes and preservation of natural mining. E-mining can also serve as a new avenue for job creation.

2. E-waste Management and Challenges in Africa

2.1 E-waste generation and imports in Africa

Blade et al. (2015) observed that Africa compared to Asia, the Americas and Europe generated the least quantity of e-waste estimated at 1.9 million tonnes in 2014. However, Africa has become one of the preferred locations for dumping e-waste. A report from the Basel Convention estimates that from 2009 to 2010, 0.1 million tonnes of e-waste was imported into Nigeria and 0.215 million tonnes (Mt) to Ghana (Amoyaw-Osei et al., 2011; Ogungbuyi et al., 2012). Egypt, South Africa, and Nigeria are the leading generators of e-waste on the continent in terms of absolute quantities at 0.37 Mt, 0.35 Mt and 0.22 Mt respectively. The challenges of e-waste dumping in Africa are fuelled and sustained by demand for cheap and second-hand EEEs, low dumping prices and tougher legislation and standards in export nations (Blade et al., 2015). Low purchasing power due feeds the rising demand for less expensive second-hand products. Unfortunately, countries in most African countries. Between 2003 and 2008 the import of second-hand EEEs (laptops, mobile phones, TVs, radio, etc.) into Ghana from Europe and North America rose by a factor of 3 (Amoyaw-Osei et al., 2011). The problem with these imports is that a significant amount of these devices is non-functional and irreparable. In 2010, it was reported that about 30-40% of all imported electronics into Ghana was declared non-functional. But, 50% of the imports were repaired while the other 50% (40,000 tonnes) were designated as e-waste (Amoyaw-Osei et al., 2011. Ghana imported computers worth $23.7 million in 2004; this figure rose to$59.4 million in 2009, a growth rate of 250%. Most of the imported computers were second-hand, but 80% were faulty (Oteng-Ababio, 2010).

2.2 Lack of e-waste management policies in Africa

High-income countries have efficient and effective domestic e-waste recycling capabilities, whereas low and middle-income countries mostly rely on informal and unregulated recycling practices which make countries in Africa fertile grounds for attracting large volumes of e-waste from around the world (Brigden et al., 2008). Fu et al. (2012) reported that in recent times tougher restrictions had been placed on importation and informal recycling of e-wastes in most Asian countries. This implies that e-waste flows previously intended for those nations are channelled to destinations in Africa. Many African countries do not have policies and legislations aimed at controlling and monitoring recycling and disposal of e-wastes. It is reported that Cameroon and Nigeria have made some significant progress in enforcing their national e-waste legislations, while most Eastern and Southern African countries have managed to minimise e-waste dumping by instituting strict measures at preventing such imports (Oteng-Ababio, 2010; Blade et al., 2015). For example, South Africa is the only African country that has a working and operational e-waste recycling system in place while Nigeria and Kenya have introduced measures to limit the importation of used computers by raising duties to 25% (Oteng-Ababio, 2010). Ghana passed its legislation on e-waste in 2016. A combination of lack of proper policy framework for e-waste management, lack of stricter legislation and infrastructure for proper recycling has led to e-waste dumping locations like the Agbogbloshie site which is one of the world's largest and well-known e-waste sites and was ranked among the top ten most toxic threats in the world by Blacksmith Institute and Green Cross Switzerland (Amoyaw-Osei et al., 2011; Bernhardt and Gysi, 2013).

2.3 Environmental and Health Issues Related to E-waste

2.3.1 The impact of e-waste open air burning on surface soil

One of the largest e-waste dump sites in the world is the Agbogbloshie site in Ghana. Tue et al. (2016) conducted a study on surface soil contamination of the Agbogbloshie site with the specific aim of determining the concentration levels of the following DFCs namely; Polychlorinated dibenzo-p-dioxins/dibenzofurans (PCDD/Fs), Polybrominated dibenzo-p-dioxins/dibenzofurans (PBDD/Fs), mixed halogenated (brominated and chlorinated) dibenzo-p-dioxins/dibenzofurans(PXDD/Fs) and dioxin-like polychlorinated biphenyls (DL-PCBs). PCDD/Fs are generated when materials made from chlorinated polymers such as polyvinyl chloride (PVC) coated wires undergo combustion (Duan et al., 2011; Hibbert and Ogunseitan, 2014). While PBDD/Fs are produced when brominated flame retardants (BFRs) undergo thermal or photolytic degradation and when plastics containing BFRs are burnt in the open (Duan et al., 2011). The combustion of materials containing a mixture of chlorine and bromine generates the mixed halogenated (chlorine and bromine) PXDD/Fs (Brigden et al., 2008). Tue et al. (2016) observed the following at the Agbogbloshie site: (1) Sample soils collected from areas where open e-waste burning occurred were reported to be heavily contaminated with chlorinated and brominated DRCs, (2) Concentrations of PCDD/F and PBDD/F in the soil were found to be among the highest levels ever reported at dry weight values of (18–520 ng/g) and (83–3800 ng/g) respectively, (3) PBDFs and PCDFs were found to be the dominant compounds mainly due to combustion of PVC coated wires to recover copper and (4) The concentration levels of PXDFs were observed to be equivalent to those of PCDFs

2.3.2 The impact of e-waste open air burning on human health

Terrestrial and aquatic living systems are potentially at risk of Pollution by polybrominated organic pollutants, dioxins, furans, and polycyclic aromatic hydrocarbons during open air incineration or landfill disposal of e-waste (Akcil et al., 2015). Several studies conducted at Agbogbloshie e-waste site have revealed significant concentrations of toxic elements and compound such as arsenic, copper, lead, mercury, and DRCs in ash, dust, sediment soils and water samples (Brigden et al., 2008; Chama et al., 2014; Itai et al., 2014; Tue et al., 2016).The health implications of human exposure to these elements at the site were studied by Srigboh et al. (2016), where the urine and blood of both male and female workers at the Agbogbloshie site were examined. The conclusions from that study were as follows: (1) The essential elements within the blood and urine were found to be within the biomonitoring reference ranges, (2) Cadmium and lead of workers at the site were higher than populations elsewhere at values of 1.2 mg/L (median) and 6.4 mg/dl (67% above U.S. CDC/NIOSH reference level) respectively and (3) Urinary arsenic levels were found to be 38.3 mg/L which is 39% above U.S. ATSDR value and higher than populations outside Agbogbloshie.

2.3.3 The socio-economic and environmental implications of small-scale mining in Ghana

Many countries in Africa are struggling to deal with environmental challenges associated with artisanal and small-scale mining (SSM) because it offers employment directly or indirectly to both skilled and unskilled labour in mostly rural communities (Aryee et al., 2003; Hilson, 2006; Amankwah et al., 2015). According to the Minerals Commission of Ghana, the number of persons estimated as directly employed within the SSM sector is above 1 million (Bansah et al., 2016). Ntibrey (2016) reported that, in 2014, the SSM sector of Ghana both legal and illegal contributed 1.49 million ounces of gold which represents 34.3% of the total gold produced. SSM is so lucrative that, abuse is causing serious environmental and health problems. Workers are exposed to several dangers including ground failures which have led to many fatalities. Dust and fumes inhalation and high noise levels can cause respiratory related ailments and hearing impairment respectively. Studies by (Aryee et al., 2003; Bonzongo et al., 2003; Bansah and Bekui, 2015) reported on the adverse environmental consequences of SSMs namely; destruction of flora and fauna, land degradation, rechannelling and contamination of water bodies with heavy metals, high total suspended solids and total dissolved solids and increased turbidity. One primary concern is the continued use of the mercury amalgamation method for extraction of gold which is poisonous to humans, contaminates soils, water bodies and wildlife (Bonzongo et al., 2003).

E-mining offers a greener opportunity for absorption and utilisation of persons who may be rendered unemployed as many governments are trying to restrict or entirely ban small-scale mining.

3. Why E-mining?

The demand from the electronic industry on globally mined metals are 50% of tin, 44% of copper, 30% of silver, 14% of the platinum group and 9% of gold (Golev et al., 2016). Many studies have shown a steady decline in ore grade of metals globally, and therefore mining companies are compelled to employ much more expensive state of the art technology to obtain finer deposits of ore grades to meet the demands globally (Van Eygen et al., 2016). Betts (2008) observed that printed circuit boards (PCB) have precious metal concentrations that are ten times more the respective ores. The PCBs from laptops, smartphones, etc. possess the highest amount of valuable materials capable of yielding USD 23,568/ton of revenue constituting 3-6% of generated e-waste and contains over twenty (20) precious metals (eg. aluminium, copper, gold, platinum and silver) (Cucchiella et al., 2015; Golev et al., 2016). In 2014 e-mining yielded 300 tonnes of gold which was 11% of the total global gold production of 2770 tonnes (Blade et al., 2015). The incentive for e-miningis that an estimate of 60 different metals is retrievable from e-wastes (Namias, 2013). A study by Cui and Forssberg (2003) reported that e-waste mining has an energy-saving dimension with findings showing that there is 95% energy savings for Aluminium, 85% for Copper, 74% for Iron, Steel, 65% for lead, and 60% for Zinc. Heacock et al. (2016) reported that while e-miningcan result in lessening the demands for the mining of natural resources, it simultaneously helps in reducing greenhouse emissions. Therefore, the benefits of e-mining are in two folds namely; precious metal retrieval which is essential because of the global shortage of these metals in the electronic industry and the environmental and health benefits (Golev et al., 2016).

3.1 The process of E-mining

E-mining is the recovery of valuable metals from e-waste. The basic approach employed by most recycling companies includes; dismantling, physical separation and then end-processing routes. The end-processing stage includes; hydrometallurgy, pyrometallurgy and bio-metallurgy for recovery of base and precious metals (Blade et al., 2015).

3.1.1 Pyrometallurgy

Pyrometallurgical involves the burning of mechanically crushed waste in a furnace or molten bath as a means of eliminating plastics, flammable and refractory material and metal oxides from the slag phase followed by recovery and purification of metals. Zhou et al. (2010) proposed a modification to the pyrometallurgical process for metal recovery from specifically PCBs where 12 wt.% NaOH was used to recover metal from slag and clean the pyrolysis gas effectively. The metal recovery achieved was 92% Ag, 85% Au and 68% Cu. Pyrometallurgy is the most commonly utilisede-mining method in Industry (Tuncuk, 2012). The limitations of pyrometallurgy are listed in Table 1.

3.1.2 Hydrometallurgy

Hydrometallurgy is a process of recovering metals through chemical leaching. The environmental advantages of hydrometallurgyhave made it attractive and the preferred route. Studies by (Ni et al., 2013; Tue et al., 2013), provide the following reasons for the preference of hydrometallurgy namely; minimal or Gas emission is zero, No or low dust generation, lower energy consumption, The recovery rate is high, and Slag is not generated. Limitations of hydrometallurgy are shown in Table 1. Hydrometallurgy is reported to give the best yields in precious metal recovery and there for the best option for e-mining (Cui and Zhang; 2008).

Table 1: Limitation of pyrometallurgical and hydrometallurgical processes in e-mining

Pyrometallurgy	**Hydrometallurgy**
Plastics in e-waste are used as an energy source instead of coke. Therefore, plastic recovery is not possible	Hydrometallurgy processes are usually slower and time-consuming. The reduction of e-waste mechanically is time-consuming.
Iron and aluminium transform to oxides within the slag making their recoveries very difficult	Reports indicate that 20% of recoverable precious metals is lost during mechanical dismantling.
There are dioxins which are toxic and emitted during smelting of e-waste feed. The effects of these emissions can be minimized by integration of expensive specialised equipment. Pyrometallurgy plants for metal recovery are therefore costly requiring substantial investments.	Cyanide leachants are highly toxic and harmful to the environment and humans and require strict adherence to safety standards. Halide leachants needs oxidising and strong acids (corrosive) conditions for optimum metal recovery which makes implementation of this process difficult. Thiourea leachants are very expensive and have high consumption rate, hence, restricted to only gold extraction. Thiosulfate leachants are not as expensive but have higher consumption than the other leachants, making the process slower.
Ceramics present in e-waste feed can cause loss of precious and base metals because slage volume increases.	
Pyrometallurgy helps only partially to recover precious metals with partial purity. Hydrometallurgical and electrochemical processes are required to recover pure metals.	
The diversity and complexity of e-waste feed make its smelting and refining challenging.	

(Hilson and Monhemius, 2006; Cui and Zhang, 2008; Khaliq et al., 2014)

3.1.3 Leaching

Leaching involves the use of a solvent to obtain a soluble constituent from a solid. Acids and halides are mainly used for leaching of e-waste. Acid leaching is often used to dissolve base metals before leaching of precious metal with cyanide, or other solvents are done. To recover metals, additional processes such as electrorefining, chemical reduction or crystallisation are required. A two (2) stage approach of starting with sulphuric acid leaching in the presence of H2O2 or O2, followed by the extraction of precious metal in cyanide, thiosulfate thiourea, etc. (Quinet et al., 2005; Kamberovic´ et al., 2011).

3.1.4 Cyanide Leaching

Cyanide leaching is often the preferred option to other methods because of the high recovery delivery at a cheaper cost. Recovery of precious metals like gold (Au) and silver (Ag) have been successfully achieved from ores, concentrates and e-waste using cyanide leaching. Obtaining gold from cyanidation is an electrochemical process where an anodic reaction results in gold cyanide formation from the dissolution of gold in an alkaline cyanide solution while the cathodic reaction involves the reduction of oxygen (Akcil et al., 2015). Montero et al. (2012) conducted experimentation on direct cyanide leaching of PCBs and observed 77% of copper dissolving simultaneously with gold and silver but at lower levels of 48% and 52% respectively. Quinet et al., (2005) reported recovering of metals from PCBs using three leaching solutions namely; oxidative sulfuric acid (dissolves copper and part of silver), oxidative chloride (dissolves palladium and copper), and cyanide (dissolves gold, silver and palladium and any copper left). The results revealed that 99% palladium, 95% gold and 93% silver were recovered from the cyanide solution through absorption on activated carbon. The major drawback is the toxic nature of cyanide effluent which when left untreated or reclaimed is harmful to the environment. The above-stated drawback of cyanide use has led to the development of non-cyanide leaching methods where non-toxic lixiviants such as aqua regia, iodine, thiourea and thiosulphate are utilised for valuable metal recovery (Akcil et al., 2015).

3.1.5 Non-Cyanide leaching using Thiosulphate and Thiourea

Thiosulphate leaching is a non-cyanide, nontoxic, environmentally friendly and economical form of leaching (Akcil et al., 2015). This type of leaching must be done in the presence of ammonia to ensure stabilisation of copper and other metals that facilitate the rapid decomposition of thiosulphate (Marsden and House, 2006). Therefore, for the recovery of gold from PCB, a two-stage approach of pre-leaching to remove copper followed by leaching with thiosulphate lixiviant to remove gold is recommended. Ficeriova et al. (2011) used ammonium thiosulphate as leaching lixiviant to recover 98% of gold (Au) and 93% of silver (Ag). Another non-cyanide leachant that has been used to recover gold and silver successfully is thiourea. Leaching is conducted in the presence of an acidic medium and ferric ions for optimal metal recovery. Using thiourea leaching when e-waste of average particle size 154 µm was used resulted in recoveries of 90% (Au) and 50% (Ag) while using PCBs of average particle size 0.84 mm resulted in recoveries of 100% (Au) and 100% (Ag) (Li et al., 2012).

3.1.6 Biometallurgy

Biotechnology is receiving a lot of attention because of the capability of microbes to selectively bind metallic ions at the surface of the cell and uses a protocol that is environmentally prudent and economically sound with regards to operational cost and energy consumption (Cui and Zhang, 2008; Tuncuk et al., 2012).

3.1.7 Bioleaching

Bioleaching is an abiotic or chemical dissolution process where metallic solubilization is carried out by protons as a result of bio-oxidation and leaching. It is primarily used for the recovery of precious metals from e-waste using micro-organisms and products of their metabolism (Brandl et al., 2008). The microorganisms often utilised for bioleaching include; Chemolithoautotrophs bacteria (e.g., Acidithiobacillus ferrooxidans and Acidithiobacillus thiooxidans), Thermophiles (e.g., Sulfobacillus thermosulfidooxidans and Bacillus stearothermophilus and Metallosphera sedula), and heterotrophic fungi (e.g., Aspergillus niger and Penicillium Simplicissimum and Cyanobacterium violaceum) (Brandl et al., 2008; Ilyas et al., 2010; Pradhan and Kumar, 2012). Pradhan and Kumar (2012) recovered metals from e-waste using both single (Chromobacterium violaceum) and mixed cultures (Chromobacterium violaceum and Pseudomonas aeruginosa) of cyanogenic bacterial strains for bioleaching. Results revealed recoveries of Cu (79%), Au (69%), Zn (46%), Fe (9%) and Ag (7%) when single cultures of Chromobacterium violaceum was used while a higher yield of Cu (83%), Au (73%), Zn (49%), Fe (13%), and Ag (8%) were observed when mixed cultures was used. The diverse and complex nature of e-waste provides conditions that facilitate the growth media of the microorganisms which can initiate secondary reactions that can negatively influence (poor metal yields and slow leaching rates) the solubilization of metals through absorption of metal, passivation and precipitation (Sasaki, 2011).

4. Discussion

E-mining has excellent benefits, however, only 20% of the gold that is recyclable from e-waste is retrieved as most of the metal is lost to inefficiencies within each step of the recycling process. The most losses occur during the collection, dismantling and pre-processing steps. The weakest link within the e-mining process is the collection stage which can be organised efficiently by governmental agencies to minimise gold-bearing fraction losses (Akcil et al., 2015). The principal economic motivation for e-mining is the recovery of precious metals like gold, hence innovative methods that seek to minimise loss of these metals are a necessity.

Informal recycling which involves open burning introduces heavy metals, plastics, toxic compounds and gases into the soil which is harmful to the environment, water bodies, animals and humans. The high toxic levels in the soil at Agbogbloshie brings to fore the need for urgent adoption of measures in the form of enforcement and implementation of e-waste legislation and policies by the mandated state institutions and the introduction of tax incentives for investors within the recycling industry. A long-term e-waste management framework and infrastructure that ensures sustainability and establishes a holistic recycling system to eliminate or minimise open burning and landfill disposal is recommended.

E-mining has the potential of leading the crusade for reducing the exploitation of finite metal resources through traditional mining and hence ensuring the conservation of primary metal resources. E-mining or Urban mining will reduce the amount of waste generated from mining and processing of ores while minimising existing volumes and newly imported e-waste. It is economically rewarding because, for every selected volume, precious metals, ferrous and non-ferrous metals can be recovered which is different from traditional mining which is metal specific. The devastation to forests and lands due to mining activities will be minimised while pollution caused by e-waste to the environment from heavy metals, plastics and toxic solvents and gases released during landfilling or open air incineration will be minimised.

5. Conclusion

The non-biodegradable and environmentally harmful characteristic of landfill disposal and informal recycling of e-waste presents a unique opportunity for the development of innovative and economically efficient processes to deal with this problem. The approach recommended in this study is e-mining which does not only solve the environmental issues but provides a greener alternative for mining investors. The financial and environmental motivations for e-mining are presented in this review. The techniques for metal recovery from e-wastes were Pyrometallurgical and hydrometallurgical and biometallurgical routes. The effects of weak or non-existent e-waste management policies, legislation and infrastructure in many African countries is contributing to e-waste dumping sites like the Agbogbloshie site. The potential effects of improper recycling and disposal techniques can result in e-wastes introducing toxic substances like dioxins into the soil, atmosphere and water bodies which are detrimental to plants, wildlife and humans

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DII-2017-045

Lightning Protection and Local Earthing Systems of Weighbridges Infrastructure: A Case Study of Kafue Weighbridge

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Abstract

This paper discusses the causes of increased failure rate of modern instrumentation due to lightning effects on various weighbridges of road network infrastructure in Zambia, and describes steps taken by the Department of Electrical and Electronics Engineering of the University of Zambia (UNZA), in particular for the Kafue Weighbridge, to address this problem. The increased failure rate is aggravated by high transistor integration of semiconductor ICs, when this miniaturised low power equipment fabricated from these new technologies is installed and operated in overly electrically disturbed environment without appropriate power conditioning, lightning and surge protection. In Zambia, lightning effects cause most such damages especially during the rainy season. Preliminary investigations and studies carried out on the Road Development Agency (RDA) road network weigh bridges instrumentation installations of Kazungula, Livingstone, and Kapirimposhi revealed a total lack of proper lightning and surge equipment protection. Utilising the findings of study, the department designed and installed local earthing and lightning protection systems (LPS), guided by appropriate installation standards, as a first measure of protection at the new Kafue Weighbridge which is located about fifty kilometres (50) from Lusaka. A peculiar noteworthy aspect of importance of this LPS, that resulted in very low earth resistance value, was the bonding of the bonded local and lightning earth termination system to the nearby massive buried metallic weighbridge platform foundation. Low earth resistance value is a significant requirement for lightning, surge protection and electrical installations in general.

Keywords: effective earthing, instrumentation, lightning protection system, road weigh bridge

1. Introduction

Lightning induced damage of modern equipment has worldwide been increasing steadily in the past thirty years (DEHN+SOHNE, 2016). The adverse effect being due to reduced transistor dielectric strength as a result of high transistor integration of electronic semiconductor circuitry (ICs). The high capacity and fast miniaturised equipment fabricated from these technologies that require low power to

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operate are easier to damage when installed in overly disturbed electrical environment (FIPS 1993). Advances in material semiconductor technology has been able to integrate over a billion transistors in a single IC package, that is interconnected by thousands of wires which can fit in the width of a human hair (DMT Channel 2016).

Weigh- bridge operations in Zambia are heavily dependent on such measurement equipment, computers and other Information and Communications Technology (ICT) instrumentation that include switches, servers, telephone and security systems. The RDA weigh-bridge ICT system is networked in such a way that instrumentation is in constant communications with the headquarters and with each other. In recent years, equipment damage on these weighbridges has been increasing especially during the rainy season as a result of lightning effects. This problem has resulted in costly repairs, equipment replacement and especially prolonged operational downtime.

Studies conducted at Kazungula, Livingstone and Kapirimposhi weighbridges in Zambia revealed lack of proper installation and inadequate equipment lightning and surge protection.

To resolve this problem, elaborate schemes of power conditioning earthing and lightning protection, taking in account applicable international installation standards at all points need be carefully implemented (DEHN+SOHNE, 2016). For the new Kafue Weighbridge, LPS systems for the two houses were designed and installed after taking in account the resistivity measurements, risk factors and lightning density of the site.

Given the fact that the other terminal of a direct lightning strike is the earth, it is a requirement that earth termination system of a robust LPS must be as low as possible. To obtain low resistance values, the area of contact of the LPS earth termination with the earth must be big, and of good soil conductivity. As the buried weighbridge metal platform makes contact with the soil over a large area, it was perceived that bonding of the installed earth termination systems of the local, utility neutral and the LPS to the nearby weighing platform metal would result in low earthing resistance. When this was implemented, a very low earthing resistance was achieved, an important requirement for a robust and effective LPS.

2. Methodology

2.1 RDA mandate in Zambia

The RDA is a statutory body mandated to coordinate national road construction development programs and maintenance of the road infrastructure in Zambia and interspaced at different strategic points along the major highways are weighbridges designed to weigh, and regulate local and international heavy duty vehicles. The weighbridges in particular fall under the Axle Load Control Unit (ALCU) of the RDA, charged with the responsibility of minimising the negative impact of overloading on the road network and bridges. Road network being critically important to economic development of any country, especially to a land linked country like Zambia which is bordered by eight countries, all of them requiring to transit through it, properly regulated usage of roads and bridges translates directly in road maintenance savings that would be channelled to other governmental sectors like health and education (Kapasa et al., 2016).

2.2 Equipment failure on RDA weighbridges

Table 1 is a list of recorded equipment failure on the RDA weigh bridge infrastructure, in the period from 2011 to 2013.The damages occurred over a wide area ranging from Solwezi in the North-Western province, Livingstone and Kazungula in the Southern Province and Mpika in the Northern Province. The affected equipment were mainly ICT hardware comprising computers, routers, switches, servers, traffic lights and display boards. (Kapasa, et al., 2016).

The list of affected equipment all fall in the category of modern equipment fabricated from highly integrated semiconductor ICs and in all cases cause of damage was attributed to lightning effects (Table 1). Applied interventions by RDA indicate replacement of all damaged equipment in addition to LPS system installation to avert further damage.

Table 1: List of faults at various RDA weighbridge sites due to lightning effects

Weighbridge Station	Date	Damaged Equipment	Possible cause	Intervention
Solwezi	12/12/2012	JagXtreme indicator, Router, Ethernet switch, Server, two computers, four traffic lights and two display boards	Lightning	All parts were replaced and lightning protection was installed
Kazungula	01/11/2013	JagXtreme, two traffic lights, one display and two computers	Lightning	All parts were replaced and lightning protection was installed
Livingstone	01/02/2012	JagXtreme, four traffic lights, two displays, Router, ethernet switch and two computers	Lightning	All parts were replaced and lightning protection was installed
Mpika	01/12/2011	JagXtreme, four traffic lights, two displays and two computers	Lightning	All parts were replaced and lightning protection was installed

Source: (Kapasa et al., 2016)

2.3 Effects of advances in semiconductor technology

Enumeration of the obvious observed and measurable causes of equipment failure is done, as a narrative to provide background of the effects advances in semiconductor technology has on equipment response to powerline disturbances from various sources in general. Prior to the era of automation, control and ICT applications, weigh bridge operations were mainly performed by electro-mechanical systems and then, damages were rare, hardware being mainly electro mechanical with high dielectric strength. Transistors used in electromechanical systems were then discrete, making this kind of equipment more resilient to powerline disturbance that would damage modern electronic systems. Vulnerability of modern equipment to poor power quality caused by advances in semiconductor technologies that have managed to pack over a billion transistors in a single IC with thousands of interconnections that fit in the width of human hair has been documented. Assemblies of small but complex networked equipment are the result. Lack of understanding of this in many African developing countries has led to inadequate equipment protection and resultant increased equipment damages, costly equipment replacement and prolonged downtime.

2.4 What are power line disturbances?

Variations of voltage from the nominal value that exceed the minimum or maximum rated values on supply power lines are power line disturbances. Similar disturbances can also occur on lines that carry information to equipment like networked computers, transducer sensors (load cell as applied to RDA weighbridge instrumentation) and antenna cables. Figure1 shows some of powerline disturbances on a phase line from nominal voltage.

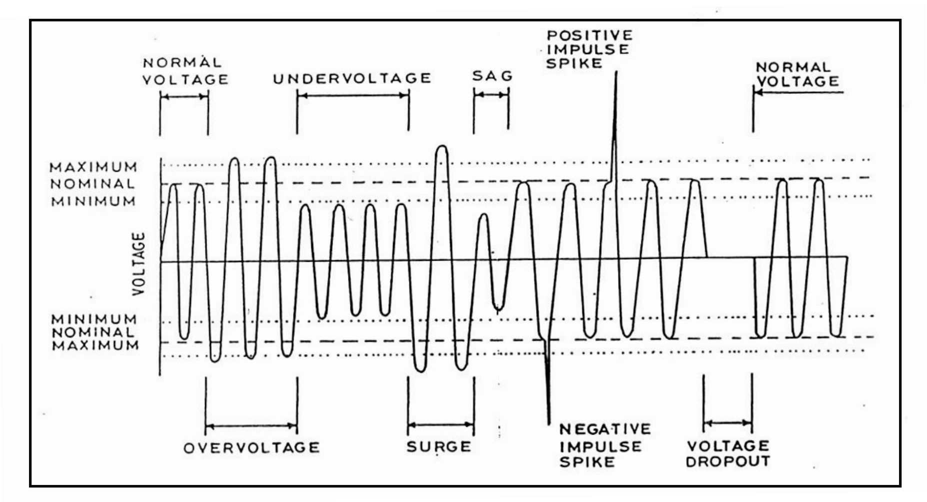

Figure 1: An example of "powerline disturbance" on a power line (IAEA/AL/091, 1991)

2.5 Generation of powerline disturbances

Load switching activities; electrostatic discharges; and lightning effects are main causes of disturbances that directly or indirectly interact with electrical grid networks and information-bearing lines (ICTs). Components that form electrical systems are connected by transmission conductors that have distributed resistance, capacitance and inductance. The system network response to different types of excitation (disturbances), as alluded to above, may generate different other forms of disturbance that permeate the grid. While switching activity is confined to the power source and load interaction, electrostatic discharge and lightning effects are externally injected into the system.

Sudden changes in voltage and currents of utility conductors give rise to current and voltage spikes that can be damaging to modern equipment. The explanation of generated damaging voltage and current spikes are derived from the capacitive and inductive current and voltage relationships of , $\boldsymbol{V_l = L\,di/dt}$and $\boldsymbol{i_c = C\,dv/dt}$with stored energies given by $\boldsymbol{0.5L} \times \boldsymbol{I^2}$ and $\boldsymbol{0.5C} \times \boldsymbol{U^2}$. When released into interconnected resistive based equipment load, this extra energy can result in the destruction of the hardware (Schimanski, 1991)

2.6 What is lightning protection system?

Schemes employed to intercept direct lightning strike and convey the current to earth in an orderly way without affecting contents and persons in the building is Lightning Protection System (LPS). Figure 2 is a schematic diagram of an LPS comprising air termination, down conductor and earth termination.

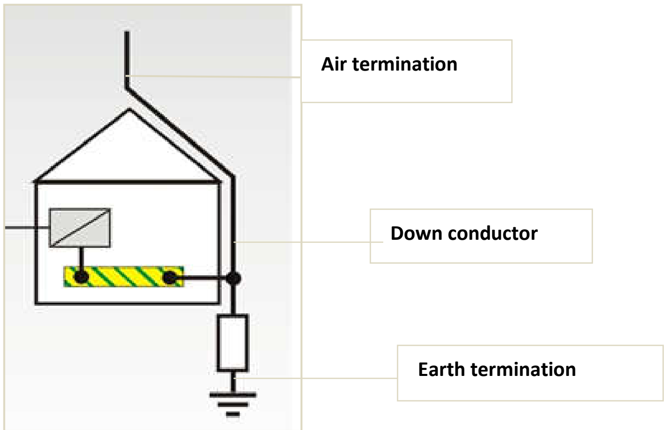

Figure 2: Lightning protection system illustration

2.7 Lightning induced damages

Direct and indirect lightning effects damage civil structures and instrumentation. Instrumentation damage in particular occurs when over current and voltage are induced in equipment connected cables, and coupling lightning current to conductors by capacitive, inductive or galvanic means. Capacitive and inductive coupling is by electrostatic and magnetic coupling while galvanic is by current conduction.

3. Equipment and Methods

Surveys and investigations were carried out at Kazungula, Livingstone and Kapirimposhi weighbridges where power and data wiring, earthing and protection schemes were studied and evaluated. The survey included discussions with relevant personnel. Kazungula weighbridge was found to have no LPS installed while the Livingstone and Kapirimposhi weigh bridge LPS were both not correctly installed.

3.1 LPS installation at New Kafue Weighbridge

For the new Kafue Weigh Bridge, the following procedure was carried out in the installation of the LPS.

- Soil resistivity measurements, utilising Metrel earth measurement meter were obtained using four-point soil resistivity measurement method. For both the weighing and the certification houses. Figure 3, shows the four point Werner method. The bridge is used with four equidistance electrodes.

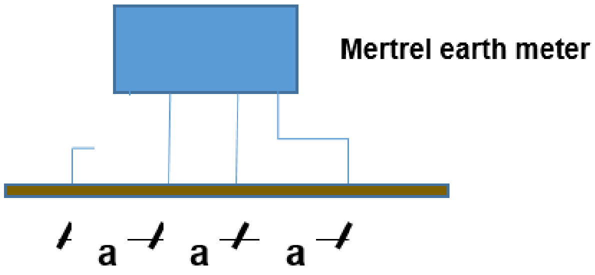

Figure 3: Measurement of soil resistivity, Werner method

- Earthing system arrangement chosen for both LPS earth termination and local earthing systems for both houses was earth mat type. Earth mat method was chosen as it offered large contact area with the soil for lower earthing resistance.
- Fabricated earth mats of about 80cm by 60cm were placed in the trenches of about $1m^2$ by 1.5m depth.
- A single flat copper cable served, as the earth connecting cable, down conductor and air termination up to spike on roof top. The roof was perforated to run the conductor flash on the wall without making sharp bends.
- The local earth mat placed in its own trench about ten meters from the LPS earth termination mat were bonded by together by a 70mm multicore copper cable.
- Both earthing systems were in turn bonded to two weighing metallic platform structures. Dimensions of the platforms being 5m by 5m for the abnormal load scale and 25m by 4m for the normal load scale. The buried metallic foundation structures could not be assessed.
- Installation of the lightning and earthing systems at the certification house, located about 300m from the weighing house, was as described above except for platform bonding.
- Final bonding of earthing systems of the two separate civil structures was done through the armour shield of the power cable that supplied power to both houses.

Figures 4 and 5 below are schematics of the LPS installation arrangement at the weighbridge and certification houses respectively. Please note the clear bonding between the LPS earth and local termination to the weighing platform which insures low earth resistance in Figure 4 and the bonding between LPS and local earthing utilising an extra earthing spike in Figure 5.

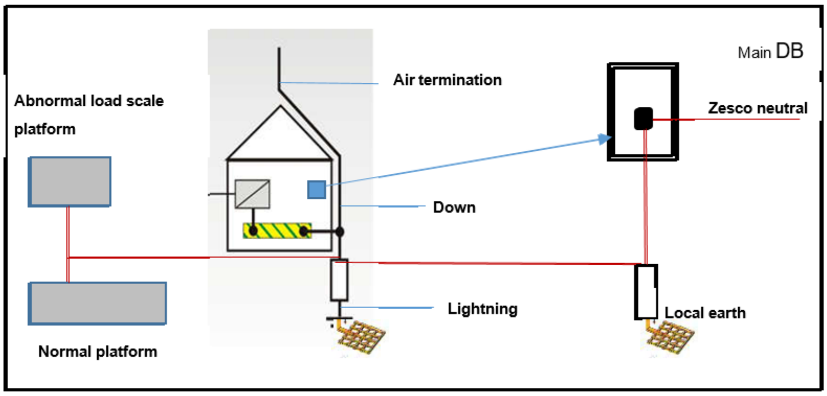

Figure 4: Illustration of the correct LPS arrangement for weighing civil structure at the new Kafue facility

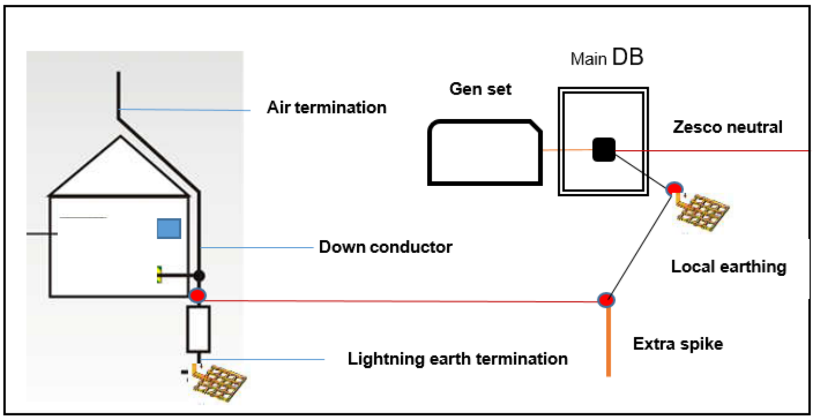

Figure 5: Illustration of the correct LPS arrangement for certification civil structure.

4. Results

Table 2 shows measured soils resistivity at the earth mat locations for the two houses. The soil resistivity of the weighing house was lower than that of the certification house situated about 300m away. Table 3 shows the measured earthing resistance of both the weighing and certification houses. Table 4 shows the calculated earthing resistances of the bonded earth mats before connection to the weigh bridge platform, using equation1. Finally using the calculated earthing resistances of the earth mats, utilizing the principle of resistors in parallel, the unknown platform resistance was estimated as stated in the last line.

$$R = \frac{\rho}{4}\sqrt{\frac{\pi}{A}} \qquad \textbf{(1),}$$

Where R is the earthing of earth resistance in ohms
ρ is effective soil resistivity in ohm meters
L is total length of the buried electrode conductor and
A is total area of the buried mesh conductor

Table2. Soil resistivity measurements at the weighing and certification houses in ohm-meter Ω.m

Civil structure / Direction	Weigh house Ω.m	Certification house Ω.m
East	21.2	44
West	24.0	34.5
North	-	-
South	-	42

Table 3: Total measured earthing resistance, ohms Ω

Structure	Measured earthing resistance Ω
Weigh house	0.17
Certification house	0.63

Table 4: Calculated earthing resistances using equation 1 and measured soil resistivity ρ - Ω

Civil structure / Earth mat	Weigh house Ω.	Certification house Ω.
R_l local earthing	14.4	25.7

Calculated earthing resistance of the buried weighing ($R_{w.}$) platform metal structure using resistance in parallel, as was estimated to be $R_w = 0.17\Omega$ at the weigh bridge.

5. Discussion

Protection of modern equipment from power quality related problems require correct installation of surge protection, power conditioning and lightning protection, and overall good wiring, earthing and power source to load matching. For the New Kafue weigh bridge installed LPS, the calculated earthing resistance for the fabricated earth mats were 14.4 ohms and 25.7 ohms for the weighing and certification houses respectively, values considered to be high for LPS.

For the Weigh house, situated close to the two weighing platforms, with buried metallic foundation, bonding of the LPS earth termination to the platforms gave a low measured earthing resistance of 0.17 ohms compared to the calculated earth mat value of 14.4 ohms. This is considered to be a good value and a requirement of an effective and robust LPS. Equation 1, which states that the earthing resistance of an earth mat is inversely proportional to the square root of surface contact area of the mat is supported. The certification house situated about three hundred meters from the weigh house was bonded to the low platform earthing by the utility power cable amour shielding on the meter box at the main DB. This achieved LPS earthing resistance of 0.63 ohms, compared to 25.7ohms calculated value.

With regard to the certification house however, the bonding to remote platform will not work well when the LPS at this house takes a direct lightning strike. The three-hundred-meter power cable will present appreciable inductive reactance impedance (**ωι**) that will be seen by a high frequency lightning signal. As a result, most of the current will flow in the local and LPS earthing systems. This results in high potential rise at these points. To get around this problem, local earth mats contact area should be increased in addition to installing earth ring around the civil structure to equalise the potential differences and distribute the currents to various ring spikes.

Comprehensive protection scheme for weighbridges, like the new Kafue Weighbridge, should include surge protection for both data and power lines and power conditioning. However, from this work, it has been found that LPS can take advantage of the presence of the massive metallic weighing platform to create low resistance earthing systems at all weighbridges.

6. Conclusion

As modern equipment continues to be vulnerable to damage caused by poor power quality and lightning effects, protection that includes lightning, surge protection and power conditioning should be installed on all RDA weighbridge instrumentation.

This paper has presented the design and installation of a lightning protection system as a first measure in the protection of modern equipment installed at the new Kafue Weighbridge. Bonding of the local earthing and LPS earth mats to the nearby weighing platform produced a low earthing resistance of 0.17 ohms and 0.63 ohms for weigh and certifications houses respectively. With the availability of weighbridge metallic infrastructure on all RDA weighbridges, effective and robust LPS systems can be implemented that will result in protected equipment and reduced downtime of RDA weighbridges and indeed other weighbridges elsewhere.

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Integrated Infrastructure Investment, Procurement and Finance

DII-2017-016

Leveraging Land Based Resources and Instruments for financing Urban Infrastructure Development: A Case of Kitwe City, Zambia

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Abstract

Zambian towns are characterized by critical shortages of essential urban infrastructure resulting in degraded physical environment, inadequate shelter, unhygienic living conditions, informality and poor quality of life. This paper argues that although various methods of mobilising finance for infrastructure delivery have been tried the gap is growing. The paper argues that a relatively neglected approach for raising infrastructure finance is that of using land based financing instruments and tools. The study aimed to investigate how municipalities in Zambia leverage land based resources to raise infrastructure finance. Specifically, the study aimed to assess how municipalities applied land leases to deliver infrastructure. Using the City of Kitwe as a case, the study investigated how the municipality applied the land lease to redevelop part of the Freedom Park and Kitwe Zoo. Data was collected mainly from secondary sources including relevant Council and Parliamentary Reports and other literature. Interviews were conducted with planners, municipal and other urban experts. The findings revealed inadequate capacity and technical and administrative inability of the Council to apply the land leases to redevelop Freedom Park and Kitwe Zoo. The study concluded that the Council should have signed legally binding contracts instead of MoUs; that a Special Purpose Vehicle should have been established and that capacity building should have been prioritized. The study recommended a review of all land leases and agreements with private developers and assessment of the potential of applying other land based financing instruments be assessed to ensure a win-win situation for all. There is need to take into account all legal requirements, cultural context, condition of land markets and the administrative and technical capabilities of municipalities.

Keywords: infrastructure, land-based financing, land leases, urban

1. Introduction

Today over half of the world's population lives in urban areas and by 2050, this figure is expected to increase to two-thirds. Asia and Africa are urbanizing faster than other regions and will contribute a significant share of the additional 2.5 billion people that will live in urban areas by 2050 (United Nations, 2014). African cities experience huge urban infrastructure deficits which result in large urban

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areas without access to basic services. It is estimated that over 200 million or 62% of people in Sub Saharan Africa live in slums without adequate services and infrastructure urbanization rates result in the continuing growth of poorly serviced areas. Zambia, with over 15 million inhabitants of whom 6.1 million or 40.5 percent live in urban areas and an urban growth rate of 4.3 percent is experiencing critical shortages of urban infrastructure such as roads, water supply, sanitation systems, solid waste management, drainages and electricity (CSO, 2015).

In Zambia the infrastructure deficit is manifested in severely degraded and unsightly physical environment, acute deficiencies of basic services, housing, unhygienic living and working conditions, pervasive and ubiquitous informality which translates in poor quality of life for the majority urban residents. In some emerging towns urban infrastructure and social services are virtually none existent. Unless major collective efforts to substantially increase the supply of urban infrastructure are made, the shortages will persist and even intensify in the long term. Conventional methods such as pricing of infrastructure (Toll Gates, fuel levy etc.), private sector investments, money borrowed from capital markets, grants, loans, and advances or contributions from bilateral and multilateral agencies, pensions and insurance funds, corporations and non-governmental organisations have all been applied by state and local governments but with minimal impact due to the sheer scale of the need.

Non-conventional methods like urban land taxation, conservation of developed urban land, land banking, land readjustment and pooling, PPPs in land development, Town Planning Schemes, and real estate development, fees and service charges and other land based financing (LBF) instruments have also been tried but some not the expected levels. Both conventional and non-conventional methods have their merits and demerits which should be carefully weighed before application to a specific municipal locality. This study postulates that one of the relatively neglected approaches for raising financing is the use of land based resources. Land is a readily available resource which if optimally planned, allocated and used could help municipalities generate significant revenues for infrastructure delivery. that the lack of innovation on the part of state and local governments to leverage LBF instruments to fill the infrastructure financing gap is a major constraint to sustainable urban infrastructure delivery. Other constraints such as administrative ability and weak governance arrangements only exacerbate the problem. Due to the pros and cons of adapting LBF instruments to the local context, factors such as solid legal foundation, the history and cultural norms associated with land, the condition of land markets and the administrative capabilities of implementing agencies must be considered.

2. Methodology and Research Design

A mixed method approach involving a case study, qualitative and quantitative analysis were used in the study. Specifically, the City of Kitwe was used as a case to investigate how municipalities leverage land based resources to raise infrastructure finance. The study assessed how the Council applied “land leases” to develop the Freedom Park and Kitwe Zoo. According to (Yin, 1994:1), the case method is an important strategy when responding to the ‘how’ and ‘when’ questions, when there is little control over events and when the focus of the research is on contemporary phenomenon within some real-life context. It permits “an investigation to retain the holistic and meaningful characteristics of real life events” such as changes in the social, political and economic aspects of communities, an individual life cycle, organisational and managerial processes (Yin, 2004:3). The method allowed data collection which provided creative opportunities by going beyond the conventional approach (Creative Consulting and Development Works, 2010). Qualitative research assumes a holistic perspective by providing a contextual understanding of the complex interrelationships between causes and effects that affect human behavior, allowing the use of interviews and observations (Goetz and Le Compte, 1984). Secondary data was collected from Council and Parliamentary reports and other literature while primary data was collected by interviewing various experts and stakeholders. A total of 50 respondents were planned to participate in the study. A comprehensive literature review of Land Based Financing instruments, cases and best practices was conducted.

3. Literature Review

Cities in developing countries are urbanizing rapidly at the rate of over 4 percent annual resulting in huge demand and deficits in urban infrastructure. Land can be used as a basis for generating revenue to provide infrastructure and urban services. When land is used in this way the process is called "Land Based Finance" (LBF), a collective name given to a range of instruments by which local governments expand their revenue base and generate funds that will help them realize their service delivery, infrastructure development and maintenance goals (UN Habitat, 2016). The broader contexts within which the LBF tool is being developed are local governance and sustainable urbanization. Muwonge and Ebel (2014) observe that two forces that shape the world of development policy are globalization and localization or decentralization. The responsibility for land-based revenues and fees should be assigned to local governments, including granting some degree of autonomy in setting tax rates (ibid, 2014). The process involves both valuing land and collecting fees, which can be divided among different levels of subnational governments (Bahl and Cyan, 2011b). Local government is often in a superior position to administer local revenue collection, especially taxes and fees tied to land (McCluskey and Bell, 2008).

The LBF tool is premised on the fact that urban land is a key factor of production and an important source of financing for urban development, including infrastructure, social housing and basic services (Walters, 2016). The preference of land based financing over the conventional methods is that LBF provides a flexible and adaptable set of instruments with revenue generating potential which is often have better economic, spatial and social impacts than other tools (Walters 2016). Land-based financing has the merit that it draws private finance into the funding of urban infrastructure, in contrast to the conventional approach (Graham, 2016). It also provides for a greater role of the private sector in building this infrastructure. Nevertheless, for land-based financing to be effective it does require a capable city backed by a capable state. There needs to be a sound plan for infrastructure in the city, appropriate engineering standards, sound land use management procedures and the ability to engage with developers to set up agreements regarding the scope, standards and timing of the infrastructure provision and any payment requirements. These requirements vary based on the type of land-based financing required, with the emphasis on technical factors in the case of 'in kind' contributions – as the developer is building infrastructure which needs to be integrated into city-wide infrastructure systems - and financing arrangements in the case of land leasing and development charges.

Land Based Finance instruments can be defined and classified based on relevance for common policy goals, minimum requirements for using each instrument. The major instruments include the recurring tax on land and, often, immovable structures on the land, betterment charges and special assessments, Developer Exactions and Land Value Increment Taxes, Sale of Development Right, Land leases and land sales and Transfer taxes and stamp duties (Walters, 2016). Conceptually land leases and landsales are instruments often used by governments who own either all or substantial sections of land. When a government makes the determination to mobilize revenue using these land assets, they frequently consider either selling the land or leasing it. The sale of public lands converts one type of public asset (land) into another (cash) through the sale of the land to the private sector. This requires that the government must have land that it considers to be no longer needed for public purposes. This is an important judgment with very long-term consequences. Caution in reaching such a judgment is required. There must be a market for the land while the land should be sold through a transparent process, such as an auction, in order to ensure that full market value is obtained. If it is desirable for policy reasons to discount the land below full market value, the discounting should be transparent and fair. Care should be taken that all proceeds from the sale are appropriately accounted for. This is a straightforward technique to generate one-time revenue for high-priority, long-term projects, but it should be used with great caution and only with full transparency and public consultation.

Leasing publicly owned land through multi-year leasing agreements for either annual or one-time revenues, or both, creates a leasehold interest that allows private entities to develop the land and potentially sell the lease in a secondary market. The government entity must have available land and it must have the administrative capacity to administer and regulate a leasehold system. To develop a leasehold system, a government must identify public land appropriate for leasing and unlocking value, develop a specialized institution to manage a leasehold system, earmark revenues for specific purposes, and develop a compensation policy for current tenants of public land. Governments without a strong administrative ability to manage such a system have not found success in generating meaningful revenue. Additionally, the more control the government relinquishes in leasehold agreements typically results in the prospect of more revenue. The most successful systems, in terms of revenue generation, are those that are modeled closely on freehold systems.

A key assumption for LBF instruments is that the value of land is socially determined and can be influenced by public actions (Walter, 2016). Just as value is socially determined, land markets are socially constructed and require certain conditions to exist and thrive. If the land-based financing instrument under consideration requires a reasonably well-functioning land market, actions might be needed to strengthen the land market. Determining the best way forward in adopting, adapting and implementing a land-based finance instrument requires careful consideration of the level of administrative resources required and where those resources are located within the government. If the administrative resources do not currently exist, they must either be developed or acquired if the overall effort is to be successful. Graham (2016) argues only 20 percent of municipal revenues can be raised from such sources and hence the need to try and test other LBF instruments such as betterment levies, developer exactions, land banking, land pooling and re-adjustment, PPPs for land development, and town planning schemes.

A number of cases of land-based financing in developing countries were reviewed. In Cairo, Arab Republic of Egypt an auction of desert land for New Cities was conducted in May 2007 involving 2,100 hectares and which raised $3.12 billion to be used to reimburse costs of internal infrastructure and build a highway connecting to Cairo Ring Road. Another project involved the private installation of "public" infrastructure in return for developable land which started in 2005 and mobilized $1.45 billion of private infrastructure investment plus 7% of serviced land which was turned over to government for moderate-income housing. In Mumbai, India, an auction of a financial center land (13 hectares) was done in January 2006, Nov. 2007 by Mumbai Metropolitan Regional Development Authority (MMRDA) which raised $1.2 billion, to be used primarily to finance projects in Mumbai's metropolitan transportation plan.

In Bangalore, India, a planned sale of excess land to finance access highway to a new airport to be built under public-private partnership was expected to raise $500+ million. The land will, however, be used for ministry buildings and government-built industrial space (Petersen, 2008). In April 2007 in Istanbul, Turkey, a sale of an old municipal bus station and former administrative site raised $1.5 billion in auction proceeds to be dedicated to capital investment budgets while in 2006 in Cape Town, South Africa a sale of Victoria and Albert Waterfront property by Transnet, the national transportation authority raised $1.0 billion, to be used to recapitalize Transnet and support nationwide investment in core transport infrastructure. In Bogotá, Colombia, a betterment levy resulted in the collection of $1.0 billion between 1997 and 2007 while $1.1 billion was planned for 2008 and 2015 for financing a city street and bridge improvement program (ibid, 2008). The cases reviewed clearly indicate how local and state governments can leverage land based resources to raise infrastructure finance.

4. Case Study: Freedom Park and Kitwe Zoo Developments, City of Kitwe

The City of Kitwe is the second largest urban centre in Zambia lying at an altitude of over 1295m in the central part of the Copperbelt. Kitwe with an area of 777 square kilometres and a population of 700,000 inhabitants (CSO, 2010) is the economic hub and largest industrial centre of the Copperbelt boasting mining and service- oriented industries. Figure 1 below illustrates the location map for Kitwe. About 139,902 ha is gazetted as State Land which may be leased out for a fixed period of 99 years. About 18, 330 ha of land in the city is leasehold property. Leasehold land is concentrated along the Banks of the Kafue and Mwambashi rivers where it is used mainly for farming and grazing.

Kitwe City Council was established by the Local Government Act, Cap 281 of Laws of Zambia with the main objective of providing public services such as refuse collection, road maintenance, policing, street lighting, cleaning services, social and health services (KCC, 2016). Freedom Park, Stand No 7732 and so named for its former and current use for political events is located in Parklands in the Centre of the City along Kitwe Stream while the Kitwe Zoo, Stand No. 6936, is a natural extension of Freedom Park. Combined the two stands take up a large portion of prime urban land in Kitwe as shown in Figure 2.

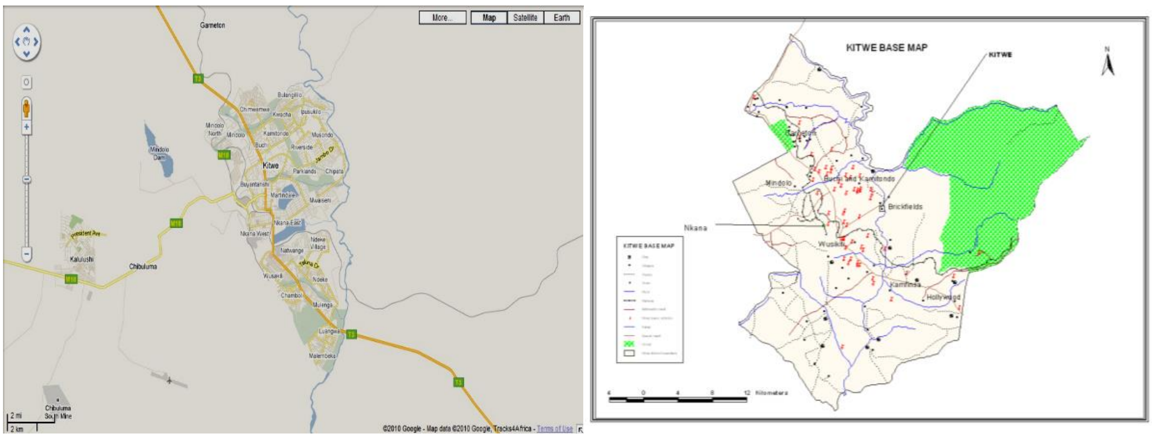

Figure 1: Location and Base Map of Kitwe

Kitwe City like most Zambian cities has experienced a spike in conversions of and encroachment on prime urban land. Areas most affected include those zoned for open spaces, parks and recreation. One reason cited for conversions is poor maintenance and falling standards of these facilities which has motivated both local and foreign businesses force the Council to convert all or parts of these facilities for commercial and other uses. While this may be deemed a natural process of urban development, the conversion of open spaces, parks and recreation areas has translated into loss of public amenities and is against sound urban planning principles. The sprawling Freedom Park and adjacent Kitwe Zoo have not been spared in this gentrification process.

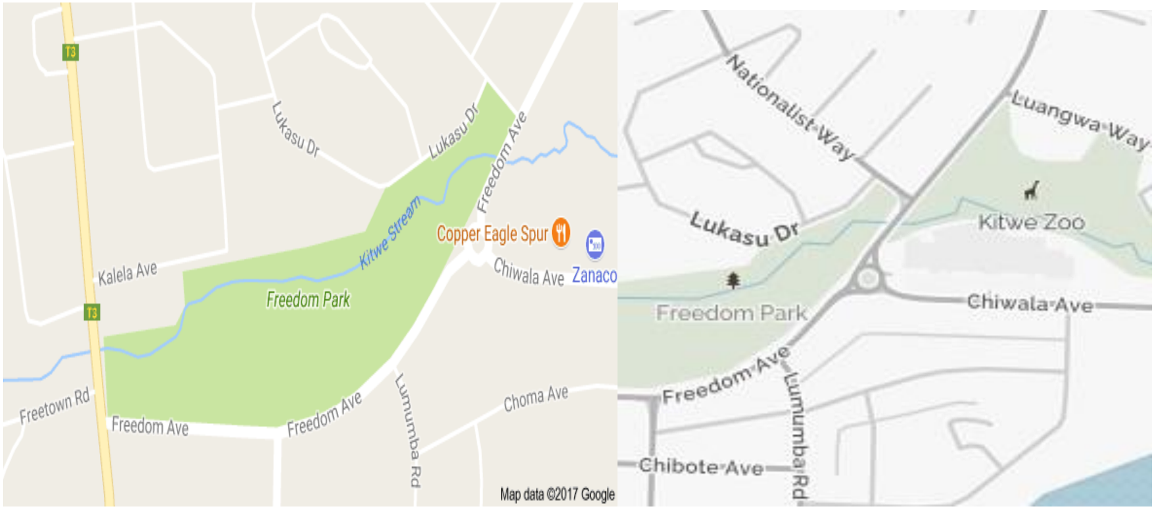

Figure 2: Location of Freedom Park and the former Kitwe Zoo

Bowing to pressure from developers and in its quest to bring world class developments to the City, Kitwe City Council entered into agreements with two named developers for the commercial development of Freedom Park and the Kitwe Zoo. In October 2001, the Council entered into a memorandum of understanding (MoU) for the redevelopment of Kitwe Zoo Stand No 6936 into a modern housing complex for a reported minimum value of US$2,000,000. According to the MoU, the developer was to reimburse the Council a reported sum of US$12,000, the value of existing developments on the said piece of land as well as pay the Council a non- refundable commitment fee of US$10,000. The MoU was valid for a period of twelve months starting from 15th October 2001 to 15th October 2002. The developer was further requested not to reassign, sublet or part with (resale) the land or in any other way surrender control of the land and the project without permission of the Council.

In February 2007 a second land lease was granted to another developer to develop part of the Freedom Park Stand No. 7732. This amounted to a partial sale of public land since an element of outright purchase of land was implied in the Memorandum of Understanding (MoU). The developer proposed to put up a filing station, shopping mall and hotel with a minimum construction value of US$15,000,000 within a period of 36 months. The developer paid a plot premium of US$350,000 in addition to liquidated and ascertained damages at a rate of K420 (US$100) per day for the total number of days the project would remain incomplete beyond the stated completion period. The developer requested the Council not to allow the development of a shopping mall within a radius of 7km from the proposed mall at Freedom Park.

5. Results and Discussion

The study findings first reveal that main sources of funds for Councils are Government grants and other revenues such as property rates, fees and levies. For example, the Kitwe City Council received K33, 611,333 in form of grants from the State while collecting revenues amounting to K120, 675,906 (GRZ, 2013. By succumbing to pressure from developers to convert or rezone the Freedom Park and Kitwe Zoo, major recreational areas and public amenities for the City, instead of looking for alternative land, the Council demonstrated inability to leverage land as resource. Vacant land was readily available especially on the outskirts of Kitwe but instead of directing the developers to such land the Council succumbed to requests to rezone the Freedom Park and Kitwe Zoo with the consequent loss of public amenity. Regarding the LBF instruments the Council preferred to adopt the "Land Lease model" in which the publicly owned land was leased to two developers at different periods. It was however found that good principles, minimum requirements and key assumptions for implementing land leases with the two named developers were not strictly followed resulting in irregularities in agreements, administrative and technical lapses in administering the land leases with the developers. This eventually resulted in failure of both the developers and the Council to implement the proposed projects at Freedom Park and Kitwe Zoo.

It was evident also that the Council did not develop a specialized institution (or Special Purpose Vehicle) to manage the land leases but opted to manage the development process themselves. The lack of specialized technical and land administration skills contributed to the developers taking advantage of the situation and not meeting the condition of the agreements. The developers did not meet the legal requirement in land leases to develop state or public land within a stipulated time of 18 months. Although the developers initially put up a Filling Station and five high cost houses at the Freedom Park and Kitwe Zoo respectively, arguably to meet the legal requirement of developing the land and hence avoid repossession of the land by the Council or State, the undeveloped portions of the leased land were eventually surrendered to the City Council who reallocated them to other developers. Further as time went on it became clear that the developers could not manage to raise the financing to kick start the proposed developments. This resulted in both leased lands lying idle for many months and even years contrary to the agreed conditions of the lease agreements.

Although the City Council identified the public land appropriate for leasing and succeeded in unlocking land value, this was only achieved amid lengthy protestations and legal actions from environmental activists and the general public. The Council was able to successfully rationalize their actions by stating that only a portion of Freedom Park and the disused Kitwe Zoo were leased out. The Council was also paid compensation, though the amounts involved were deemed low compared to the actual value of the public land. Further the Council did not have a strong administrative ability to manage the two land leases as reflected in their failure to compel the two developers to generate adequate financing for the projects. The fact that the agreements were merely MoUs instead of valid legally binding contracts meant that the Council still wielded control over the leased land which made it difficult for developers to mobilise private financing for the projects. According to Walters (2016) the most successful land leases, in terms of revenue generation, were those that were modeled closely on freehold systems where public land was sold to the developers.

The administrative lapses related to reported lack of or nonexistent records at the Council to show how the developer was identified and selected (GRZ, 2013). This had potential to raise questions of lack of transparency and uncompetitive engagement. The developers also took too long to complete the projects, contrary to the agreements. The developers were however quick to put up some developments – a filling station and some houses – at the Freedom Park and Kitwe Zoo to avoid repossession. Although this attracted a surcharge from the Council and the State, it was clear the developer took advantage of a gap in the legal requirements to protect their position. Although the developer initially paid compensation in liquidated and ascertained damages, the developer reportedly stopped paying ground rent which accumulated to unsustainable levels while the Council stopped claiming liquidated and ascertained damages considering that the project was still incomplete (GRZ, 2013).

The provision in the agreement with the Freedom Park developer which restricted development of other shopping malls within a radius of 7 km amounted to uncompetitive behavior. It also implied that the developer retained the right, though not legally binding, to develop within a radius of 7 km which included the Kitwe Central Business District, Kitwe Zoo and on land up north. The Freedom Park remained undeveloped for a lengthy period of time resulting public outcry and State pressure on the Council to cancel the lease. It was reported that legal action was taken and the Freedom Park land surrendered back to the Council, who in turn has leased it to another developer. Similarly, the study found administrative and technical lapses in the manner the Kitwe Zoo land lease was administered. The developer only built five (albeit expensive) houses as opposed to a modern housing complex and mall as agreed. The Council requested the Commissioner of Land to repossess the land but the latter advised the Council that the developer had actually fulfilled a legal requirement under the Lands Act by putting up some houses. Only the undeveloped section of the Kitwe Zoo could be repossessed, which subsequently was leased to another developer.

The study also found that the Council had failed to enter into lease agreements with various property owners within the City. For example, between 2011 and 2013 the Council only had thirty seven (37) leased properties on their books. Further the lack of Title Deeds for many privately and publicly held land and properties was major impediment to Council's ability to raise revenues. In 2013 only seventy (70) properties had title deeds while Council have the Ministry of Lands issue title deeds were limited by lack of funding and other factors. The Council rationalized the rezoning of Freedom Park and Kitwe Zoo by stating that the land could be put to good use and earn the municipality additional revenues from the subsequent land value capture. Other stakeholders including the developers argued that, like many Parks and Recreation areas and Open Spaces, Freedom Park and the Kitwe Zoo were not well maintained and were in a state of dereliction and so could be leased out to improve the condition. The mines which had helped maintain these facilities had since withdrawn their support (KCC, 2003).

6. Conclusion

In conclusion, the study findings demonstrate that, with regard to LBF instruments, the value of land is socially determined and can be influenced by public actions. This was the case in Kitwe were the public protests and pressure from activists and the State resulted in the developers surrendering the undeveloped portions of the leased land. Just as value was socially determined, the study also demonstrated that the land market in the City of Kitwe was socially constructed and so, as Walter (2016) argues, requires certain conditions, such as valid contracts and administrative and technical capacity, to exist and thrive. Clearly in the case of Kitwe, implementation of the land leases required a reasonably well-functioning land market. In view of what transpired actions might be needed to strengthen the land market in the City. The study also demonstrated that determining the best way forward in adopting, adapting and implementing a LBF instrument requires careful consideration of the level of administrative resources required and where those resources are located within the local government. If the administrative resources do not exist, they must either be developed or acquired if the overall effort is to be successful. Finally, the study demonstrated the need to take into account the local contextual factors such as a solid legal foundation, the history, values and cultural context associated with the land being leased, the condition of land markets and the administrative capabilities of implementing agencies when adopting LBF instruments and options.

In light of the findings, the study recommends that the KCC should review its portfolio of public and privately held land and properties and put in place measures for effective and efficient land value capture an review all lease agreements and MoUs with other private developers, mine owners, railways and statutory. It is further recommended that in future arrangements the KCC should, for specific cases, consider outright sale of public land but only with pre-conditions for development of social and urban infrastructure such as affordable housing, access, roads and so on to ensure a win-win situation for all. Councils in Zambia rely mostly on recurring property taxes, transfer taxes and stamp duties for, fees and levies for revenue collection. Finally, there is an overriding need to develop the technical and administrative capacity of the KCC and other municipalities to better understand, apply and leverage the various LBF instruments to deliver urban infrastructure and basic services on a sustainable basis.

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DII-2017-019

Unpacking the impact of public transport infrastructure investments on transformations in the City of Johannesburg

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Abstract

In the age of smart cities and globalisation, smart mobility is not only a vital component in the physical functionality of cities but also an economic and social performance of the modern urban centres. Urban transformations that are taking place in South African cities exhibit a strong shift towards the adoption of smart cities concepts that entail smart governance, mobility, economy, living, environment and people; hence prioritizing the economy and the society's needs. There have been massive innovative public transport systems developments in the City of Johannesburg since 2010, which are the rapid Gautrain, Gaubus and Rea Vaya bus as a way of complimenting the already existing Putco bus, Metro bus and Metro rail services. Paradoxically, the impact of such innovations particularly on socio-economic development of the City of Johannesburg has not been highlighted conclusively in existing literature. Consequently, this paper seeks to explore and highlight socio-economic benefits of innovative public transportation systems in communities focusing on the City of Johannesburg. To comprehend this, the study used a mixed approach of qualitative, quantitative and spatial investigation. Questionnaires, key informant interviews, maps from ArcGIS software, as well as crowd sourced data from Echo-Echo software were applied. This helped to reveal the socio-economic impact, developmental trends as well as perceptions of commuters using the innovative public transit systems. Research results revealed that innovative public transit systems contribute to socio-economic benefits however, a lot still needs to be done to improve their impacts on ordinary citizens and residents in the City of Johannesburg. Pursuant to that, the paper ends by recommending that there is need for strong linkages between innovative and sustainable public transportation development and socio-economic imperatives within communities and societies.

Keywords: City of Johannesburg, economic development, public transport systems, smart cities

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1. Introduction

The world is moving towards a paradigm shift of the smart cities concept in both developing and developed countries, consequently promoting sustainable development that conserves the environment and caters for socio-economic sustenance. At the heart of this concept is smart mobility which is not only a vital component in the physical functionality of cities but also economic and social performance of the modern urban centres (Peal and Goetz, 2015; Zheng and Peeta, 2015). Recently there has been an increasing demand for innovative public transportation in developing countries across the world, South Africa being one of which is committed to developing these integrated and innovative public transportation in its cities (Cardinale et al., 2014; Ryser, 2014; Schwaberger, 2014). Urban transformations that are taking place in South African cities reveal a strong shift towards the adoption of smart cities concepts that entail smart governance, mobility, economy, living, environment and people hence it should cater for the economy and the society's needs (Giffinger et al., 2007; Chen et al., 2014; Wendt et al., 2014).

Gauteng Province in South Africa took the path towards developing smart mobility in three of its metropolitan cities, that is, the City of Johannesburg Metropolitan Municipality, Tshwane Metropolitan Municipality and Ekurhuleni Metropolitan Municipality respectively. There have been massive innovative public transport systems developments in the City of Johannesburg since 2010, that among others include the Gautrain, Gaubus and Rea Vaya bus services as a way of improving the already existing Putco bus, Metro bus and Metro rail services (COJ, 2015; SITPF, 2013; Kolluru and Jain, 2015). However, the impact of such innovations particularly on socio-economic development of Johannesburg communities has not been highlighted conclusively in existing literature hence there is need to further explore and highlight socio-economic benefits of innovative public transportation systems in the City.

This paper explores the impact of innovative public transport systems on socio-economic transformations in the City of Johannesburg, this is to search for the relationship between public transport provision and its impact on socio-economic development as well as other issues surrounding urban public transport which are central to the establishment of strategies aimed at improving underprivileged sectors of the City. As a final point, the paper provides evidence of a problem that is vastly affecting social groups in the City of Johannesburg as a result of social exclusion exaggerated by inefficient public transport services. Section 2 of this article discusses a theoretical synopsis on literature about public transport and their impacts on socio economic development as well as unpacking the relationship between accessibility, socio-economic exclusion and public transport in the City of Johannesburg. Section 3 discusses the case study focused on investigating the impact of public transport on socio-economic development in the City of Johannesburg. Section 4 covers the methodology that was used in this study. Section 5 discusses results of the public transport impact of socio-economic development in the City of Johannesburg and lastly Section 6 offer the conclusion and discussions.

2. Conceptual Framework

The world is a global village that is continuously evolving into a Smart village where countries facilitate development in a sustainable and smart way were socio-economic development is highly prioritized (Ferris et al, 2010; Kamga et al, 2013; Tang and Thakuriah, 2012). At the centre of the smart cities concept is the smart mobility in relationship with smart people and smart governance (see figure 1). Over the years through industrial revolution transportation remains one of the most important innovation and service rendering people's needs economically and socially (Transportation Research Board, 2009), moreover increase in demand perpetuate the need for transport provision hence the need to increase and improve public transportation is important. Moreover, the increase in transportation is a result of the ever increasing population in many countries worldwide and studies show that this will be the case in years to come if a solution is not found to solve this problem, therefore the continuing increase in demand encourages the need for development of innovative public transport in support of existing ones (Transportation Research Board, 2009, Tillner, 2014; Zhukova and Smirnova, 2014). Innovative public transport service providers have been successful in implementing rapid bus and rail transit as well as improving existing modes of public rail and road transport hence attracting users to use public transport to enhance its full functionality for the betterment of the economic, social and environmental benefits of the country and its citizens (Hadasa et al., 2014; Hino et al., 2011; Ibarra-Rojas et al., 2015).

Figure 1: Smart city concept. (Source: Cohen, 2015)

Central to these efforts is a focus on reorienting current public policies that promote costly and destructive transportation and land use development patterns towards more economically efficient, equitable, and environmentally sound outcomes that strengthen communities and enhance the quality of life (Agostino et al., 2014). Sustainable transportation and smart growth are linked, as a result smarter growth patterns will be difficult to achieve without more sustainable transportation approaches; significant transportation improvements will be difficult to achieve without more sensible development practices (Tuominen and Ahlqvist, 2010). The City of Johannesburg had since adopted and implemented Transit Oriented Development (TOD) to bring its communities together and sustainably develop corridors (NDP, 2012). TOD is a well-known worldwide urban phenomenon linking transport infrastructure to property development in a sustainable way. It is evident that TOD principles, developed carefully within a South African context could help urbanize South Africa in a rapid, sustainable way.

Sustainable transportation systems are meant to transport individuals and groups of people whilst ensuring to stimulate social inclusion hand-in-hand with development (Gudmundsson, 2004; Miranda and Rodrigues da Silva, 2012; Cobbinah, Black and Thwaites, 2011; Cobbinah, Erdiaw-Kwasie and Amoateng, 2015). Furthermore, many cities in many countries around the world have implemented this concept to legislature, strategic plans, policies and other frameworks that will help facilitate smart development and TOD.

3. Case Study: City of Johannesburg

The Gautrain, Rea Vaya, Putco, Metrorail and Metrobus are located in the Johannesburg Metropolitan City of Gauteng province, South Africa (Figure 2). Johannesburg Metropolitan City is the most competitive economic hub of the country and the fastest growing city in terms of the economy, development and population. It is home to both the wealthy and poor, residents and refugees, global corporations and emerging enterprises with diverse ethnic groups (COJ, 2013).

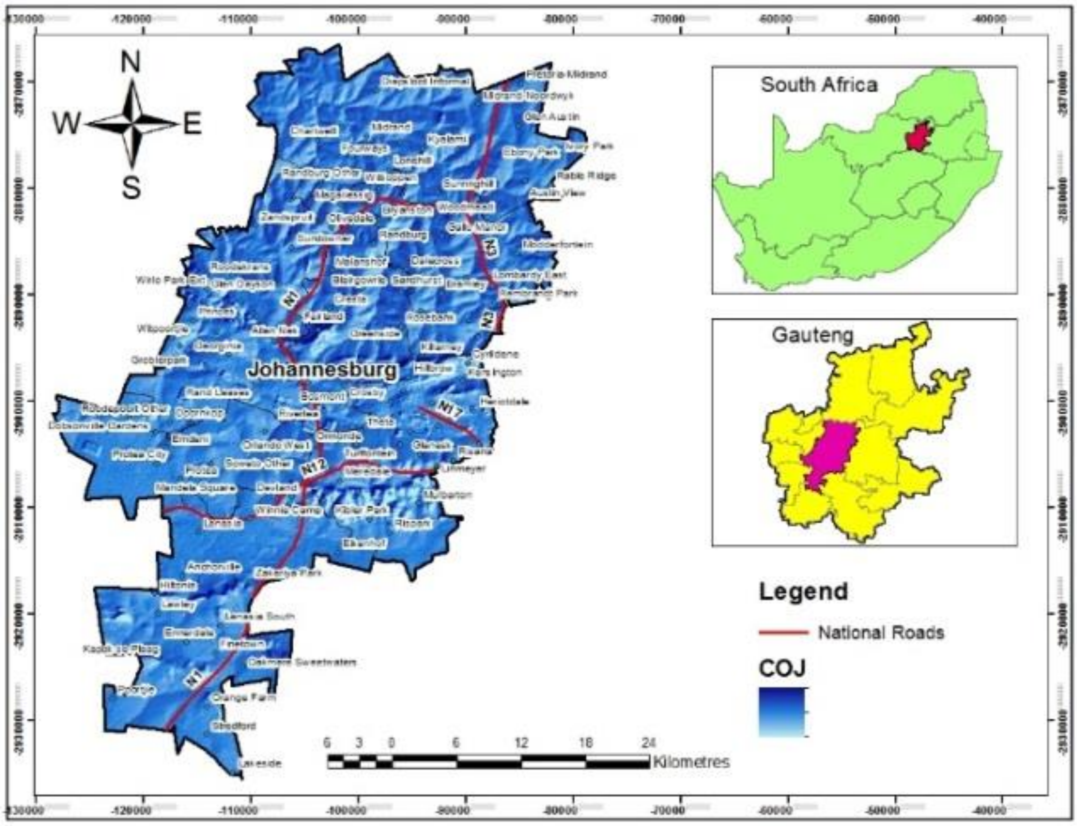

Figure 2: City of Johannesburg. (Source: Own source)

Johannesburg has the largest population in South Africa with an estimated population of 4.4 million (Stats SA, 2016). The Gautrain, Putco and Metrorail operates in three metropolitan cities in Gauteng province namely City of Johannesburg, City of Pretoria and Ekurhuleni metropolitan municipality, however Metrorail alone operates 4 provinces (Gauteng, Western Cape, KwaZulu-Natal, Eastern Cape) in South Africa. These three areas form a city region which is the economic heartland of South Africa and are the only cities in South Africa having a rapid transit train. The Rea Vaya and Metrobus only operate under the jurisdiction of the Johannesburg Metropolitan City across many communities and city centres.

4. Methodology

Echo-Echo software was used to mine crowd sourced data from social media platforms such as Twitter and Facebook. The data revealed commuters locations that is used to show the infiltration of these public transport platforms within the City of Johannesburg. The results assisted in showing spatial integration, socio-economic transformations and presence of public transport within the City. Travel behaviours helped to reveal the socio-economic effects of public transport in the City of Johannesburg. Echo-Echo software was used to conduct the analysis of data collected from social media. It also assisted with qualitative and quantitative understanding of language usage, the psychological drivers behind conversations, language and linguistic insight, advanced word clouds, topics, category analysis and crucial data in determining socio-economic transformations in the City (Oliveira and Welch 2013).

5. Results and Discussions

This analysis counts the number of times the different rail and bus services have been mentioned. The graph in Figure 3 indicates that social media feeds have been dominated by the mention counts of the more than other public transportation. The mention count of the Gautrain reached its peak in the year 2014 with 80 000 feeds made within that year. Second to this is the Gautrain bus with a volume of 5 000 social media feeds followed by Putco bus (1000 social media feeds in 2014), Metrobus (1000 social media feeds in 2014) and Rea Vaya bus (0 social media feeds from 2010 to 2015) (see Figure 3). The reason for this trend could be that the use of social media has reached its peak in the last two years in South Africa, especially with the Gautrain using social media platform to acquire feedback from their commuters and to convey any crucial matters to their commuters.

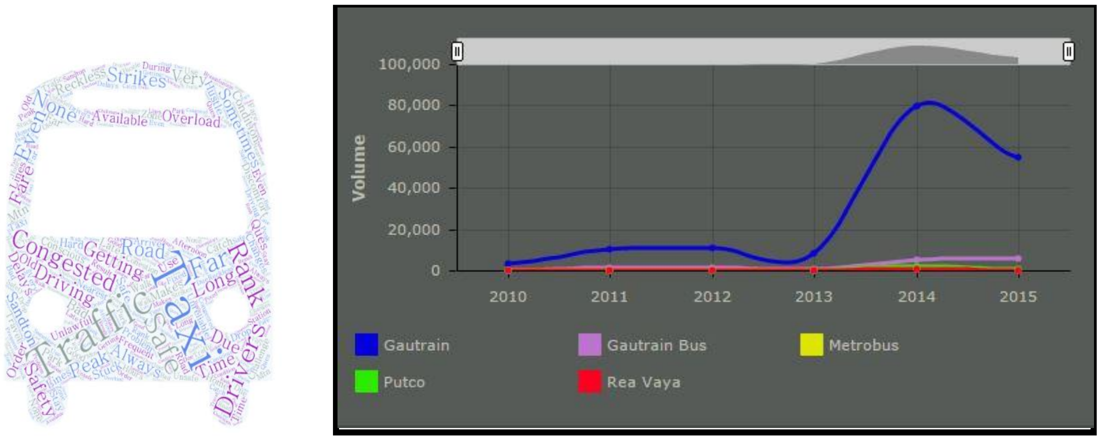

Figure 3: Mention Count (Source: Echo-Echo, 2015)

Figure 4 above shows the percentages of commuters who have used the train and different bus services to travel to areas of leisure such as malls, zoo's, stadiums etc. The graph indicates that in the year 2011, there was 3.5% of Putco commuters using the bus services either to travel to areas of leisure or promotions of leisure areas which were in proximity to the Putco stations. In the very same year, the Gaubus, Gautrain, Metrobus were trailing behind with only 1% of the commuters using these services for leisure (see Figure 4). However, Rea Vaya did not have any mentions until 2013 when there was a gradual increase in the percentage of commuters who have mentioned areas of leisure and the Rea Vaya bus. Both the Gautrain and Gaubus mention counts reduced from the year 2010 to 2015. This could have been due to the price hikes of the rapid rail and bus services. The gradual use of urban public transport for leisure proves that urban public transport investments have transformed the Gauteng Province through improvement in social cohesion by participating in social media, supporting social events and spatially invested in integrating areas of leisure with micro level communities in the province. These investments have also contributed to the development of Transit Oriented Development (TOD) such as mixed land uses along urban public transport routes that connect economic nodes. The development of mixed land uses have contributed to urban regeneration in cities across the province.

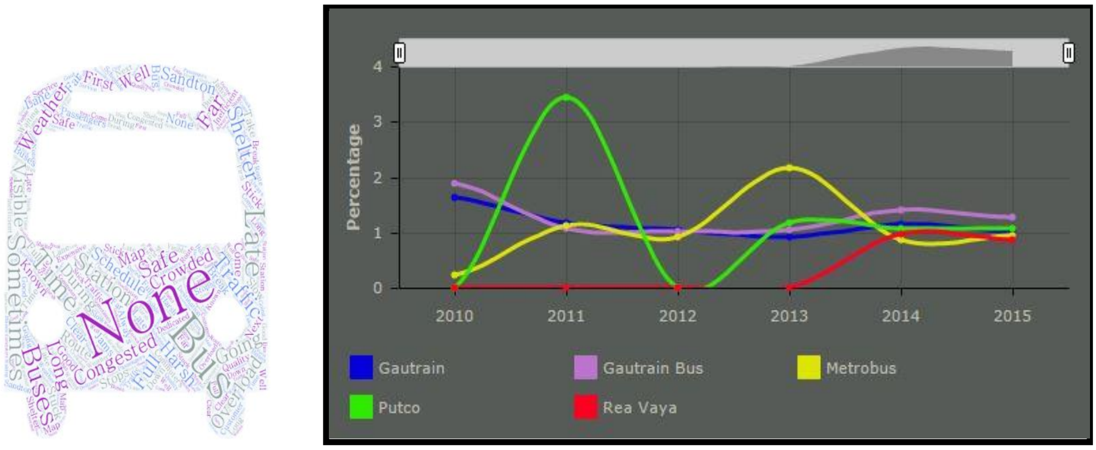

Figure 4: Leisure (Source: Echo-Echo, 2015)

Figure 5 shows the percentage of commuters who have mentioned the word 'home' in their Facebook posts or tweets, making reference to the rail and different bus services. From the graph, one can tell that in 2010 there was a very large percentage of Metrobus commuters who made social media comments using the word 'home'. This was either through advertising accommodations which were close to the Metrobus stations or people simply talking about their experiences using the Metrobus when they travel from their homes to different locations. The graphs show that other public transport services such as Gaubus, Gautrain and Rea Vaya had reached the peak in 2014 suggesting that many people used these public transport to travel home either interchanging from one of these modes to another hence showing integration of public transport systems in the Johannesburg Metropolitan city. As a result, urban public transport investments in the Gauteng Province contribute to spatial integration between micro level communities, the metropolitan cities and other economic nodes. TOD and the expansion of urban public transport infrastructure to small communities have promoted economic opportunities such as malls to open in micro level communities hence increasing employment and improving socio-economic state of many small communities.

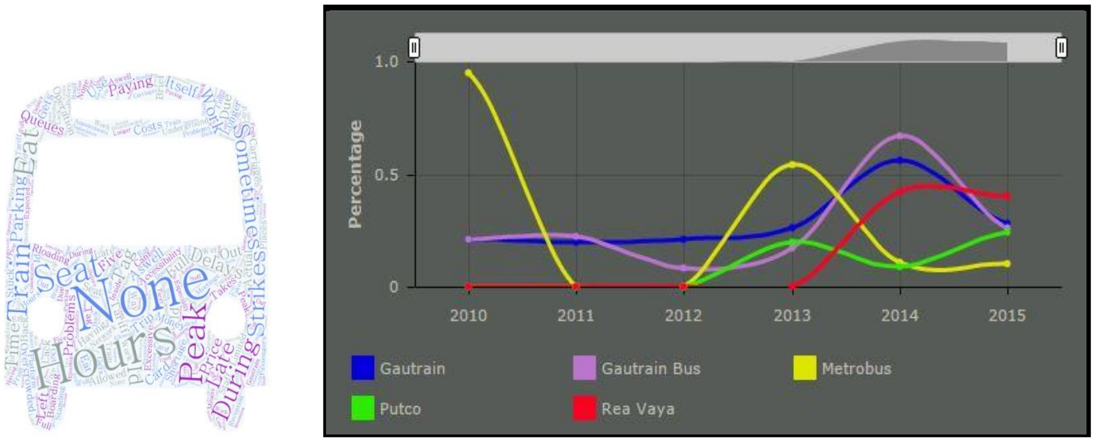

Figure 5: Home (Source: Echo-Echo, 2015)

The graph (see figure 6) above shows percentage of people who use the different bus services to commute to work. The graph indicates that the Rea Vaya bus services had a stagnant percentage of commuters using the bus services. However, the percentage of commuters who use the bus service to get to work increased drastically from 2013 onwards. The low percentages of the Rea Vaya commuters between the years 2010 to late 2012, could be a result of having the bus service being relatively new and people not being familiar with it. The Metrobus during the 2010 to 2011 had a high percentage (4.4%) of people using the bus service to commute to work. This percentage however, had a sharp drop between the years 2011 to 2012. Thereafter, the percentages increased and then decreased from the year 2012 to 2014. From 2014 to 2015, there was a constant number of commuters using this bus services. This fluctuation is a result of the bus fare hikes because according to the graph, the years 2013 and 2014 reveal a decrease in the number of commuters who use the Metrobus to commute to work. Simultaneously, there was an increase in the number of commuters who used the Rea Vaya bus services to get travel to work. Both the Gaubus and Gautrain have fluctuation between 3% and 4% as compared to other modes meaning their commuters have managed to use the Gautrain services for work purposes constantly. Consequently, this shows that urban public transport in Gauteng province is invested towards achieving employee trip reduction from micro-level communities into metropolitan cities and other micro city centres by improving spatial integration and allowing easy access in Gauteng Province.

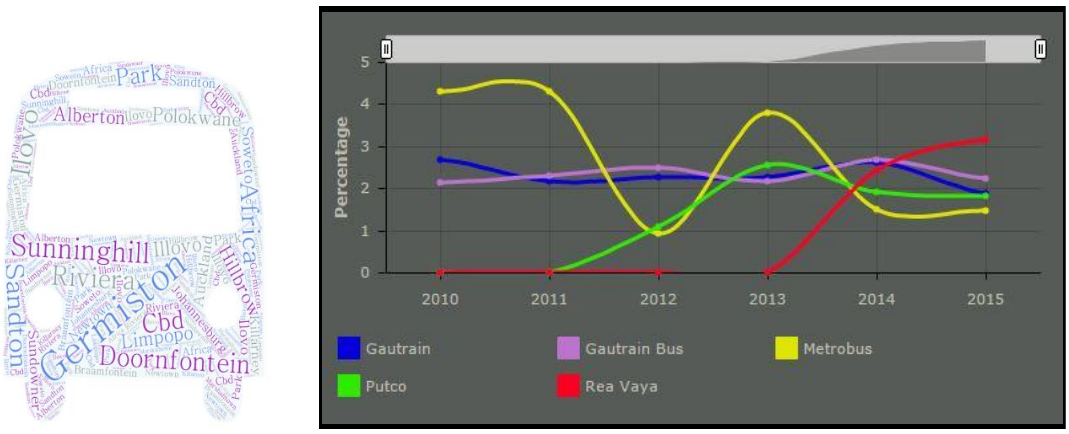

Figure 6: Work (Source: Echo-Echo, 2015)

Figure 7 is a snapshot of City of Johannesburg map with an indication of the number of tweets and Facebook posts which have been made by commuters using the train and the different bus services. The different coloured circles represent different number of tweets and Facebook posts and they are as follows:

- Blue icon = 1 tweet
- Blue = less than 10 tweets
- Yellow = less than 100 tweets
- Red = less than 1000 tweets
- Pink = less than 10 000 tweets
- Purple = less than 100 000 tweets

From figure 7, it can be deduced that there is a lot of social media activity taking place in the Gauteng province, specifically between the Johannesburg and Pretoria region. The map indicates that in Johannesburg there is an accumulated 14 104 tweets and Facebook posts which have been made on the basis of trending topics centred on the Gautrain, Gaubus, Metrobus, Rea Vaya and Putco. This could be a result of the integration of public transport in the Central Business District (CBD). Therefore, more of the tweets regarding the topics on the Gautrain, Gaubus, Metrobus, Rea Vaya and Putco are from their commuters and some from residents.

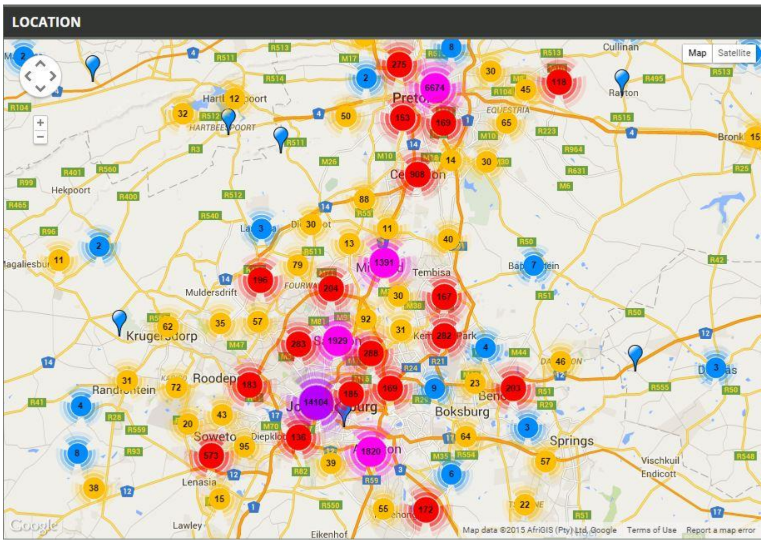

Figure 7: Location analyses (Source: Echo-Echo, 2015)

Figures 7, 8 and 9 further indicate that not a lot of social media activities taking place on the East and West of Johannesburg exists, as there are less tweets and Facebook posts being made in those locations. However, the map also indicates areas which have the second highest number of tweets and Facebook posts. These areas are the neighbouring cities such Pretoria and Kempton Park. The Gautrain, Gaubus, and Rea Vaya does not operate in some of Gauteng's cities such as Springs and Krugersdorp. However this high number indicates that the train and bus service was trending on the social media even in the area where it is not operating. This could be due to consumers complaining and bringing forth their desires of having the Gautrain, Gaubus, and Rea Vaya operating in their respective cities.

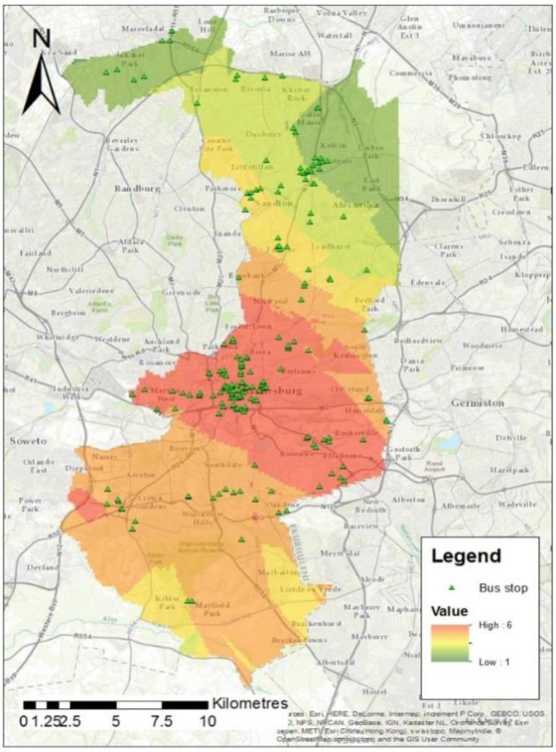

Figure 8: Rea Vaya Sensitivity analysis

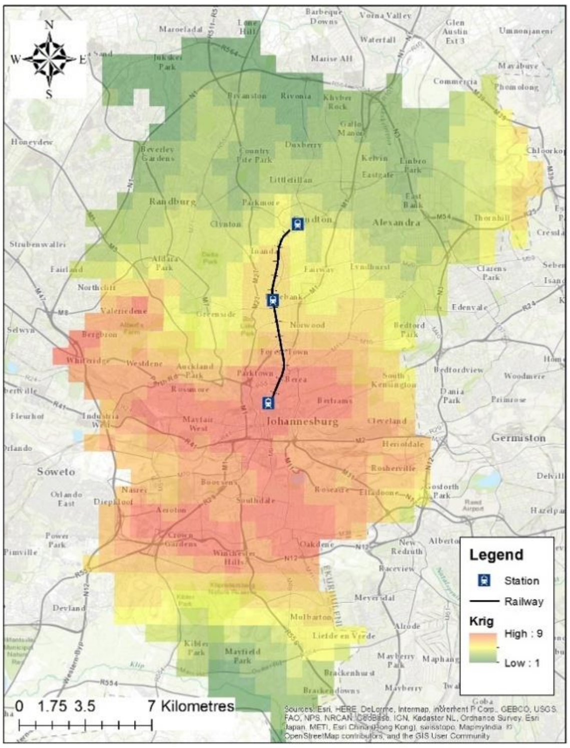

Figure 9: Gautrain Sensitivity analysis

(Source: Own source)

6. Conclusion

This study contributes toward unpacking the impact of innovative public transport systems on socio-economic transformations in Gauteng province, in conclusion that innovative public transport investments in Gauteng does contribute to socio-economic transformations. However, to a moderate extent the lack of accessibility to multiple urban public transport systems and rapid transit in disadvantaged areas away from city centers has proven that innovative public transport still needs to expand further from city centres, hence socio-economic needs of people far from urban centres will ultimately be met. The solution to addressing these gaps are to include the currently marginalized areas that do not have full access to these modes of urban public transport in policies to ensure they are included in priority expansions and for future mobility development. Social media has improved perceptions of the public about urban public transport and has created a platform for commuters to communicate directly with service providers. However there still remains an economic gap as not everyone who uses urban public transport use social media at all or as a result of restricted access because of unaffordability of data for the social media services. Traffic demand management has been improved through rapid rail and bus transit as they have their own dedicated lanes that do not suffer the consequences of traffic congestion. Socio-economic challenges such as safety, convenience, reliability, affordability and accessibility of urban public transport systems have improved over the years, the multiplicity of modes and investments in multi modal integration has improved urban public transport standards.

7. Limitation and Further Research

This research has explored the impact of innovative public transport systems on socio-economic transformations in the City of Johannesburg. Future studies could expand the scope of the study through increasing data collection tools to collect more data in the study area and beyond, as well as to allow for more factors to be identified and analysed. The recommendations herein are approaches primarily aimed at stimulating public transportation usage by commuters in Johannesburg. Future studies can also factor in the viewpoints of other key stakeholders, such as city planners and public transportation agencies.

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DII-2017-063

Leveraging Public-Private Partnership as an Effective Tool for Infrastructural Development in Emerging Economies: An Integrative Review

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Abstract

Approximately 1.6 billion, 22% of the world's population are considered to be living in extreme poverty. Of these, roughly 390 million are located in sub-Saharan Africa. To eradicate extreme poverty, it is imperative that investment in infrastructural development – such as heavy civil projects - is encouraged in countries hit the hardest by poverty as infrastructural development plays a key role in reducing extreme poverty and driving sustainable economic growth. Although investment in infrastructure has increased significantly over the past two decades, concern abounds regarding the performance of some heavy civil projects. Several factors such as ineffective procurement processes have been identified as factors that lead to poor project performance in several countries. Moving to more innovative procurement and financing practices such as Public-Private Partnership (PPP) could spur economic growth. Due to its unique integrative risk sharing platform, PPP is considered an effective project delivery strategy that could drive infrastructural development in emerging economies. Nevertheless, barriers to the wide adoption of PPP on capital intensive heavy civil projects exist. No prior study succinctly summarized the overriding benefits of implementing PPP on such projects, neither did any study identify key barriers and drivers. The present study fills this gap by adopting an integrative review process to synthesise past studies on the implementation of PPP on heavy civil infrastructural projects in developing countries. Findings from the present study indicate that benefits accrued to PPP and pertinent to developing countries include timely delivery of a project, improved budgetary certainty, improved emphasis on accurate life-cycle analysis, increased innovation, etc. Furthermore, political instability, frail project pipelines, weak legal and regulatory framework were identified as key barriers to successful implementation of PPP while controlled privatisation, risk transfer, increased economic diversification, enhanced investment environment were identified as key drivers. The study recommends the development of adaptable frameworks that would improve the future implementation of PPP in developing countries.

Keywords: developing country, heavy civil construction, infrastructural development, public-private partnership

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1. Introduction

Approximately 1.6 billion, 22% of the world's population are deprived of basic infrastructure such as adequate transportation system, safe drinking water, shelter, sanitation facilities, etc. (Hulme 2015). Of these, roughly 390 million are located in sub-Saharan Africa (Economic Commission for Africa 2017). Several efforts have been made towards tackling these unwanted statistics. To eradicate extreme poverty, it is imperative that investment in infrastructural development is encouraged. Past studies have shown that lack of mobility is significantly linked to social disadvantages which lead to increased poverty (Ohnmacht et al. 2009, Lucas, 2012). To reduce poverty, it is essential that investments towards transportation related projects are increased. While clamoring for increased investment in transportation infrastructure, it is paramount that processes are put in place to minimize cost, demand and risk estimation, schedule, safety, uncertainties associated with executing transportation projects (Hampton, 2009; Kim, 2010; Salet et al., 2013). One way to improve the performance of infrastructural projects is through implementing innovative and effective procurement processes (Pakkala 2002). Due to its transparent and risk distribution capacity, public-private partnership (PPP) is identified as an effective project delivery mechanism that could improve the delivery of infrastructural projects in emerging economies (including developing countries) (Ministry of Foreign Affairs of the Netherlands 2013).

Regardless of the potential benefits accrued to PPP, barriers to its wide adoption on transportation projects in developing countries exist. The objective of the present study is to first identify and document critical success factors (CSF) required for successful implementation of PPP on transportation projects. Next, case studies of projects successfully executed in developing countries are evaluated. The findings from the literature review were compared to extractions from the case study to provide contextual information that should encourage future adoption of PPP on transportation projects in emerging economies.

1.1 Motivation

Infrastructural development such as transportation infrastructure is considered a key driver for reducing poverty across the globe (Gannon and Liu 1997). Regardless of the increasing investment in transportation infrastructure, the performance of transportation projects struggles to meet expectations due to several reasons including procurement and contract management. Although procurement tools such as PPP shows considerable promise, the implementation and diffusion of this innovative contracting process seem slow in developing countries (MFDP 2009). Therefore, the present study seeks to identify critical success factors under which PPP could flourish when implemented on transportation infrastructure projects in emerging economies.

1.2 Research method

To achieve the present study objectives, the researchers combined the strengths of an integrative literature review and case study approach. A case study is an ideal approach since the present study includes a programme-oriented exploration where the researchers have little control over is required (Yin 2009). These methods are considered sufficient to meet the study objective (Torraco, 2005; Osei-Kyei and Chan 2015). A three-step approach was implemented to conduct the integrative literature review. First, keywords relevant to the study such as public-private partnership, 3P, PPP, PFI in conjunction with, transportation infrastructure, transportation project, transportation procurement etc. In addition, words such as critical factors, success factors, and critical success factors were used to interrogate several data bases. Specifically, Scopus was the primary data base consulted since it is widely used in literature review studies and is considered robust (Osei-Kyei and Chan 2015). Nevertheless, Web of Science and Google Scholar were used as secondary data bases to validate articles found in Scopus thereby increasing the meticulousness of the integrative literature review process. Next, the amassed articles were inspected to identify those germane to the present study. Articles identified in phase one were included if the following criteria were met: published within the last 30 years, and included the specified keywords in the title or abstract. Lastly, each article related to the study was reviewed and synthesized to extract key information pertinent to the study. Following the integrative literature review, three projects that exemplify the successful application of PPP in transportation projects in emerging economies were identified and discussed in order to extract CSFs.

2. Literature Review

2.1 Impact of transportation infrastructure on poverty

Transportation infrastructure plays a vital role in the everyday life of individual around the world – including those in emerging economies. Not only does transportation infrastructure improve the livability of a people (Okoro et al. 2017), it offers an effective mechanism to reduce poverty. According to Gannon and Liu (1997), providing transport facilities can reduce poverty by increasing economic efficiency and enhancing opportunities. In addition, "*it [transport infrastructure] enables the supply of goods and services around the world; and allows people to interact and generate the knowledge and solutions that foster long-term growth*" (World Bank 2017). To address the spatial distribution of transportation systems and improve the reach of disadvantaged persons, investment in transportation infrastructure is encouraged.

2.2 Infrastructural projects financing and performance

Generally, infrastructural expenditure consumes a reasonable fraction of a country's gross domestic product (GDP). For instance, the US spent $416 billion (2.4% of GDP) on infrastructure in 2014 while Australia and China on average spend about 5% and 9% of its GDP on infrastructure development (McKinsey Global Institute 2016). This expenditure denotes the critical role infrastructure plays in most developed countries. In order to improve global competitiveness and economic performance, governments in emerging economies and developing countries have increased funding for infrastructural projects (Allport 2008). In addition to government spending, a significant amount of resources has been committed towards transportation infrastructure development from various sources. For instance, as at 2016, the World Bank Group, through the International Development Association (IDA) and International Bank for Reconstruction and Development (IBRD) had over 209 active projects totaling $4.2 billion (World Bank 2017). These projects are funded with a mixture of funds from private investors and the government.

As highlighted previously, the potential severe impact of the uncertainties surrounding the execution of transportation projects in addition to project-specific constraints calls for concern since a failed transportation project could have an unfavourable ripple effect on the economy. It could be argued that the impact of a failed transportation project has a greater impact on individuals in emerging economies given their limited access to adequate alternative means of mobility. According to Luke et al. (2017), transportation infrastructure projects are prone to the high rate of failure due to poorly justified feasibility studies and poor operation management. To address these issues, an effective financing and project procurement model such as PPP is essential.

2.3 Public-private partnerships

Although there is no universally acceptable definition for PPP, it is the generic term for a medium-to-long-term relationship between public and private sector with the primary objective to deliver infrastructure service to the public. PPP combines the strength of the public and private sector's – sharing risk across the board to those well positioned to mitigate it. PPP draws on the technical expertise and efficiency of the private industry while relying on the regulatory framework and oversight of the public sector (Ks et al., 2016). PPP takes a holistic approach which extends over the entire lifecycle of a project. PPP execution process is generally delineated into four stages: planning and identification of candidate projects; preparation; implementation and procurement; and contract management of contract term (PPP Certification, n. d.). Sectors where PPP can be applied successfully include physical infrastructure (roads, bridges, ports, etc), the energy sector (hydro power, rural energy, renewable energy, etc), information and communication sector, environmental sector (water, sanitation, waste management systems), basic services (health and education).

However, despite the contribution of PPPs in infrastructure delivery, the challenges associated with PPP projects in developing countries cannot be ignored. This view was supported in Ernst and Young (EY), 2015), in which it was stated that despite increasing recognition of the role of PPP as a mechanism to bridge the infrastructure gap in light of fiscal constraints, in Africa and other developing economies, remains constrained by limited financial markets, inadequate legal and regulatory frameworks, an absence of technical skills within government agencies, and political and national risks (Ernst and Young (EY), 2015). In Zambia, for instance, the efficacy of adopting PPPs is marred with the legal red tapes inherent in the PPP Act of 2009, which does not favourably provide a policy framework for risk transfer, delineation of responsibilities and dispute resolution among parties (Ngoma et al., 2014). There is rather emphasis on administrative procedures and involvement of multiple public agencies, which do not augur well with decision-making among usually conflicting parties in a PPP. Consequentially, there are inappropriate tax increases and discontinuation of concessions due to low investor confidence and instability of government. Likewise, in Nigeria, ineffective and inefficient institutional and legal framework poses a challenge to successful adoption and implementation of PPPs. Such challenges as poor transparency in concessionaire selection, lack of knowledge of and experience in PPP legislation and concession agreements, poor project preparation and lack of bankable studies, poor allocation of risks and management, poor procurement procedures and processes management are thus evident in PPP arrangements (Mudi et al., 2015). Governments' demonstrable commitment to the PPP model through consistent and transparent legislative and institutional frameworks can lower the risk of adverse changes that can reduce investor confidence and deter participation (EY, 2015).

2.4 Application of PPP on transportation infrastructure projects

As at 2016, approximately 139 developing countries were exploring increasing private participation in infrastructural development (World Bank Private Participation in Infrastructure Database 2016). Nevertheless, the extensive use of PPP across developing countries as a means to plug the infrastructural gap has not achieved the expected uptake for various reasons (Ministry of Foreign Affairs of the Netherlands 2013). For instance, in 2002/2003, Botswana's Ministry of Finance and Development Planning (MFDP) announced their intention to increase the use of PPP as a procuring and financing mechanism in the public sector. The government considered PPP an effective tool for ensuring sustainable investment in infrastructure and managing public finance in a sustainable way. Regardless of creating a PPP policy, Botswana struggled to drive interest in the actual implementation of PPP on capital projects – including transportation infrastructure (MFDP 2009). According to Delmon (2015), for PPP to be a viable procurement option, a strong political will is required, effective legal regulatory structure, access to financing (debt and equity), guaranteed revenue stream (user charge, etc.), credit enhancement (collateral), and effective project selection, preparation, and implementation system are required. These are considered PPP critical success factors.

3. Public-Private Partnership Critical Success Factors for Transportation Infrastructure

For a project to achieve success, it is essential that CSFs applicable to the specific project are identified. Identifying CSFs is essential to management since they identify the key areas where a positive result is a necessity (Hwang et al., 2013). Although Osei-Kyei and Chan (2015) conducted a comprehensive literature review of PPP critical success factors published between 1990 and 2013, the scope of the literature was broad (not specific to transportation infrastructure). Given the uniqueness of transportation infrastructures and the uncertainties associated with such projects, it is permissible to assume that the CSF associated with transportation projects would differ from those captured by Osei-Kyei and Chan (2015). In addition, it is likely that additional literature on PPP related CSF has been published between 2013 and 2017. This assumption is justified by Osei-Kyei and Chan's (2015) work which states that the number of CSF-related research published in 2013 (6) represented 200% increase when compared to the number of articles published in 2011 (2). Therefore, the integrative literature review was conducted to determine the CSFs pertinent to transportation projects and possibly extend findings published by Osei-Kyei and Chan (2015).

Ten articles were identified through Scopus following the key word probe. As mentioned earlier, a secondary search was conducted using Google Scholar and Web of Science which identified five articles overlooked by Scopus. Following a close inspection, one article discovered through Scopus was dropped since it was not relevant to the study. In addition, three articles identified through the secondary search were excluded since they did not meet the inclusion criteria. Therefore, ten studies (Scopus = 8; Web of Science and Google Scholar =2) that met the inclusion criteria were analysed. In total, 24 CSFs pertinent to transportation infrastructure were identified following content analysis. Below are the 24 CSFs ranked in an ascending order (based on their frequency of appearance in literature). Table 1 shows the top 5 CFSs identified through integrative literature review process.

(CSF1)Thorough and realistic cost/benefit assessment, (CSF 2)social support, (CSF 3)transportation infrastructure is needed, (CSF 4)political support and stability, (CSF 5)technical feasibility of project, (CSF 6)experience, Commitment/responsibility of public/private sectors, (CSF 7)shared authority between public and private sectors, (CSF 8)capable public and private partners, (CSF 9)favorable investment climate, (CSF 10)stable macro-economic environment, (CSF 11)competitive procurement process, (CSF 12)transparency of procurement process, (CSF 13)well-organised public agency, (CSF 14)sound economic policy, (CSF 15) efficient procurement process, (CSF 16)appropriate risk allocation and risk sharing, (CSF 17)favourable legal framework, (CSF 18)good governance, (CSF 19)availability of suitable financial market, (CSF 20)implementation of innovative technologies/ solutions, (CSF 21)government provides a guarantee, (CSF 22)revenue forecasts, (CSF 23)community engagement program, (CSF 24)performance specification/payment mechanism.

The top five CFSs identified through content analysis are: thorough and realistic cost/benefit assessment, social support, transportation infrastructure meets a need, political support and stability, and technical feasibility of the project with a frequency of 90%, 90%, 80%, 89%, and 80% respectively. Using a factor analysis approach, Chou et al. (2012) identified 10 critical success factors pertinent to high-speed rail projects while Macario et al. (2015) identified 5 critical success factors that could influence any transportation infrastructure.

Table 1: Top five critical success factors based on the frequency of occurrence.

ID	Critical success factors	Source	Year	Frequency	Percentage Frequency	Rank
CSF1	Thorough and realistic cost/benefit assessment	Chou et al.; Mladenovic et al.; Hsueh and Chang; Smith and Gannon; Wang; Murray; Askar and Gab-Allah; Kaenzig et al.; Bae and Joo.	2012; 2013; 2017; 2008; 2015; 2007; 2002; 2008; 2016	9	90	1
CSF2	Social support	Chou et al.; Mladenovic et al.; Macario et al.; Hsueh and Chang; Smith and Gannon; Murray; Kaenzig et al.; Askar and Gab-Allah; Bae and Joo.	2012; 2013; 2015; 2017; 2008; 2007; 2008; 2002; 2016;	9	90	1
CSF3	Transportation infrastructure is a need	Mladenovic et al.; Hsueh and Chang; Smith and Gannon; Wang; Murray; Askar and Gab-Allah; Kaenzig et al.; Bae and Joo.	2013; 2017; 2008; 2015; 2007; 2002; 2008; 2016.	8	80	3
CSF4	Political support and stability	Mladenovic et al.; Macario et al.; Wang; Smith and Gannon; Kaenzig et al.; Askar and Gab-Allah; Murray; Bae and Joo.	2013; 2015; 2015; 2008; 2008; 2002; 2007; 2016.	8	80	3
CSF5	Technical feasibility of project	Chou et al.; Mladenovic et al.; Hsueh and Chang; Wang; Murray; Kaenzig et al.; Askar and Gab-Allah; Bae and Joo.	2012; 2013; 2017; 2015; 2007; 2008; 2002; 2016.	8	80	3

4. Case Study Illustration

Following the successful identification of 24 transportation infrastructure CSFs, it is important to verify if all 24 CSFs are relevant within the context of emerging economies and developing countries. Therefore 3 case studies from developing countries are presented below:

Case Study 1 (CS1): Bus Rapid Transit, Project, Bogotá, Colombia

Urban migration is an increasing phenomenon in developing countries due to the promise of a safer environment and a better livelihood. This growth put a strain on the infrastructure of the city absorbing such influx. Bogota, a city of close to 6.5 million in Colombia experienced a similar scenario and witnessed severe bottlenecks in the transportation sector. To meet the growing demand, a bus rapid transit was proposed by the Mayor's Office as an effective means of alleviating the growing congestion in Bogota. Design, planning, and investment were executed by public institutions in Bogota while the private industry provided technical input and operated the system. Trans Milenio's primary objective was to create cost effective transportation that would improve urban productivity in Bogota. After the implementation of the BRT system, users are saving approximately 223 hours a year. It is also considered the most popular public project in Bogota.

Case Study 2 (CS2): North Luzon Expressway, Luzon, Philippines

Approximately 50% of Philippines 91 million residents live on the island of Luzon which houses Manila, the capital city. North Luzon Expressway is considered the primary transportation corridor connecting Manila to central and north Luzon. This corridor handled a high traffic volume of more than 160,000 vehicles a day. The expressway was built between 1975 and 1977 by the department of public works and highways and managed by a private entity which was then bought over by the government. Years of poor maintenance, high accident and fatality rate, and growing population significantly increased congestion. Following approval of a 30-year BOT contract, the Manila North Tollways Corporation (MNTC) (four partners including a public entity and three private companies) repaired and expanded the expressway between 2003 and 2005. The total cost for the project was $384 million. To recoup the investment, MNTC assessed tolls to vehicles using the expressway. Commute time and congestion on the expressway were reduced by MNTC through widening and proactively maintaining the roads.

Case Study 3 (CS3): Port Expansion, Colombo, Sri Lanka

Colombo, the capital of Sri Lanka is home to one of three major deep water ports in Sri Lanka. Due to its geographical location, the ports in Sri Lanka are poised to be a significant global player in the shipping sector. Between 1987 and 1997, the throughput at the Colombo Port facility increased from sub-500,000 20-foot equivalent units (TEUs) to over 1.5 million TEUs. However, as at 2004, Colombo Port was losing its competitive advantage to more modern facilities. The investment was required to improve its facilities and drive up market share. To achieve this objective, the capacity of the terminals at the port and efficiency in container handling had to be significantly increased. The Sri Lanka Port Authority and several private companies signed a 30-year build-operate-transfer (BOT) concession under the South Asia Gateway Terminals Limited (SAGT partnership) in order to improve, expand, operate and manage one terminal at Colombo deep port. The project was estimated to cost $240 million but was executed under budget ($227.4 million). Throughput was increased by 45% annually and wait time was reduced from 6.9 hours to 0.9 hours.

Complete description and summary of each case study can be found using the link provided below (Source: http://academy.ssc.undp.org/GSSDAcademy/SIE/VOL15.aspx)

Table 2 highlights the CSFs extracted from each case study. It is important to note that although not captured in Table 2, at least one CSFs (out of 24) discovered through the integrative literature review process was considered a CSF in the evaluated case studies. Although not conclusive, this finding provides some validation for the identified CSFs. Furthermore, it could be inferred that the transportation infrastructure PPP CSFs for developed countries are also applicable to developing countries although the level of importance (significance of each CSF) was not ascertained.

Table 2: Critical success factors discovered in case study projects

Case study Projects	CSF 1	CSF 2	CSF 3	CSF 4	CSF 5	CSF 6	CSF 7	CSF 8	CSF9	CSF 10	CSF11	CSF 12	CSF 13	CSF 14	CSF 15
CS1	x	x	x	x	x	x	x	x	x		x	x	x		x
CS2	x	x	x	x	x	x	x	x	x				x		
CS3	x	x	x	x	x	x	x	x		x		x			x
Frequency (%)	100	100	100	100	100	100	100	100	67	33	33	67	67	0	67

CSFs'1 through 8 were mentioned in each case study leading to 100% frequency while CSF 10 and CSF 11 were present in one case study (33.33%). CSF 14 did not appear in any case study. Although not completely consistent, there seems to be a reasonable overlap between the frequency in the case studies and the findings from the integrative literature review. This finding indicates that the critical success factors required for implementing PPP on transportation projects in developing countries are similar to those required in developed countries. These views were supported in Ngoma et al. (2014) and Mudi et al. (2015).

5. Conclusion

The current study set out to identify the key factors that predict success in implementing PPP on a transportation project. To achieve this objective, an integrative literature review was conducted by the researchers to identify PPP CSF for transportation infrastructure in a developing country followed by an in-depth analysis of three case studies from developing countries to validate the identified CSFs. Results from the integrated literature review indicate that 10 articles pertinent to the current study were available. Within those 10 articles, 24 CSFs were extracted. Based on the frequency of appearance, the top five PPP transportation project CSFs are thorough and realistic cost/benefit assessment, social support, transportation infrastructure meets a need, political support and stability, and technical feasibility of the project. Analysis of the case study indicates that all 24 CSFs were identified as a CSF in at least one case study. Future research should consider conducting a more in-depth analysis using multiple case study drawn from developing countries in different regions. In addition, collecting and analysing questionnaire response from industry expert regarding the level of importance of the identified transportation CSF will provide much needed direction to future PPP proposals. Finally, a framework for adopting PPP-based transportation infrastructure in developing countries is required.

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DII-2017-048

Evaluating Financial Risks in Zambia's Public Private Partnership Projects: The Case of the UNZA East Park Mall and Kasumbalesa Border Post

Peter Mukalula[1], Mundia Muya[2]

Abstract

Emulation of the United Kingdom's PFI model has seen countries engage the private sector in bolstering aggressive infrastructure development in areas such as transport, shopping malls and institutional facilities. Developed countries have been successful at PPPs. With a rapidly increasing urbanised society and an expanding need for basic infrastructure, Zambia adopted the PPP mode of development in 2009 in tandem with the African and international community. For developing countries, budgetary constraints usually hinder sustained infrastructure development. Although governments make every effort to further development on a yearly basis through budgetary allocations, the infrastructure burden remains a daunting task. The PPP route has offered an attractive alternate way for the much needed development. But PPPs normally have numerous risks. Financial risks are but one of the risks that, ultimately, renders a project's success or failure. This is because financial risks enables that proper decision-making are made regarding projects. Projected costs that are used to compute the internal rate of return as well as the payback periods of a project, give a synopsis of the economy, in general. Regrettably, analysing of such risks is not the strength of professionals in Zambia. Using two successfully implemented projects (the UNZA East Park Mall and Kasumbalesa Border Post projects), this paper analyses the financial decisions undertaken on them. The paper shows the trajectory of the decisions made and what remedial measures could be taken. It is the premise of this paper to show that financial risks would need those schooled to identify incipient flaws in a bankable proposed project. Bankable PPP projects are what any developing country yearns for. But at what cost would decisions on such projects impact a country's tax payer who would eventually meet the cost?

Keywords: financial risk, infrastructure, public private partnership

1. Introduction

According to the Africa Infrastructure Country Diagnostic Report, Zambia needs to spend US$1.6 billion a year over the decade 2006 – 2015 to develop its infrastructure to the level found in the rest of the developing world. This estimate is equivalent to 20% of Zambia's gross domestic product (GDP) and it is double the country's rate of investment in recent years. IBRD (2010) estimated Zambia's infrastructure funding gap at US$500 million per year. These estimates have been out stripped owing to the grave challenges of attracting would-be investors seen in the incongruent governance application with regard to PPPs even though the construction sector (compared to other sectors) has been doing well the last few years and registered 18.9% as contribution to the gross domestic product (Figure 1).

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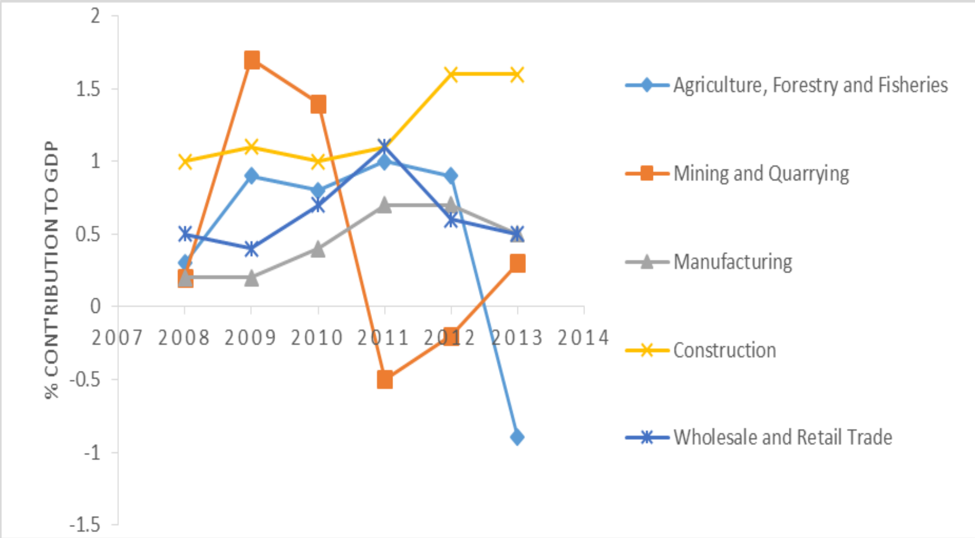


Figure 1: Construction contribution

Source: BoZ 2010, 2013 and 2015 Annual Reports

This research is part of a doctoral thesis that seeks to highlight financial risks for two implemented successful PPP projects have been contending with.

2. Literature Review

Public Private Partnerships (PPPs) have several definitions. Most definitions often retain the central feature of participation of the public and private parties. PPPs have been described as complex type of contracts which work on the premise of a synergy of the public and private sectors (Zulu and Muleya, 2009; Alshawi, 2009). Hodge and Greve (2007) called for the re-examination of the different meanings and definitions given to PPPs. Akintoye (2009) defined PPPs as contractual agreements of shared ownership between public agencies and private companies, whereby as partners, they pool resources together and share risks and rewards, to create efficiency in the production and provision of public and private goods traditionally provided by the public sector.

Byrne (1984) gave a comprehensive definition of infrastructure development that is in line with this research. He enumerated the characteristics of development as the:

(i) perception and estimation of demand for new buildings of different types;
(ii) identification and securing of sites on which buildings might be constructed to meet that demand;
(iii) design of accommodation to meet the demand on the sites identified;
(iv) arrangement of short- and long-term finance to fund site acquisition and construction;
(v) management of design and construction; and
(vi) letting and management of the completed buildings.

Financial risks are part of the fabric of ensuring successful PPPs (Akintoye, 2009; Rwelamila et al 2003). Although Zambia has sought to grow its PPP portfolio, the management of risk along with legal and regulatory constraints, procurement, capacity building and project financing have posed mounting challenges (Zulu and Muleya, 2009). The viability of such projects shows how successful the allocated risks between the partners are dealt with. Mukalula and Muya (2014) noted the use of financial appraisals amidst other appraisal tools used for decision making in Zambia's PPP evaluation. Five key components are normally used in financial (appraisal) assessment checklist (OECD's (2008) as a benchmark for a public sector comparator (PSC) exercise in streamlining public policy. The policy options envisioned by the PSC are normally based on historical costs that overtaken due to the nature of developing economies.

Adams et al (2006) suggested three reasons why PPPs are being used:

- that they reduce the burden on taxpayers in the delivery of both capital and long term service contracts by the introduction of private capital, expertise and competitive business practices to the provision of public services;
- the private sector has a higher level of efficiency and effectiveness than the public sector which is hindered by its highly bureaucratic and politicized operative processes; and
- risks associated with the provision of such infrastructure can be spread between the private and public partners hence relieving taxpayers of some of the costs incurred by decision taken long ago.

The application of PPP projects shows how that 'one size does not fit all' (Rwelamila et al 2003). Key lessons learnt over the African continent have shown the need for strong public and private sectors to enable success of PPPs (Mukalula and Muya (2014); Ndandiko (2006) and Zulu and Muleya (2009). Governments have to undertake such service delivery through the option of decentralized management and market mechanisms (Pongsiri, 2002). Governance is therefore a matter of concern. Stoker (1998) defined governance as the development of governing styles where the principles of accountability, transparency, fairness, efficiency, participation and decency are embraced. Alfen et al (2009) defined governance as a decision-making process. Governance must therefore embrace transparency in all its decision-making processes. Abednego and Ogunlana (2006) developed the good project governance (GPG) concept that is aimed at evaluating performance under the PPP procurement mode. Abednego and Ogunlana (2006) further argued that proper risk allocation is only achievable through good governance which in turn leads to better project performance (Guasch, 2004; Qu et al, 2013).

3. Research Gaps

The following knowledge gaps were identified in the reviewed literature:

(i) the need to investigate what critical success factors influence decisions made regarding risks on PPP projects;
(ii) the need to find out what an effective risk allocation mechanism must achieve to enhance decision making;
(iii) the need to measure the effects of the major risks affecting project phases;
(iv) the need to investigate net present value distribution over the project noting what beneficial effects would be obtained; and
(v) the need to investigate what appropriate risk mitigation methods are applied to successful PPP projects.

This paper discusses the fourth point listed above.

4. Methodology

Data was collected using a mixed research method that included structured interviews as well as a detailed questionnaire. Each interview lasted between 30 and 40 minutes. Extensive notes were taken during the interviews. The spacing of the interviews enhanced establishment of good contact and firm arrangement of dates and venues. The detailed questionnaire was given to professionals who had interacted with the PPP law in Zambia and results were analysed using excel and SPSS package.

5. Results and Analysis

5.1 Analysis of interview results

Owing to the fact that PPPs were novel in Zambia at the time of the study, a purposive sample of 10 stakeholder interviewees were selected based on their knowledge of the PPP procurement mode. Four main areas were the focus of the interviews which included critical success factors for PPPs, the risk perception and allocation in the project, investment objectives pursued in projects as well as what financial decision-making tools are used on projects. Descriptive analysis was used on the qualitative data collected (Silverman, 2010).

5.1.1 Background information on respondents

Respondents interviewed held high or middle level positions in their organisations. 70% of the respondents had no PPP experience while 30% had none compared to the number of years served in the construction industry (Figure 2).

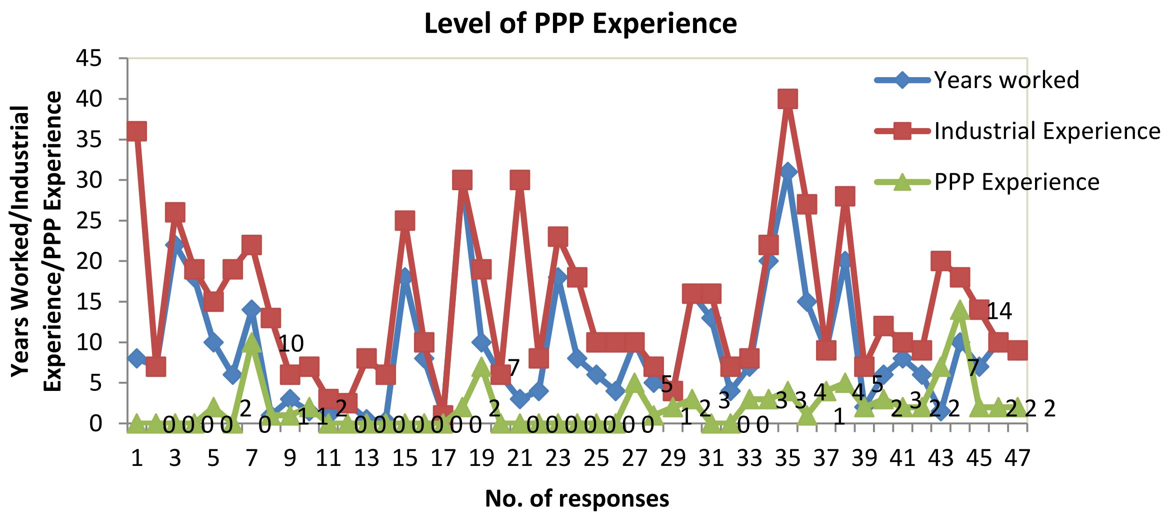
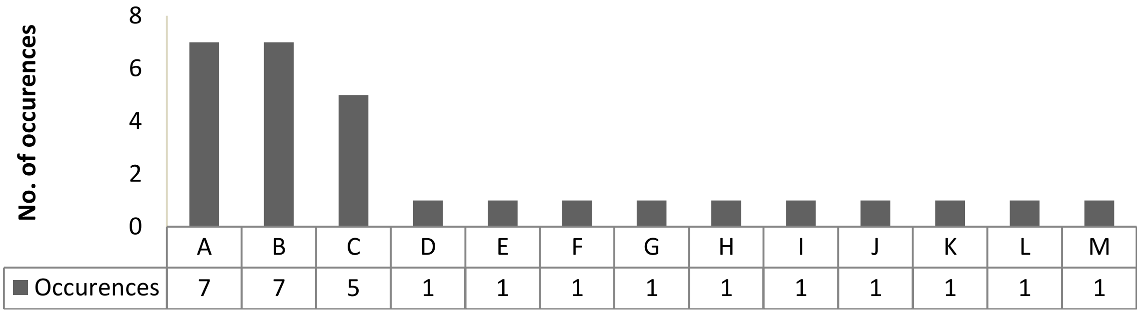


Figure 2: Experience of professionals interviewed

5.1.2 Risk perception and allocation

Interviewees were asked as to which risks would make the implementation of PPPs a difficult task. Thirteen risks were singled out as influencing the Zambian construction industry. Of these, political and high interest risk received seven occurrences, respectively. These were followed by 'lack of consistent policies' which had five occurrences. Ten risks had a single occurrence as shown in Figure 3 denoted by D to M.



A – Political risk **B** – High interest rate risk
C – Lack of consistent economic policies **D** – Foreign exchange risk
E – Global market influences **F** – Land acquisition difficulties
G – Lack of design **H** – Construction coordination risk
I – Force majeure **J** – Social risk
K – Investment risk **L** – Poor governance risk
M – Financial risk

Figure 3: Project Risks in Zambia

On the allocation of risk, interviewees were asked as to how risks should be allocated. Interviewees gave five different responses. 'Government only' bearing the risk as well as 'the best party to handle risk' each had 3 occurrences, respectively. This was followed by the private sector bearing the risk which had 2 occurrences. Sharing risk equally and having risk dealt with in other ways such as engaging a bank, each got a single occurrence from the interviewees.

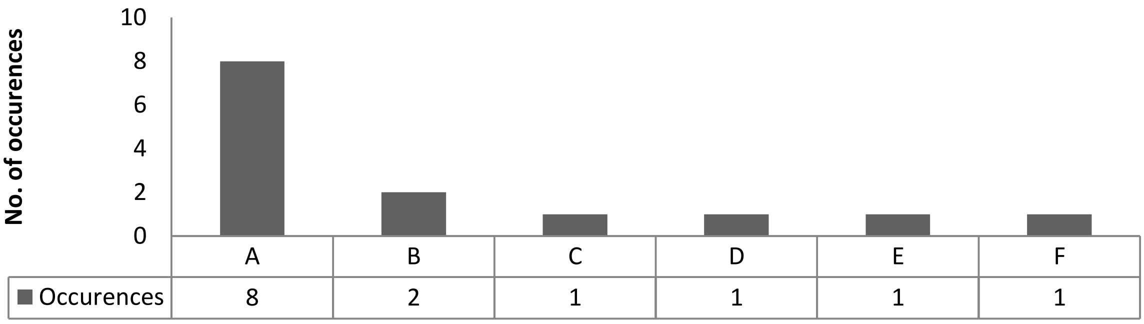
5.1.3 Investment objectives

Investment objectives are themes that PPP projects often follow. Interviewees were asked to state what objectives projects implemented had followed. The pursuit of 'social infrastructure development' had three occurrences. This was followed by the private sector that has a 'profit benefit' receiving five responses from the interviewees. Economic infrastructure was third with four occurrences. Improvement of social and economic infrastructure each had two occurrences while 'business diversification' had one occurrence indicated by the interviewees.

Interviewees were asked if the above stated objectives were aided by the PPP policy and Act No. 14. The number of respondents that agreed that the law had instigated such objectives was four while six stated that they were 'not sure'. There were no responses for those that stated 'no'. Those that had answered 'not sure' did so because they had not read Act No. 14 hence, could not correlate what was happening in the industry with the introduction of the legislation. This suggests that though there is legislation that oversees PPPs, there is lack of understanding of what is involved.

5.1.4 Financial decision-making tools

Interviewees were asked to indicate which financial decision-making tools had been used on implemented PPP projects. A total number of 6 tools were identified as shown in Figure 4. It was observed that projects applied a combination of decision-making tools. The financial appraisal tool was the most common cited by 8 interviewees. This was followed by cash flow analysis that had two occurrences from respondents. The other decision-making tools used were profit and loss analysis, development concept, cost/benefit analysis and life cycle costing which had a single response each.



A – Financial appraisals B – Cash flow analysis
C – Profit and loss analysis D – Development concept E – Cost benefit analysis
F – Life cycle costing

Figure 4: Financial decision-making tools

Respondents were asked on the effects of decision-making on project risk. The effect of using decision-making tools was that it enabled projects to be assessed which received five occurrences. This was followed by 'identification and mitigation of risk' and 'instils trust' that had two responses from the interviewees, respectively. Enhancing decision-making had 1 occurrence. The main effect of decision-making tools was the ability to make informed decisions. Interviewees were asked as to which decision-making tools were considered important for projects by financial institutions. A total number of seven decision-making tools were listed from the responses of the interviewees. Financial appraisals were the preferred decision-making tool by financial institutions as stated by six interviewees. The other utilised tools were the business plan, cash flow analysis, public sector comparator, life cycle costing, equity requirements and assurance of business, each was given a single response.

5.2 Case study observations

The two case studies conducted were those for the East Park Mall (at the University of Zambia) (Figure 5) and the Kasumbalesa Border post (Figure 6) near the Democratic Republic of Congo. Both projects were signed on Build Operate and Transfer type of PPP. Special Purpose Vehicles (SPV's) were created to facilitate the construction as well as smooth payment of loans procured for the implementation of the project. This was typically a dual entity type of structure carefully crafted for setting up the project. The agreed period of handover varied from 37 and 39 years, respectively. Amenities at the UNZA mall were to consist of retail and food shops, offices and a construction hardware facility. The Kasumbalesa facility would eventually usher in a one-stop-border post. For both cases, the payback period is most notable. The curve in figure 5 is symmetrical while the Kasumbalesa Border post one is not. Both projects were evaluated using the net present value (NPV) method over a 40-year period, which over arched the construction and handover periods for comparative purposes.

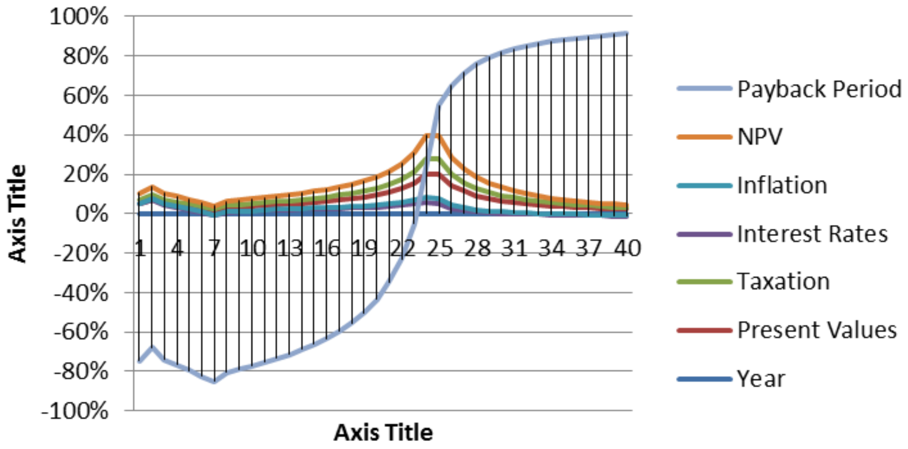


Figure 5: University of Zambia East Park Mall project

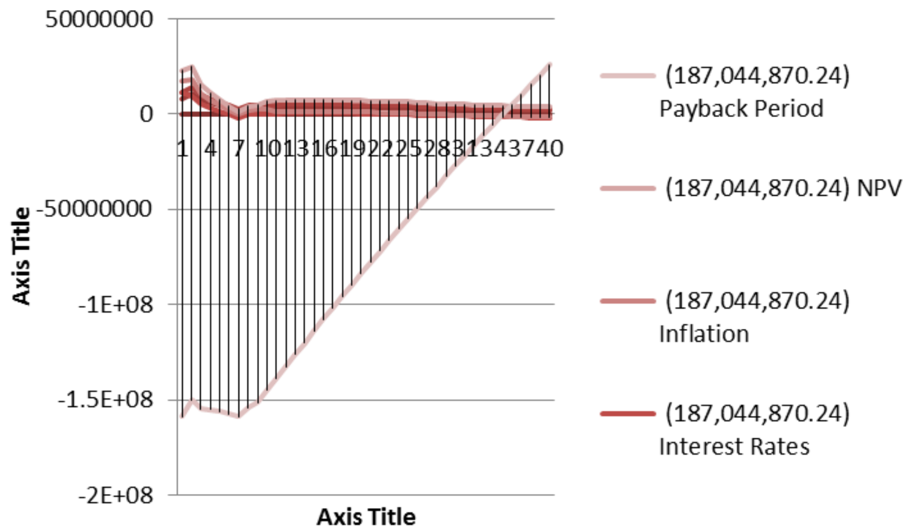


Figure 6: Kasumbalesa Border Post

The UNZA project was thoroughly scrutinised by the committee tasked to over-see the implementation of the project. From figures 5 and 6, it is worth to point out that the best tenable picture would be one seen in the UNZA case. Critical information was requested from the developer. The Kasumbalesa project, on the other hand, used varied information that suggested that the developer would make loses. This is what prompted the government to repossess the project as there was 'suspicion' of inaccurate disclosure of information. Wang (2007) stated that disclosure of accurate information normally portends successful cases. The success of the University of Zambia East Park Mall BOT implementation was because of greater scrutiny of the investors' proposals by a committee that was specially set up at the institution. Kasumbalesa Border Post BOT project (cash flows shown in figure 6), on the other hand, was temporarily repossessed by the Zambian government at some point due to inaccurate disclosure of information and later returned to the investor. Border security matters were also of great concern to the government. However, the decision to implement both projects was commendable. Owing to the fact that the dual financing structures were used to operationalise the SPV, both projects did not have complexities that were not foreseeable. The negotiation stage, which was a precursor to the construction phase, ensured that matters that would de-rail the project (such as the UNZA case) were looked into.

The decision tools stated in figure 3 (such as the cash flow analysis), would have shown the scenario obtaining for the project's financial risks to be mitigated. The internal rate of return (IRR) and payback (PB) methods would have shown the inevitable conclusion towards the success of the projects. Such was the case for the Kasumbalesa project that showed a rather unhealthy situation whose payback and handover period were rather close to each other. The suggestion was that the project was not profitable hence needed a longer time to recover invested funds.

6. Conclusion

Financial risks must be carefully considered before the implementation of project by the concessionaire. Lack of disclosure of accurate information pertaining to the project is a risk that those wishing to use PPP mode of development. A huge contingency not only affect the payment period but lengthens the hand over period. Such risks threaten to the success or failure of the project. Crucial to such risks eventually affects borrowing structures that have financed the venture. Decisions made for a project must weigh the information provided in terms of its genuineness. A careful understanding of the repercussion of financial risks is fundamental to those tasked to approve such projects. Projects would only register a healthy net present value and payback period if true information is provided by would-be investors. Only then would it be guaranteed for tax payers not to be over-burdened with unjustifiable hand-over periods. Such periods would only maximise profits to the investor and be potentially detrimental to 'beneficiaries' of PPP projects.

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DII-2017-050

Modelling the Duration of Procurement Process of Public-Private Partnership Projects in Nigeria

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Abstract

Public-Private Partnership (PPP or 3P) is a procurement strategy developed to augment infrastructure delivery and to serve as an alternative to traditional procurement method. Most countries of the world, and of course the Sub-Sahara Africa, adopted the PPP procurement model for infrastructure delivery. While some countries are still reaping the fruit of PPP model, some are yet to earn the maximum benefits from the procurement strategy because of long gestation period of PPP projects at the procurement stage. Nigeria is among those countries that embraces PPP with the passage of PPP Act into law in the year 2005. However, this article attempts to model the procurement time of PPP projects in Nigeria under the normal conditions. A mathematical model was developed for estimating the procurement time of Public Private Partnerships PPP projects in Nigeria. Secondary data from the World Bank were used and Minitab computer software version 17 was used in developing multiple regression model. The model was tested and validated using three different projects and was able to achieve the predetermined benchmark or allowance of plus or minus 10% of the established procurement time under the normal conditions. With the regression model developed, the gestation period to procure a PPP project in Nigeria was found to be approximately 635 days. This signifies that, under normal condition, it is possible to procure a PPP project in Nigeria within 635 days, showing an improvement by 4%. This time is obviously long. Unless the country strives to improve this long procurement time, its investments in infrastructure through PPPs would continue to deliver only a fraction of the potential benefits.

Keywords: procurement time, public private partnerships, regression model

1. Introduction

The traditional procurement is the oldest and most common form of public procurement. Nigeria, having been colonized by the British went ahead to adopt its governance style and business ethics. The traditional procurement approach has been practiced in Nigeria since independence. However, history has proved that traditional lump sum contracts have consistently failed to deliver projects to budget and to time (Cartlidge, 2004a). Concerned about the consistent poor performance of the traditional procurement approach, the United Kingdom (UK) government commissioned numerous studies over a span of half a century 1944-2001. These reports were meant to isolate the cause of the consistently poor results from government procurement activities (Simon, 1944; Emerson, 1962; Banwell, 1964; Latham, 1994; Egan, 1998; NAO, 2001).

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Latham (1994) and Egan (1998) were the first people that made reference to the possibility of partnering between clients and contractors for better delivery. "Partnering", as Latham (1994) had observed, 'includes the concepts of teamwork between supplier and client, and of total continuous improvement. It requires openness between the parties, ready acceptance of new ideas, trust and perceived mutual benefit. We are confident that partnering can bring significant benefits by improving quality and timeliness of completion whilst reducing costs' (Latham, 1994). However, in spite of these reports, the major construction problems of quality, cost and time overruns persisted. It has been argued that social media could be used to force policy makers to consider the 'idle' findings of project planning scholarships for onward integration into existing planning policies in order to reduce project failures which has bedevilled many megaprojects (Flyvbjerg, 2012).

Public-private Partnerships (PPP) or Private Finance Initiatives (PFI), as it was called in the UK eventually came to the fore as a result of infrastructure financing difficulties under the Thatcher regime. Under a classic PPP arrangement, the public sector specifies the services while the private sector designs and builds a dedicated asset to deliver the service, finances its construction and subsequently operates the asset and provides the services. The Public-Private Partnership model evolved out of the desire of governments to develop infrastructure while delivering important services to other sectors for which it is responsible. Even though the Nigerian government had adopted the Public Private Partnerships procurement option since 2005, the benefits have yet to be seen. PPPs have proven to be successful in developed countries and developing countries such as South Africa, Malaysia and Chile. This is as a result of spending a long and unnecessary time at the procurement phase that need to be addressed in order to achieve a successful PPP projects for infrastructures delivery and sustainable development. To this end, this article aimed at developing a mathematical model needed to calculate the procurement time of PPP projects in Nigeria under normal conditions. The finding of this study will go a long way in projecting procurement times of future projects and how to improve it.

1.1 Public-private partnerships procurement process

Public private partnerships have not been without their own problems and controversies. The general implementation process for PFI projects consists of 14 stages (Table 1) (Liu et al., 2016). There have been empirical studies which indicate that PPPs do not deliver their promised benefits (Lobina, Kishimoto, and Petitjean, 2014; Kishimoto, Lobina, and Petitjean, 2015). But a major issue has always been the duration from inception to implementation and service availability.

Table 1: Procurement timeline for West Middlesex Hospital PPP

West Middlesex Hospital PPP		
S/No	**Key milestones**	**Key milestones' date**
1	OJEU announcement	Aug-1998
2	Pre-Qualification questionnaire issued	Oct-1998
3	6 longlisted candidates issued preliminary invitation to negotiate	Nov-1998
4	3 shortlisted candidates issued Final invitation To Negotiate	Jun 1999
5	Select preferred bidder	Dec-1999
6	Full business case approval	Oct-2000
7	Financial close	Jan-2001
8	Start of construction (new build)	Aug 2001
9	Completion of construction (new build)	Mar-2003
10	First patient day	May-2003
11	Hospital completely operational	Jun-2004

Cartlidge (2004) outlined measures for reducing procurement time by enumerating 9 measures including:

- Reduce the stages for tendering from the current recommended 14 stages, an option currently under review by the Office of Government Commerce.
- Reduce time up to best and final offer
- Eliminate the best and final offer stage
- Reduce the number of bidders to two or three
- Develop the brief as fully as possible with improved project definition before issue to bidders
- Reduce the need for up-front detailed design
- Increasing and retaining public sector expertise
- Standardization of PFI contracts
- Do not ask bidders for full due diligence before preferred bidder stage, as this operation is often repeated on the request of the financiers before financial close, much to the frustration of the rest of the team who see matters that they thought were agreed and settled, unbundled for reconsideration.

The various stages that Cartlidge (2004) advocates to be excluded are very important for the effectiveness of PPP procurement, instead measures should be taken to make the processes more efficient. For example, countries like Ghana and Cameroun undertake these processes and are still able to conclude procurement in less than 100 calendar days against Nigeria’s 660 calendar days(Bank, 2015). What needs to be done is to look at the individual processes from inception to award of contract and identify the causes of delays in the process. Because, other factors could be responsible for the lengthy duration of the PPP procurement other than the processes and number of stages involved. For example, lack of high level political support for PPPs and weak public sector PPP capacity have been argued to be some of the factors responsible for long gestation periods(Yong, 2010, p. 110). Strong government support indicates to the private sector the readiness and commitment of political leaders to the project thereby building their confidence to participate in the process.

1.2 Need for the model for estimating procurement time

The importance of PPP procurement scheme for infrastructures delivery in any growing economy cannot be over emphasized; because they have been found to support foreign direct investments and economic growth. It is however important to determine the actual procurement time of PPP Projects in Nigeria under the normal condition. World Bank (2015) determined the duration of PPP procurement n ten different economy including Nigeria using survey questionnaire. The value for Nigeria was found to be 660 calendar days. However, this method was found to be crude and based on many assumptions (Bank, 2015). To this end, the need for more scientific method of calculating and arriving at the more accurate value of number of calendar days required to procure a PPP project in Nigeria arose, hence regression model will serve as the solution. Modelling using regression has been found to be reliable because it involves training of all the variables inputs in the equation (Harrell, 2015).

Therefore, the results of this study would go a long way in helping the Nigerian government understand if at all they need to do better and what they should avoid to hasten benefits realization from their pipeline of PPP projects. It is expected that the proposed PPP model will serve as a useful tool in proper planning by government officials. The finding of this study would also contribute to the growing body of knowledge and also serve as a basis for further research among academics. It is also hope that the findings will foster greater debates among academia, policy-makers, designers/planners, clients/Developers, on the relative merits of adopting PPPs as a procurement strategy and be a reference material for future discussions on the issue.

2. Research Methodology

According to (Maxwell, 2012), In order to archive objectives of any research, the researcher has to have a robust research design that will leads to a successful achievement of the objectives and testing the hypothesis of the research.

Research designs are programs or plans that guide the investigator in the process of collecting, analyzing and interpreting observations of data (Stephen and Christopher, 2004). Furthermore, the research design should be geared towards meeting the purpose of the research and to provide a program used by the researcher to answer the research questions.

2.1 Nature of data for computing procurement time of public private partnership projects in Nigeria

Secondary data sources are generally suitable for computing procurement time of Public Private Partnership Projects in Nigeria. Secondary data from World bank data-base were compiled for modelling the procurement time. However, the data was found to have a positive correlation between the variables in the equation which are suitable for modelling the procurement time of PPP projects in Nigeria.

2.2 Mathematical formulation (multiple regression)

Multiple regression analysis is used to estimates numerical relationship between and among two or more variables. It can be defined as the science of estimating in functional form, the dependence of one variable upon another.

The simple linear function is presented hereunder:

$$y = p + qx$$

Where,

p = is the intercept on vertical axis (Y– axis) i.e where the graph crosses the y axis, x = is variable and q is the gradient of the line at which the differential coefficient of y with respect to x equals to zero.

The constants "p" and "q" of simple regression liner function (y = p + qx) are determined by:

$$q = \frac{n \sum xy - (\sum x)(\sum y)}{n \sum X^2 - (\sum X)^2}$$

$$p = y - qx$$

Minitab computer software version 17 was used in finding the values of p-and-q. This technique helped in developing the mathematical equations for "forecasting" the effect of one or more variable based on another variable.

However, the use of multiple linear regression in this article is in line with the fact that the variables: concession period (CP), procurement time (PT), financial close year (FCY), Project Value (PV) has direct and positive correlations with each other as stated by Kaiser, (Kaiser and Liu, 2014). This therefore signifies that, the procurement time of PPP project is dependent on the project value, concession period, type of project (green or brown field), complexity of the project. Therefore, these variables are suitable for the equation.

2.3 Regression Model for computing procurement time of PPP projects in Nigeria

Table 2: Regression Results

Variables	Regression Equation	% R^2	F -Cal	F - Tab	P Value	Highest Correlation	Inference
procurement time (PT) Vs concession period (CP) Vs financial close year (FCY) Vs Project Value (PV)	(PT) = 7994 + 0.173 (PV) - 3.70 (FCY) + 0.479 (CP)	96.7	217.83	3.05	0.000	0.977	Significant

2.4 Discussion on result

It can be deduced from the table above, F calculated (F-Cal) 217.83 > 3.05 value of f tabulated when 5% level of significant is used, and the coefficient of correlation between the Procurement Time (PT) and Project Value (PV) was found to be = 0.977 showing a strong and significant statistical relationship among the variables involve in the equation. However, the coefficient of determination $\mathbf{R^2}$ was found to be 96.7%, this connote that, 96.7% variation in procurement time of PPP projects in Nigeria is accounted for, by a change in the combination of all the variables; namely concession period (CP), financial close year (FCY), Project Value (PV) related to PPP projects in Nigeria. It further confirms that, there is significant statistical relationship between the variables used in the prediction.

In the same vain, a regression procurement time model was derived as follows:

(PT) = 7994 + 0.173 (PV) - 3.70 (FCY) + 0.479 (CP)

Where PT = Procurement time in days, PV = Project value in million USD, FCY = The financial close year and CP = Concession period in years.

The scattered plot in figure 1, indicates the general tendency for procurement time increased to a result of increase project value for PPP project in Nigeria. This is because the scattered points are concentrated along the straight line of best fit. The finding of the wold ban

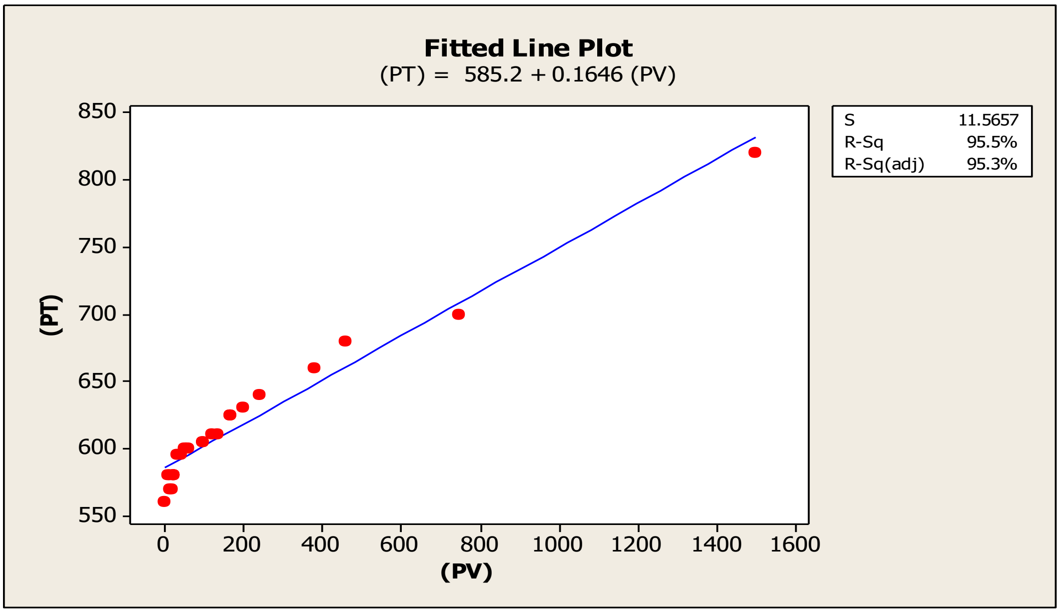

Figure 1: Regression Plot of PPP procurement time Vs Project value

2.4.1 For Example, No. 1: –

The following data which was not trained in the model is used to compute the procurement time of PPP projects in Nigeria under the current condition:

An active 'Affam Power Project' a brownfield PPP project in Nigeria has a project value of USD238 million, and was financially closed in the year 2005. The concession period for the project was pegged at 25 years.

Using the equation, the procurement time is estimated thus:

(PT) = 7994 + 0.173 (PV) - 3.70 (FCY) + 0.479 (CP)
By substituting the values in the equation, the Procurement Time (PT) can be predicted as follows:
(PT) = 7994 + 0.173 (238) - 3.70 (2005) + 0.479 (25)
7994 + 41.174 - 7418.5+ 11.975 = 628.649
PT ≈ 629 days

2.4.2 For Example, No. 2: –

An active 'West African gas Pipeline Project' a greenfield PPP project in Nigeria has a project value of USD590 million, and was financially closed in the year 2005. The concession period for the project was pegged at 30 years.

Using the equation, the Procurement time is estimated thus:

(PT) = 7994 + 0.173 (PV) - 3.70 (FCY) + 0.479 (CP)
By substituting the values in the equation, the Procurement Time (PT) can be predicted as follows:
(PT) = 7994 + 0.173 (590) - 3.70 (2005) + 0.479 (30)

7994 + 102.07 - 7418.5 + 14.37 = 691.94
<u>PT ≈ 692 days</u>

2.4.3 For Example, No. 3: –

An active 'Bullnose Port Facilities' a greenfield PPP project in Nigeria has a project value of USD142.4 million, and was financially closed in the year 2011. The concession period for the project was pegged at 25 years.

Using the equation, the Procurement time is estimated thus:

(PT) = 7994 + 0.173 (PV) - 3.70 (FCY) + 0.479 (CP)
By substituting the values in the equation, the Procurement Time (PT) can be predicted as follows:
(PT) = 7994 + 0.173 (124.4) - 3.70 (2011) + 0.479 (25)
7994 + 21.52 - 7440.70 + 11.98 = 586.7962
<u>PT ≈ 587 days</u>

2.5 Summary of Findings

The findings of the study are summarised in Table 3 and Figure 2. These reveal that time can be saved on projects where the procurement time is particularly attended to.

Table 3: Regression results

S/N	Project	Actual Procurement Time (in days)	Calculated Procurement Time (PT) (in days)	Percentage Deviation From the 660 Days
1	Affam Power Project'	654	629	-4.70
2	'West African gas Pipeline Project'	688	692	4.85
3	Bullnose Port Facilities	603	587	-11.06
	Average Procurement time of the three projects	648.33	634.67	-3.64

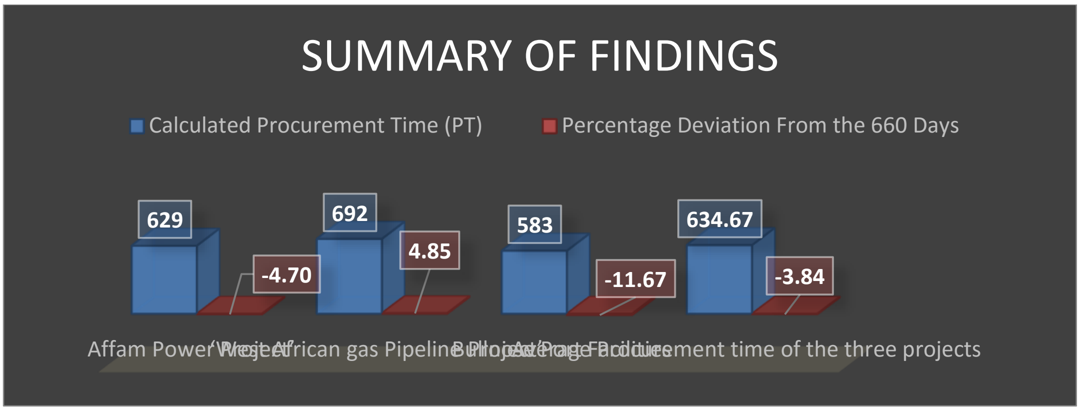

Figure 2: Bar chart showing the summary of findings

3. Conclusion

Countries such as Nigeria that rely heavily on crude oil as a major revenue source are at across roads of what to do in the face of falling crude oil prices. As the traditional source of investment shrink further in 2017, it reinforces the fact that PPPs will become indispensable as a major source of closing the infrastructure gap in Nigeria.

A mathematical model was developed for estimating the procurement time of Public Private Partnerships PPP projects in Nigeria under normal conditions. After testing and validating the model using three different project, the model was able to achieved the predetermined benchmark or allowance of plus or minus 10% of the established procurement time under the normal conditions. By taking the average procurement time of the three projects, the value of the procurement time of PPP project in Nigeria was found to be approximately 635 days. This value is less than the value of procurement time established by World Bank by 4% only. This signifies that, under normal condition, it is possible to procure a PPP project in Nigeria within 635 days, showing an improvement of by 4%. However, this value is still high compare to the 65 calendar days in Ghana and 75 calendar days in Cameroun.

However, Nigeria would only benefit from its adoption of PPPs if it improves on its procurement time, reducing it from the current 660 calendar days to the 65 calendar days achieved in Ghana or the 75 calendar days achieved by her neighbour Cameroun. Unless Nigeria strives to do this, its investments in infrastructure through PPPs would continue to deliver only a fraction of the benefits potentials.

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DII-2017-066

A Theoretical Assessment of the Challenges of Public Private Partnership in Improving Infrastructure Service Delivery in Swaziland

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Abstract

Public-Private Partnerships (PPPs) play an important role in improving the quality of infrastructure service delivery in different countries. In the construction industry, PPPs contribute to skills transfer by the private sector to the public sector and achieving greater efficiency by reducing government bureaucracy and financial burdens. However, these partnerships have challenges that hinder the implementation and delivery of infrastructure. This research examines challenges encountered in the implementation of PPP in construction projects. The study is a literature review/ survey on the challenges faced with the implementation of public private partnership in improving infrastructure service delivery on projects. The study is conducted with reference to existing theoretical literature, published and unpublished research based on international context. However, the challenges specifically are based on literature in Swaziland to identify the challenges they face and the way forward. Other scholars'works were critically examinedtodeterminethe views on the subject. The research revealed that on the political level, there are high expectations with concerns that officials expertise to handle PPP projects are not sufficient, Private sector stakeholders were concerned about the possible dominance of foreign companies. Moreover, labour feared negative consequences for workers, and part of financial sector did not see enough opportunities for PPP in Swaziland. Lack of common understanding and coordination, insufficient planning capacity and structuring support were amongst the challenges faced by PPP in Swaziland.The study will assist the Swaziland Construction Industry in improving their services in terms of delivering construction project timeously since particular strategies can be developed to overcome the identified challenges.

Keywords: construction projects**,** infrastructure, public-private partnerships, Swaziland

1. Introduction

Literature revealed that most countries are experiencing backlog in infrastructural service delivery and this has a negative impact on the economy and the residents of the country (Greve and Hodge, 2005). Most countries have been doing their best to come up with solutions to this challenge and PPPs is one of the solutions being adopted (Asmati, 2010, Babatunde and Opawole, 2012 and Greve and Hodge,

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2005). However, PPPs is not the answer to infrastructural service backlog but it can only reduce the challenge faced by our government (Asmati, 2010, Babatunde and Opawole, 2012 and Greve and Hodge, 2005). PPP's have been used in a number of countries as a means to deliver and manage public infrastructure (Asmati, 2010, Babatunde and Opawole, 2012 and Greve and Hodge, 2005).

Many countries in Africa including Swaziland depend and rely on the developments funded by the public sector (Asmati, 2010, Vilane et al, 2012 and Axis Consulting, 2013). According to Greve and Hodge (2005), PPPs are loosely defined as cooperative institutional arrangements between the public and private sectors and it has a new gained wide interest around the world. There has considerable research work conducted, both locally and internationally, on the nature and form of PPPs (Asmati, 2010). This study would focus on the challenges faced with the implementation of public private partnership in Swaziland.

1.1 Swaziland

Swaziland is very small country. It is heavily dependent on its neighbours for access to the sea, to the markets and to outside suppliers (Mashwama et al, 2016). Swaziland's population is estimated at around 1.4 million. Swaziland is Africa's last monarchy, ruled by King Mswati III, subject to constitution of 2005. The constitution involves some democratic element and protection of human right (Mashwama et al, 2016). The Kingdom is divided into four districts namely Hhohho, Manzini, Lubombo and Shiselweni District. The capital city is Mbabane in the Hhohho District with a population of around 100,000 (Thwala and Mvubu, 2009).

1.2 Swaziland construction industry

The construction industry (CI) in Swaziland is a key component of economic growth. For the developing countries the construction industry plays even a greater role in development and poverty alleviation by providing access to basic services and transport facilities (Mashwama et al, 2016). The construction companies operating in Swaziland range from small local contractors to major companies with the capability to carry out highly specialised projects. The large contractors employ about 20,000 people. The range of work undertaken in the construction industry covers small buildings, multi-level projects, roads, dams and infrastructure. Therefore, the CI is a key source of work and income in the Kingdom. The overall contribution to the Gross Domestic Product (GDP) by the construction industry was 5.8% in 2002, but it has dropped down to 2.8% in 2013 (Swaziland Business year book 2002, Central bank of Swaziland). Government is the major client in the construction industry of Swaziland. The ministry of Public Works and Transport is the Government's implementing agency on behalf of all ministries with regard to all construction capital projects (Mashwama et al, 2016). The Swaziland Government through the ministry of Public Works and Transport also has a responsibility to educate contractors and subcontractors about government's expectations of the quality of work; the process of tendering and the information required (Thwala and Mvubu, 2009). The Government of the kingdom of Swaziland, through its 25- year National Development Strategy has identified the construction sector as a priority area to provide the impetus on improve the social and economic development of the country. However, the Agriculture industry is the one that leads by contributing more to the economy of the country.

2. Theoretical overview of Public Private Partnership (PPP)

2.1 Definition of Public Private Partnership

There is no common definition for the concept of public private partnerships, as it is usually defined in relation to the various forms it assumes (Boardman, Greve and Hodge, 2010). PPP is defined as any medium to long-term relationship between the public and private sectors, involving the sharing of risks and reward of multi-sector skills, expertise and finance to deliver desired policy outcomes (Delloite, 2010). The World Bank (year) defines PPP by looking at various key elements such as the existence of a partnership style approach to the provision of infrastructure as opposed to an arm's-length "supplier" relationship (The World Bank, 2007). Both parties take either individual or joint responsibilities; risk sharing, reward and value for money (The World Bank, 2007). PPP is defined as a collaborative arrangement over one or more phases of the life cycle of a project between a government or its agency and one or more private sector parties. The rights and responsibilities are innovatively specified, with the elements of sharing risks and rewards in a long-term contractual relationship (Manchidi and Merrified, 2001).

2.2 Types and forms of PPPs

There is rich information coming out from literature in categorizing various forms of Public Private Partnerships (Chib et al., 2009). It has been stated earlier that lack of uniformity in the definition of the concept of PPP is as a result of the different forms of PPP models (UNESCAP, 2007). Literature reveals that various institutions and authors choose to classify different modes of PPP based on their understanding. However, the most common PPP modes found in various literatures include, amongst others, the following:

- *Build-Operate-Transfer (BOT).* The arrangement involves the transfer of responsibility for constructing, financing and operating a single facility to a private sector partner for a fixed period of time. At the end of that period, the responsibility reverts to the public entity (Fastrich and Girmscheid, 2007; Alfen et al, 2009, Vilane et al., 2012).
- *Design-Build-Finance-Operate (DBO).* The service provider is usually responsible for financing the project during construction. The government purchases the asset from the developer for a pre-agreed price prior to commissioning and takes all ownership risks from that time (Manchidi, et al,2006, Vilane et al, 2012, Houghton, 2011 and Koning, 2007).
- *Build-Operate-Own (BOO).* It involves the granting of ownership rights in perpetuity to develop, finance, design, build, own, operate and maintain an asset. The private sector own the asset outright and retains the ownership and operating revenue risk, with no transfer to the public sector (Alfen, et al, 2009 and Vilane et al, 2012).

The PPP models can therefore vary from short-term simple management contracts to long-term very complex contracts, based on ownership of the capital assets, responsibility for investment, assumption of risks, and duration of contract.

2.3 The rationale for the establishment of public private partnerships

The Government of Swaziland is currently facing challenges in infrastructure development and public service delivery. Moreover, the government has made slow progress in addressing the infrastructure gap due to low implementation rate of capital projects, low economic growth rate and the most recent cash flow challenges faced, not only by Swaziland but by international economies as well (Axis Consulting, 2013). Inadequate infrastructure is a constraint on growth worldwide, and particularly in developing countries. Infrastructure services are often inadequate to meet demand, resulting in congestion and they are often of low quality or reliability, while many areas are simply un-served (Ntshangase, 2002; Bovis 2010). This poor infrastructure performance especially in delivering construction projects reflects universal challenges facing governments (Bovis, 2010 and Rilley and Kraft 2010). Literature reveals that poor planning and coordination, weak analysis underpinning project selection, pursuit of political gain, and corruption, means that the limited resources are often spent on the wrong construction projects (Babatunde and Opawule, 2012; Fastric and Girmsheid, 2007 and Ntshangase, 2002). Furthermore, according to Manchidi et al (2006) and Vilane et al, (2012), there are fiscal constraints, which hinder the implementation of infrastructure projects and thus a need arises to overcome these challenges. One of the ways to overcome the challenges in infrasturtrue delivery is through PPPs as suggested by Manchidi et al (2006) and Vilane et al. (2012), who stated that given the fiscal constraints in Swaziland, Public-Private Partnerships are discussed as an alternative method of realizing infrastructure delivery and supplementing public sector resources.

Many authors and institutions have spent considerable amount of time in explaining and providing motivations for the existence of PPPs in various parts of the world, including Swaziland (Akintoye et al., 2003 and Vilane et al, 2012). The most common reason provided by many authors is the reality of lack of government budget to fund public infrastructure service delivery, and as a result they seek partnerships with the business/private sector to achieve this objective (Vilane et al., 2012, Manchidi and Merrified, 2001; Deloitte, 2010; Alfen et al., 2009). With the great number of priorities competing for public funds, governments are pressed to create more avenues to fund and meet infrastructure needs (Deloitte, 2010).

One of the key political drivers behind the PPP is the desire to improve the nation’s infrastructure and supporting public services without placing undue strain on scarce public funds and without having to increase taxation (Axis Consulting, 2013 and Alfen, et al, 2009). Other reasons for the adoption of PPP model by various governments include; skills transfer by the private sector to the public sector and achieving greater efficiency by limiting the usually lengthy government bureaucracy. The public sector is usually rich in human resources but lacks in expertise whereas private sector has more expertise but lacks in human resources (Asmat, 2010). The private sector can often react more quickly, as there is no bureaucratic hierarchy for decision making (Asmat, 2010). These views were expressed in an article by Matsapha (2017), in which it was remarked that Swaziland could reach first world status if only they could adopt the right approach to budgeting such as the PPP. The article further revealed that the performance of ministries tasked with disburding funds to finance public projects was poor and thus the need for PPPs is great.

PPPs can mobilize additional sources of funding and financing for infrastructure and they can help improve project selection, subjecting assumptions to the market test of attracting private finance (Rogerson, 2010, Wettenhall, 2003, Vilane et al, 2012 and Bovis, 2010). Countries with relatively long PPP histories have found that PPPs manage construction better than traditional procurement, with projects coming in on time and on budget more often (Bovis, 2010). PPPs can also help to ensure adequate maintenance and keep assets in a serviceable condition (Rogerson, 2010 and Rilley and Kraft, 2010). Delivered PPP projects are also of good quality. (Axis consulting, 2013 and Vilane et al, 2012). Some of the projects that were delivered successfully in Swaziland, include the following:

- Uniswa Housing, where Swazi MTN partnered with the University of Swaziland and took centre stage in providing finance for the designated capital projects at the school (Observer, 2013).
- Manzini shopping mall, which was provided to improve the socio-economic use of the land on which the development was undertaken and to complement other recent development within the city (Zwane, 2015). The project was developed under a PPP where the municipal council of Manzini issued public notice inviting expressions of interest and following a bidding process, the Manzini trade centre successfully entered into a PPP with the council.

However, the above projects among others, also faced some challenges including cost overruns, lack of policy direction, unstable governments, and so on. These are discussed further in the following section.

2.5 Challenges faced by PPPs in Swaziland

Every partnership of any kind comes with challenges and obstacles that might be a threat to success of the vision they have. Review literature shows that PPPs are faced with a lot of challenges when it comes to its implementation to deliver services in Swaziland (Axis consulting, 2013, Vilane et al, 2012 and Delloite, 2010). PPP implementation in the Kingdom of Swaziland has faced various challenges such as:

2.5.1 Lack of highest level policy direction

PPPs are lacking at the highest levels of leadership at government level. The management of PPPs from government level does not provide clearer and more predictable intent on when and why to do PPPs in general, and in specific sectors (Vilane et al, 2012). According to David Wright in a proceeding held at Ezulwini Royal hotel states that the PPP projects should be those the country needs the most and should be beneficial to the community as a whole".

2.5.2 Lack of consistent political resolve

Reviewed literature states that political leadership shows inconsistent commitment to PPPs. Commitment to PPPs suffers from the fact that policy on PPPs changes with changes in political leadership (Vilane et al, 2012).

2.5.3 Lack of Resources dedicated to fostering public private partnerships

The resources to do all that is needed to be done to foster successful PPPs are lacking in Swaziland. Less resources are devoted to promoting PPPs and building capacity within line departments or ministries and municipalities to implement PPPs (Axis Consulting, 2013).

2.5.4 Policy bias toward traditional public procurement

Literature revealed that traditional public procurement of infrastructure services is the default choice in most countries in the world (Vilane et al, 2012). Ministries must therefore, decide first if they want to consider a PPP for a given project and then prove that a PPP would provide more value-for-money than traditional government procurement (Axis Consulting, 2013).

2.5.5 Conflicting interests of parties

According to the United Nations HABITAT (2011), PPP arrangements are challenged with drastically different interests as a result of parties from different backgrounds, along with differing strategic and operational realities. As a result, relationships need to be built, otherwise projects might fail. The failure of many alliances can be traced to the partner selection and planning stages (UN-HABITAT, 2011).

Other challenges encountered in successful realisation of a PPP configuration in Swaziland include:

- Swaziland has not adopted a specific PPP legislation and these seems to be a general lack of understanding of the term PPP;
- Lack of experience- when executing complex projects from the government sector;
- Poor tender process from the government sector;
- Insufficient planning capacity as well as structuring support from the government sector;
- Lack of capital and business training for outsourced employees remain a bottleneck;
- Limited possibilities for local participation;
- Lack of competition (Natural monopoly) and political commitment to set cost recovery tariffs
- Lack of funding due to government being bad payer, for example E2,8BN was owed to a private sector after a partnership with the government, hence the private sector they discouraged to do the partnership because it could lead to collapsing of the financial system, risking depositors funds in the process (The times of Swaziland, 2012).
- the long-term planning horizon;
- the complexity of various projects;
- the institutionalized competition rules for public projects;
- the hold-up problem caused by a change in the position of partners;
- a technocratic implementation;
- Lack of information:
- reductionist measures instilling competitive norms instead of cooperative ones; and
- Cultural differences between private and public partners (Axis Consulting, 2013).
- Project development: The project development activities such as, detailed feasibility study, land acquisition, environmental clearances etc., are not given adequate importance by the concessioning authorities (Grimsey and Lewis, 2004).
- Lack of institutional capacity: The limited institutional capacity to undertake large and complex projects at various central ministries and especially at state and local bodies' level hinder the translation of targets into projects (The times of Swaziland, 2014).
- Financing availability: The private sector is dependent upon commercial banks to raise debt for the PPP projects. With commercial banks reaching the sectoral exposure limits, funding the PPP projects is getting difficult (Vilane, et al, 2012).

Literature revealed that regulatory environment must be in place in order to attract more domestic and international private funding of infrastructure, a more robust regulatory environment, hence an independent regulator, is essential (The Times of Swaziland, 2012 and Grimsey and Lewis, 2004).

3. Research Methodology

The research was conducted with reference to existing theoretical literature, published and unpublished literatures from online journals, magazines, Times of Swaziland, Conferences, Proceedings dissertations. Articles from google scholar, ASCE library, Emerald were used. A total of 41 articles were reviewed/ used and they were all relevant to the subject matter PPP. The study is mainly a literature survey/review and looks at the literatures relating to public private partnership in the construction industry. This is because, the challenge inherent in PPP arrangements also arises from the notion of building new relationships between actors that have drastically different interests and are from different backgrounds, along with divergent strategic and operational realities. The current methodology falls within the qualitative research methodology (Neuman, 2000 and Leedy, 1989).

4. Lessons Learnt

Literature revealed that Swaziland, depend and rely on the developments funded by the public sector thus bringing financial constrain to the economy (Greve and Hodge, 2005 and Axis Consulting, 2013)). Inadequate infrastructure is a constraint on growth worldwide, and particularly in developing countries. Infrastructure services are often inadequate to meet demand, resulting in congestion and they are often of low quality or reliability, while many areas are simply un-served (Axis Consulting, 2013, Bovis 2010 and Ntshangase, 2002). This poor infrastructure performance reflects pervasive challenges facing governments of Swaziland (Manuel, 2007, Vilane et al., 2012; Bovis, 2010;). Reviewed literature reveals that Swaziland has not adopted a specific PPP legislation and there seems to be a general lack of understanding of the term PPP; Lack of experience- when executing complex projects from the government sector; Poor tender process from the government sector; Insufficient planning capacity as well as structuring support from the government sector.

Furthermore, Lack of capital and business training for outsourced employees remain a bottleneck; Limited possibilities for local participation; Lack of competition (Natural monopoly) and political commitment to set cost recovery tariffs were also the major challenges faced by the implementation of PPP in Swaziland. Moreover, Lack of funding due to government being bad payer, for example E2,8BN was owed to a private sector after a partnership with the government, hence the private sector they are discouraged to do the partnership because it could lead to collapsing of the financial system, risking depositors funds in the process (Axis Consulting, 2013 and Vilane et al, 2012); The long-term planning horizon; The complexity of various projects; The institutionalized competition rules for public projects; The hold-up problem caused by a change in the position of partners; A technocratic implementation; Lack of information: reductionist measures instilling competitive norms instead of cooperative ones; and Cultural differences between private and public partners (Axis Consulting, 2013).

In addition, project development activities including detailed feasibility study, land acquisition, environmental clearances etc., are not given adequate importance by the concessioning authorities (Grimsey and Lewis, 2004). Lack of institutional capacity: The limited institutional capacity to undertake large and complex projects at various central ministries and especially at state and local bodies' level hinder the translation of targets into projects (Axis Consulting, 2013) were amongst the challenges in Swaziland. Financing availability: The private sector is dependent upon commercial banks to raise debt for the PPP projects. With commercial banks reaching the sectoral exposure limits, funding the PPP projects is getting difficult (Vilane, et al, 2012). poor planning and coordination, weak analysis underpinning project selection, pursuit of political gain, and corruption, means that the limited resources are often spent on the wrong projects (Axis Consulting, 2013 and Vilane et al, 2012) were key contributors to hindrance of ppp implementation. One of the key political drivers behind the PPP is the desire to improve the nation's infrastructure and supporting public services without placing undue strain on scarce public funds and without having to increase taxation (Axis consulting, 2013 and Alfen, et al, 2009). Other reasons for the adoption of PPP model by various governments include amongst others;

skills transfer by the private sector to the public sector and achieving greater efficiency by limiting the usually lengthy government bureaucracy. Public sector is usually rich in human resources but lacks in expertise whereas private sector has more expertise but lacks in human resources (Asmat, 2010). The private sector can often react more quickly, as there is no bureaucratic hierarchy for decision making (Vilane et al, 2012 and Asmat, 2010).

5. Conclusion

This article has examined literature relating to the challenges faced with the implementation of Public Private Partnership in construction projects. Through PPP, Both the private and public sector stand to benefit and public sector is able to leverage private sector resources for infrastructure development, improvement and maintenance. The public sector is able to tap into private sector efficiencies and also benefit from the skills transfer from the private sector. Moreover, the Private sector gets an opportunity to influence and introduce changes and innovations to traditional Government methods both for infrastructure development and service delivery because PPP's are based on output on the output and the process is left to the private sector. From the above challenges revealed by the literature Swaziland must have a strong political commitment to policy implementation, Adopt a legal fame work; Ensuring that private sector participants are able and willing to participate in the processed sponsored by government and they must provide necessary services and capital for the Government. Transparency and accountability is encouraged.

6. Recommendations for Further Studies

The concept of PPP is relatively new in the functioning of the Swaziland economy, and therefore, it will require further research which will seek to closely examine on how the PPP initiatives can be entrenched as a reliable mode of delivering effective service delivery. Further research should also be conducted in assessing the approach and attitude of government institutions towards the PPPs, and thereby measuring the involvement of PPPs in the broader government infrastructure development projects. If indeed PPPs are perceived as an effective and efficient means of delivery infrastructure, it will be interesting to see as to what extent PPPs are involved in the overall government infrastructure development programme.

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DII 2017-053

Centralised vs. Decentralised Electricity Generation in Zambia: Sustainable Options in the Context of Climate Disturbances

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Abstract

This paper utilises methodology and results outlined in a previous paper to investigate the feasibility of a hybrid large scale centralised and residential solar photovoltaic (PV) approach to address the rapidly growing electricity demand in Zambia and the electricity deficit caused by droughts due to climate disturbances. It was found that the best centralised generation approach prioritised solar projects with the highest generation/cost ratio, producing power at US0.042/kWh, which is comparable with existing hydro generation costs of USD0.02-USD0.03/kWh. For decentralised generation, the solar PV generation potential of Lusaka, Zambia's capital was analysed. In particular, the ability of on-grid and off-grid rooftop PV to meet the deficit was assessed, and it was found that a fully decentralised approach is not economically feasible, as it costs between 6 and 12 times as much as existing generation per kilowatt-hour. Finally, a series of hybrid centralised-decentralised scenarios were considered, and the 70% centralised, 30% decentralised approach was found to best address Zambia's electricity shortage. Not only would the cost of power be affordable, but it would also have a quicker implementation time, greater consumer autonomy and ease of planning, more diverse sources of funding, and would enable Zambia to become a continental leader in renewable energy.

Keywords: centralised and decentralised generation, climate change, renewable energy, rooftop solar PV, Zambia

1. Introduction

The current paper brings together three discrete fields - centralised vs. decentralised generation, the estimation of urban rooftop potential, and economic and political feasibility – for application in Zambia in the context of climate change and drought. It investigates summarizes two energy alternatives, large scale centralised generation and residential solar PV, to augment the existing energy infrastructure in Zambia and address both the rapidly growing electricity demand and the electricity deficit caused by droughts due to climate disturbances. Specifically, it strives to answer the question of what respective roles can centralised and decentralised generation play in Zambia as the impact of climate change becomes increasingly evident??

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A previous paper by the same authors (Ismail, et al., 2017) outlines the methodology and results used for this paper (referred to below as "the Methodologies paper"). This paper also builds on analysis conducted by McPherson and Ismail (McPherson & Ismail, 2017), which analyzed the generation potential of both rooftop solar in Lusaka and centralised solar and wind sites. Furthermore, this paper presents part of the research work contained in the University of Toronto Engineering Science thesis by the lead author (Ismail, 2017). The thesis contains additional references used as background in this research.

2. Results and Discussion

This paper conducts an analysis of whether a centralised, decentralised, or hybrid solution is the most effective way of mitigating Zambia's electricity shortage in addition to existing generation. The first part of the analysis discusses the economics of the two options, considering cost of power produced, investment costs required, transmission infrastructure costs, amongst others. The second part of the analysis explores a hybrid centralised-decentralised solution, and will examine its political and socioeconomic impact.

2.1 Centralised generation scenarios

The first approach was to determine the most effective centralised generation solution to Zambia's shortage. 9 scenarios were considered to deduce the best approach to a large, centralised generation solution in 2015, 2020 and 2030. An in-depth description of these scenarios and the analysis conducted can be found in the Methodologies paper.

By comparing project cost, generation dispersion, average deficit, and resource quality, Scenario E1 is the recommended approach to address the deficit between 2015 and 2030, as it will enable the country to most effectively minimize the economic impact of a generation shortage over the next 15 years. Additionally, given the deficit relief that additional generation in 2020 provides, capital investments in new centralised renewable generation projects can be staggered, giving the government time to secure contracts with international developers and banks. It also gives them time to develop and implement the necessary policies and regulations.

Under Scenario E1, and given the assumptions stated in the Methodologies paper, the cost of power was determined to be \$0.042/kWh when considering entire cost of the scenario (project cost and transmission costs). If only the project costs are considered, the cost of power was calculated to be \$0.035/kWh, which is comparable with existing centralised hydro generation costs between \$0.02/kWh and \$0.03/kWh (International Renewable Energy Agency, 2013). Regardless, Scenario E1 would be highly profitable to a developer, assuming they receive a purchasing-power agreement of \$0.06/kWh from the Zambian government.

2.2 Rooftop solar

The ability of solar home systems in Lusaka to address Zambia's generation deficit was also explored. The Methodologies paper considered two configurations for decentralised rooftop solar – grid connected and non-grid connected. The total cost and the cost of power of various configurations of centralised and decentralised rooftop solar scenarios were examined. A detailed description of the scenarios considered and the determination of their costs can be found in the original paper. It was determined that a solely rooftop solar approach to addressing Zambia's electricity deficit was too expensive, costing between 6 and 12.5 times more than conventional electricity sources in Zambia. Furthermore, urban electrification is a resource intensive, arduous and slow process, and therefore there would likely be delays in its implementation. During this extended execution period, Zambia's deficit will remain, which will continue to hamper its economy, and will be only be slightly offset by the operation of additional hydro and coal generation by 2020. Therefore, decentralised solar in Lusaka alone cannot effectively address Zambia's generation shortage. Thus, there are two options: to solely use large, centralised, renewable energy generation sites or use a hybrid generation scheme involving rooftop solar and large centralised projects. The latter will be explored in Section 2.3, which discusses the cost and the socioeconomic impact of the possible approaches.

2.3 Hybrid generation scenario

The hybrid generation scenarios considered three combinations of centralised and decentralised generation – 70% centralised and 30% decentralised (70/30), 50% centralised and 50% decentralised (50/50), and 30% centralised and 70% decentralised (30/70). The centralised generation component assumed the E1 approach, which was identified as the most effective solution in Section 2.1. The decentralised component assumed that all of Lusaka's load would be supplied through off-grid solar PV, with the remaining national demand being provided by on-grid decentralised generation. Thus, for each scenario, although the percentage contribution of on and off-grid changed, the deficit addressed by off-grid was the same. Justification for these assumptions as well as a detailed comparison of the hybrid generation scenarios can be found in the Methodologies paper.

Zambia has the resources needed to address its generation shortage, they just need to be cultivated in the most effective manner. From a purely cost of power basis, a 100% centralised generation solution is the clear-cut choice - consistent with other findings, centralised generation is invariably cheaper than decentralised generation (Taylor & So, 2016). However, there are other factors that must be considered in addition to cost of power, most notably the time required to implement the generation projects, consumer autonomy, ease of planning and sources of funding.

2.3.1 Beyond the costs - a case for the 70/30 scenario

Considering the factors mentioned, the 70/30 scenario (70% centralised, 30% decentralised) is not only the best approach, but enables Zambia to provide cheap power in the short term while also helping to lay the groundwork for greater urban electrification in the future. In this scenario, approximately 90% of decentralised generation would be off-grid with the remaining 10% being on-grid.

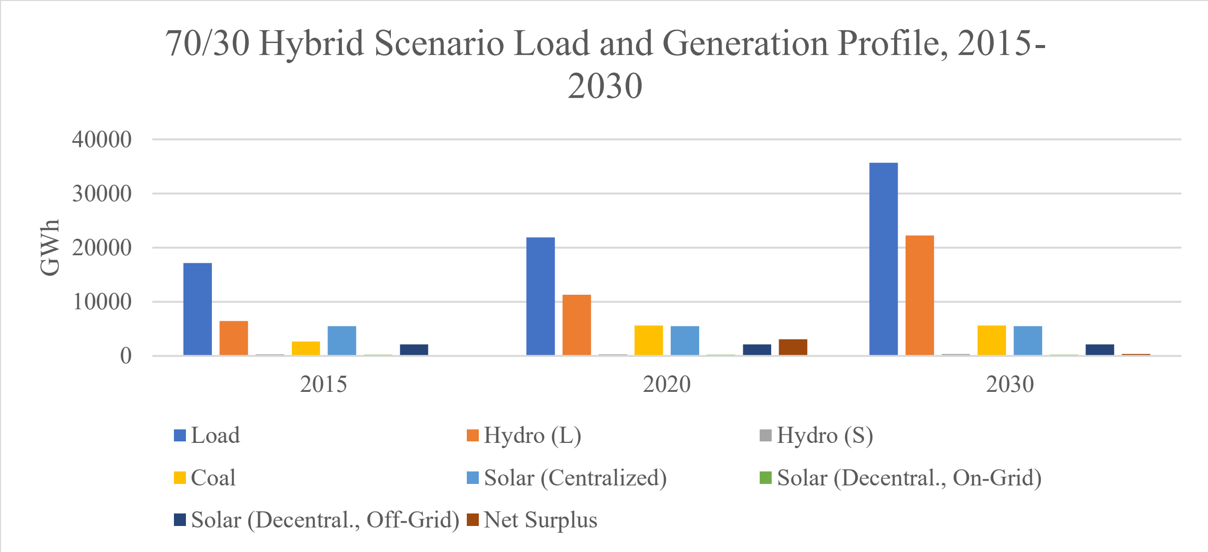
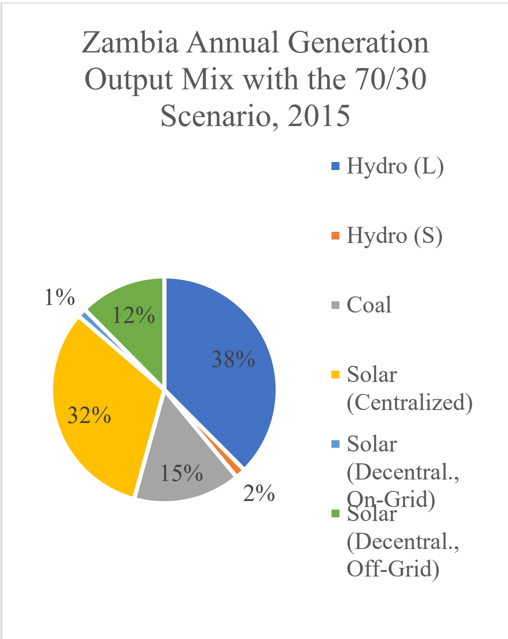


Figure 4: 70/30 Hybrid Scenario Load and Generation Profile, 2015-2030



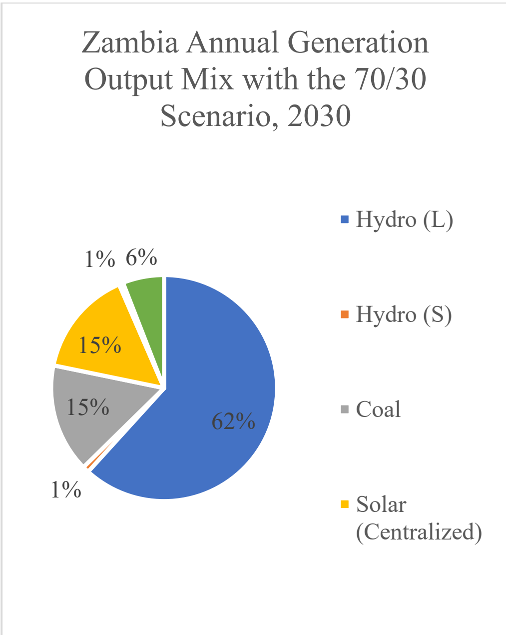


Figure 5: Zambia Annual Generation Output Mix with the 70/30 Hybrid Scenario. 2015 (left), 2030 (right)

Implementation Time

Due to the severity of Zambia's impending generation deficit and its economic impact, additional generation must be deployed quickly. Although new hydro and coal projects by 2020 will partially mitigate Zambia's deficit, there will still be a significant deficit, which is detrimental to Zambia's economy. The 70/30 scenario enables a quick deployment of off-grid decentralised generation (< 1 year) to partially mitigate Zambia's deficit immediately without compromising on the ability to generate cheap power from large, centralised solar. The deployment of large-scale fully-centralised generation takes at minimum two years, due to the financing, site surveying, project and transmission infrastructure construction necessary, even with the expedited World Bank's Scaling Solar Program. Off-grid decentralised generation, on the other hand, is significantly faster to implement, with a household rooftop installation taking approximately 3 days (Maehlum, 2014). Although Lusaka's electricity demand only represents 12% of Zambia's total electricity, off-grid solar home systems can still cut the national deficit in half in 2020. This would save Zambian government a significant amount of money that would otherwise be spent on importing electricity and reduce the effect on the country's GDP. The 70/30 approach would promote this rapid mitigation via off-grid solar panels, and is clearly advantageous over a fully centralised approach which would take at least two years to implement.

Consumer Autonomy

Zambia's electricity infrastructure has historically been unreliable, with frequent shortages and high power losses (International Renewable Energy Agency, 2013). Through the 70/30 approach, having an off-grid decentralised rooftop solar component gives Lusaka homeowners and businesses autonomy in Zambia's economic capital, building urban electricity resilience. This reduces the impact of electricity shortages on the economic capital of Zambia, and thus on the country's GDP. Furthermore, it gives these owners financial independence as they are no longer paying a monthly electricity bill on a national level, and instead are only paying for their solar panel. Additionally, by off-setting electricity demand, additional electricity can be given to the manufacturing sector, leading to a more optimized rationing of electricity to further minimize economic impacts and keeping large-manufacturers, such as Good Time Steel, profitable. A fully centralised or on-grid decentralised approach would provide little to no autonomy for homeowners and businesses, as they would be fully dependent on the grid to supply reliable electricity.

Ease of Planning

Planning national and urban electricity infrastructure can be extremely complex. However, through the utilization of centralised, off-grid decentralised, and on-grid decentralised generation through the 70/30 approach, this complexity is minimized relative to the other scenarios considered for several reasons.

Firstly, the centralised component of the solution enables the government of Zambia to leverage learnings from its experiences with the World Bank's Scaling Solar program to more effectively and expediently plan transmission infrastructure and site development. Furthermore, if the government takes a holistic national transmission approach with an eye on the future, this planning process can help engender long-term energy policy centered on renewable generation that can help to develop the necessary infrastructure for Zambia to become a leader in centralised renewable generation in Southern Africa. Additionally, from an investment perspective, the development of viable energy policy and plans will attract additional foreign investment into Zambia, which furthers the country's growth potential (Kyambalesa, 2009). Moreover, included in these policies can be a mandate for local universities regarding the proliferation of technical energy talent, which can give Zambia significant knowledge capital in sub-Saharan Africa.

Secondly, the 70/30 approach utilizes off-grid decentralised solar, which is extremely easy to plan - it requires a home or business owner to assess their property, compare panels and battery storage units, and install the system. This process is quick and inexpensive, enabling approximately half of the electricity deficit to be off-set expediently by 2020.

Thirdly, due to the relatively easy planning of the centralised generation and off-grid decentralised solar and their ability to address the shortage in 2020, minimal pressure is placed on grid-connected decentralised solar to generate electricity immediately, and instead encourages the government to take the necessary time to properly conduct urban distribution planning studies and develop the requisite policy, both of which can be significantly. Furthermore, because only 3% of new generation would come from grid-connected decentralised solar, a lower penetration rate would be required compared to other scenarios.

To conduct planning most effectively for the 70/30 scenario, a holistic and long-term approach must be taken. This necessitates politicians to prioritize and publish legislation and plans that addresses Zambia's energy needs over the coming decades. It also requires governments and institutions on a municipal and national level to come together and agree on a course of action for the future. This means that the public, municipal and federal governments should agree on an appropriate budget and policies for long term urban electricity planning, which would further increase Lusaka's infrastructure capital. Furthermore, technical studies should be done to identify the protective electrical assets (e.g. reclosers), new substations and transformer stations, the requirements for an enhanced system operating unit, and the optimal location of transmission and distribution lines and their routes.

Cost of Power

Although off-grid decentralised solar is quicker to plan and implement, it is significantly more expensive. Solar panels with storage cost approximately $10/W, while those without storage cost $6/W not including the cost of connection to the grid in comparable African countries (Taylor & So, 2016). Utility scale solar costs between $1-$2 per watt, yielding an immense difference in the cost of power - utility scale solar would cost 4.2 cents per kilowatt-hour which is comparable with existing hydro and coal generation, whereas a fully decentralised solar system with storage would cost nearly 30 cents per kilowatt- hour - almost a 10-fold increase. Through the 70/30 scenario, there would be two separate ways to purchase power: coupled large centralised solar and on-grid rooftop solar, and off-grid decentralised solar panels through consumer owned solar panels. This approach enables those who can afford solar panels to deploy them, simultaneously mitigating the national energy deficit, while ensuring that the population at large has access to cheap electricity via grid-connected generation.

For the majority of Zambians, who can't currently afford their own solar panels, grid connected generation would cost at most 4.7 cents/kWh, but will likely be closer to 4.2 cents/kWh since grid-based generation will be entirely centralised solar, hydro, and coal until 2020 through the 70/30 scenario, as discussed previously. The introduction of grid-connected decentralised solar after 2020 will likely become more affordable than current costs as the mass production of solar panels in emerging markets such as China becomes more ubiquitous. For owners who can afford off-grid solar panels, although they will be initially paying more for power, they are also paying for autonomy and reliability, which for homes and businesses in Lusaka has a major impact on quality of life (International Renewable Energy Agency, 2013).

Sources of Funding

Given the immense investment required to address Zambia's generation shortage, multiple sources of funding are imperative. The 70/30 approach enables Zambia to leverage its existing network of investors while also diversifying funding sources to minimize the cost to tax-payers.

For the centralised solar generation component, it can be assumed that the funding process and sources would be similar to the recently announced First Solar project, and would primarily be through the World Bank's Scaling Solar program (International Finance Corporation, 2016). In this case, the Zambian government would pay solar developers, such as First Solar, a very attractive 25-year purchasing power agreement (PPA) at a fixed rate of 6c/kWh for the entirety of the contract (International Finance Corporation, 2016). The developers would then be responsible for acquiring financing and constructing the project (International Finance Corporation, 2016). Finding investor and developer partners should be an expeditious process given that there are several who have shown significant interest in developing large, centralised solar projects in Zambia (Scaling Solar, 2017). Regarding the financing of transmission infrastructure, it is likely that the Zambian government would pay, as this would be a state asset. This financing will likely be a reallocation of tax dollars from purchasing imported electricity to investing in Zambia's long-term future and creating jobs. Alternatively, since the policy and federal budgets necessary to nationally finance transmission infrastructure can take a significant amount of time, the government could look at taking loans from the World Bank or privatizing their transmission infrastructure to expedite construction.

For the grid-connected rooftop solar, if the Zambian government adopts a feed-in tariff (FIT) contract approach, then home and commercial owners would purchase and finance their solar panels themselves and the government would pay the owners for the electricity they produce on a per kWh basis. These payments would come from tax dollars and appropriate legislation would need to be implemented for a standardized national FIT program. Additionally, urban distribution infrastructure would have to be constructed and financed, likely by the government.

In the case of off-grid SHS, residential and commercial owners would pay for their system entirely and wouldn't receive any contract from the government. The government could provide subsidies and fund a solar advertising program to promote the use of off-grid solar panels in Lusaka.

Additional Benefits

There are additional benefits accrued through the 70/30 scenario, primarily the creation of a solar PV marketplace and Zambia becoming a regional leader in renewable energy.

Firstly, through the introduction of off-grid rooftop solar panels to address Lusaka's load, a marketplace for rooftop solar PV panels will be created in Zambia, which reduces their price, as seen in the United States, making it more affordable to the general consumer (Barbose & Darghouth, 2016). Additionally, the creation of a marketplace enables additional suppliers to enter the market, driving up competition and driving down price consumer (Barbose & Darghouth, 2016)(Melitz & Ottaviano, 2008). Furthermore, it augments existing measures taken by the Zambian government to increase electrification rates within Lusaka, as a marketplace would establish credible vendors and enable the government to test solar PV policy, thus reducing their learning curve. As discussed previously, to do this most effectively the government of Zambia should implement a program advertising the benefits of rooftop solar, which has been proven to further drive demand for solar home systems consumer (Barbose & Darghouth, 2016). These measures would subsequently enable more citizens to afford solar panels, thus improving electrification rates more rapidly.

Secondly, the 70/30 approach would enable Zambia to become a continental leader in renewable generation, both on a centralised and an urban scale. It would enable Zambia to have the first city in

Africa to be entirely powered by rooftop solar while also having one of the largest aggregate renewable generation capacities in the continent. This would only further attract investment and make Zambia an expert in this sector, increasing an already rapidly growing GDP. Furthermore, due to the technical nature of these projects, their development would increase the knowledge capital in Zambia for renewable energy, which would create more demand for Zambian talent in Africa due to the rapid proliferation of renewable technologies.

3. Conclusion

Given the dependency of Zambia's electricity system on hydro-generation and the increasing impact of climate change on the country's levels, Zambia has been subject to prolonged droughts yielding significant electricity deficits and hampering an already fragile economy. This paper recommended that a hybrid approach of 70% centralised solar generation and 30% decentralised solar generation (90% off-grid and 10% on grid) would be the most effective in addressing Zambia's electricity deficit between 2015 and 2030. Doing so would not only alleviate the energy crisis, but would lay the framework for Zambia to rapidly electrify its capital city and become a continental leader in renewable energy.

This paper assumed that Zambia will experience 15 consecutive dry years between 2015 and 2030, immensely hampering hydro generation. Although this is unlikely, research has shown that weather events in the Sub-Saharan Africa region will be more drastic, with more intense precipitation occurring over shorter periods and prolonged dry seasons. Therefore, sustained shortages will still occur and will need to be addressed for the country's economic and social health. Although this research will likely not directly influence policy, it might initiate discourse around the most sustainable and effective ways for SSA countries heavily impacted by climate change, such as Zambia, to address electricity shortages and holistically build robust energy infrastructure. Doing so would enable these countries to minimize the economic impacts of climate extremes.

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DII-2017-011

Biomass Pellets for Application as an Alternative Solid Fuel in Southern Africa: A Review

Musaida Mercy Manyuchi[1], Charles Mbohwa[2], Edison Muzenda[3]

Abstract

Sub-Sahara Africa is agro based and because of this, huge quantities of agricultural waste are generated and if left to rot are great emitters of greenhouse gases like carbon dioxide and methane. Yet this agricultural waste has potential to be converted to biomass bio pellets, a source of energy which is renewable and eco-friendly due to the integrated production processes mainly pyrolysis. Temperatures between 200-600 °C are employed to come up with bio char which is compacted to bio pellets using various technologies which include slow and fast pyrolysis as well as hydrothermal carbonisation. The bio pellets are emission free and have calorific values ranging from 28-45 MJ/kg making them suitable for use as a solid fuel. The adoption and application of these bio pellets in Southern Africa brings a source of energy that promotes sustainable development.

Keywords: agricultural waste, bio pellets, energy, production methods, sustainability

1. Introduction

The sub Sahara Africa is agro based and agro waste that is generated on a daily basis provides a potential for biomass pellets production. Biomass bio pellets, a domestic energy source presents a promising renewable energy opportunity that could provide an alternative and renewable source of energy in place of the use of fossil fuels in Southern Africa in terms of heating and cooking purposes as well as combined heat and power generation. Biomass energy meets a major fraction of the energy demand in both rural and urban are as of most developing countries in Southern Africa (Baruya, 2015). The use of biomass for substitution of fossil fuels has an additional importance from climate change consideration perspective since biomass pellets has the potential to be carbondioxide and methane neutral (Miranda et al., 2015). The decreasing availability of fuel wood due to deforestation in most of the developing countries has necessitated the efforts be made towards efficient utilisation of biomass bio pellets. Bio pellets from agricultural waste can then be a complimentary source of domestic and industrial energy in replacement to firewood, gas, coal and electricity. Straw which is one of the raw materials that can be used for bio pellets production is shown in Figure 1.

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Figure 1: Straw which can be converted to biomass pellets (Baruya, 2015)

The production of bio pellets from agricultural waste exemplifies the potential of appropriate technology for biomass waste utilisation; it saves trees, hence combating desertification by providing an alternative energy for burning and 40% more efficient for domestic and industrial (Saeed et al., 2015). Examples of agricultural waste used for bio pellets production include rice husks, baggase, wheat straw, nut shells and pine wood agricultural waste (Saeed et al., 2015). Table 1 gives the physicochemical characteristics of the agricultural waste used to produce bio pellets and the respective bio pellets values. This review then focused on the assessment of the process factors affecting biomass production as well as the process technologies involved.

Table 1: Physicochemical characteristics of agricultural waste used for bio pellets production

Biomass type	**Moisture (%)**	**Ash (%)**	**Raw material calorific value (MJ/kg)**	**Bio pellet calorific value (MJ/kg)**
Rice husks	7.7	17.9	15.2	32.0
Baggase	7.2	20.1	15.6	43.8
Wheat straw	6.8	22.8	14.5	41.0
Corn	11.6	3.8	16.4	28.4
Walnut shells	4.95	6.3	18.8	45.2
Pinewood	4.27	4.4	19.2	38.9

Source: Saeed et al. (2015) and Sharma et al. (2015)

2. Factors that encourage Bio Pellets Adoption

2.1 Socio-economic

Use of bio pellets can reduce manufacturing costs meaning greater profits for the manufacturers and farmers or it would mean lower prices for the final users. Bio pelletizing presents many microenterprise opportunities that include the production of the presses from locally available materials and empowerment of communities. Bio pellets made from agricultural waste are a desirable fuel because they produce a hot, long-lasting and virtually smokeless fire due to the densification technology (Shukla and Vyas, 2015).

2.2 Sustainability considerations

The utilisation of agricultural waste from biomass pellets will not only help in solving the environmental pollution problems associated with the disposal of the agricultural waste but also help in conservation of natural resources which are fast depleting as is the case in for example coal and firewood. The use of bio pellets also lowers greenhouse gas emissions from industries (Shukla and Vyas, 2015). Co-firing of bio pellets with coal is also encouraged to minimize the society's dependence on coal.

2.3 Technical considerations

Plants making bio pellets known to be operational in the developing countries and are quite successful commercially (Shukla and Vyas, 2015).

3. Bio Pellets Production Processes

Processeslikedensificationorcompaction, pelletizing, and carbonisation (pyrolysis) are needed to transform agricultural waste into an acceptable form of domestic, industrial and agricultural fuel. The detailed production process for bio pellets is shown in Figure 2.

Agricultural waste can be highly compacted to form a bio pellet which takes on the burning behaviour of coal. Due to their great density, agricultural waste bio pellets have a higher calorific similar to that of firewood (Adapa et al., 2011). Biomass pellets can be used as an alternative to coal or wood for domestic and industrial energy needs. The charcoal bio pellets have a higher calorific value ranging from 20-30 MJ/kg which are comparable to wood bio pellets and agricultural waste bio pellets (Shukla and Vyas, 2015). Figure 3 gives the various types of bio pellets from agricultural waste.

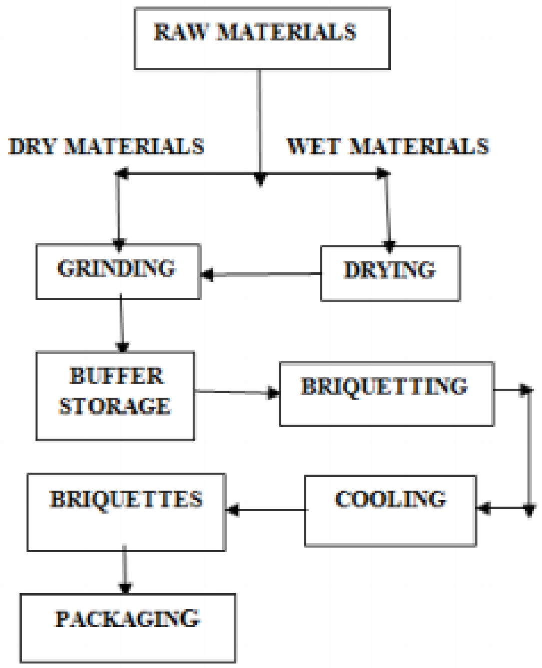

Figure 2: Conventional bio pellets making process (Shukla and Vyas, 2015)

Figure 3: Different types of biomass pellets (Sharma et al., 2015)

4. Factors affecting Bio Pellets Production

4.1 Raw material used

Mostorganic materials rich in carbon and hydrogen are suitable for the manufacture of bio pellets. Materials with high carbon content are preferred and it is this difference in the carbon content which makes their calorific value to differ.

4.2 Process temperature

Temperature, particularly the compressive and carbonisation temperature, affects the characteristic of the bio pellets produced. Highly carbonised agricultural waste due to use of higher temperatures around 200-800°C produce high quality raw material for bio pellets (Mayhead et al., 2011).

4.3 Moisture content

Moisture content must be as low as possible in bio pellets; the moisture content must be kept as low as 10 % (Shartma et al., 2015). High moisture content in bio pellets lowers their heating value thereby reducing their calorific value.

4.4 Quantity of binding agent

During the bio pellet making, it has been noticed that at least 8% of the binder is required. The binder composition has been improved by the addition of cow dung which has reduced the need for binder to almost 5% by mass in both types i.e.carbonised and raw agricultural waste giving a cheaper, economical and environment way for bio pellet production.

4.5 Energy content and thermal power

Bio pellets have a certain amount of energy that is converted through combustion into final energy to be used for heating measured in joules and results in heat energy, carbon dioxide and water as by products. Thermal power is the ratio between the thermal energy that is produced and the time spent to produce it (Adapa et al., 2011; Sharma et al., 2015). It expresses the amount of final heat transmitted to a thermal vector and it is measured in joules/sec.

5. Bio Pellets Production Process Routes

Biomass bio pellets are produced using various production processes including pyrolysis, hydrothermal carbonization and gasification. These processes are described in detail in the following subsections.

5.1 Pyrolysis

The bio pellets production process via pyrolysis involves three stages which include pre-drying of the biomass, pyrolysis, and the cooling of the bio char and this takes place in the absence of oxygen. During pyrolysis, the biomass is decomposes into three end products: bio char, tar and aqueous solutions and gases. The process must have a heat integration system which allows the combustion of volatiles in an afterburner and use the flue gas to directly or indirectly heat the biomass pre-drying process (Liu et al., 2014). The process factors which are controlled during pyrolysis are the temperature, residence time, moisture content, raw material used and the heating rate. The process factors affect the total yield and properties of bio char produced and its physicochemical properties (Mayhead et al., 2011). In cases where the moisture content of the biomass is high, the carbonizing process takes longer and some of the biomass remains uncarbonized, thereby reducing the quality of the bio pellets produced (Sharma et al., 2015). The pyrolysis process can be further divided into 3 types which are fast, mild and slow.

5.1.1 Fast pyrolysis

Fast pyrolysis involves the quick heating at temperatures of 500- 800 °C and devolatilization of organic matter by thermo chemical processes under anaerobic conditions (Liu et al., 2014). Fast pyrolysis products include small amounts of bio char and gases which contain tars and volatile gases than can be liquefied. The focus of fast pyrolysis is on the yield of liquid products which can go as up to 75%.

5.1.2 Mild pyrolysis

Mild pyrolysis is also termed torrefaction and it takes place at relatively low temperatures of 200-300 °C over moderate residence times of 1-3 hours. The major products of mild pyrolysis are bio char of around 70% yield and 30% pyrolysis gases. The mild pyrolysis process begins with stages of preliminary heating, drying, drying and intermediary heating considered allowing evaporation of water and achieving the required mild pyrolysis temperature (Liu et al., 2014).

5.1.3 Slow pyrolysis

During slow pyrolysis of the biomass, the biomass material is carbonized over long periods of time at temperatures of around 400 °C. The main yield is bio char as well as small amounts of tar and gases (Liu et al., 2014). The main process parameters considered are the residence time, temperature and the heating rate. All of these parameters affect the total bio char yield and properties of bio pellets. Lower temperatures and longer residence times will yield high quantities of bio char. A summary of the various pyrolysis conditions is given in Table 2.

Table 2: Summary of pyrolysis processes (Mayhead et al., 2011)

Pyrolysis type	Terms used	Temperature (°C)	Residence time	Products
Slow	Charcoal making, Carbonization	300-400	Hours-days	Bio char
Mild	Torrefaction, Torification	200-315	5-30 minutes	Bio coal
Fast	Fast pyrolysis Flashy pyrolysis	400-600	1 second	Bio oil Bio char Gases

5.2 Hydrothermal carbonisation

Hydrothermal carbonization (HTC) is a thermo chemical pre-treatment process where biomass is treated in hot compressed water to produce bio pellets (Erlach et al., 2011). HTC involves removal of mechanical impurities, crushing, homogenisation and soaking of the biomass. The biomass is crushed and reduced to a grain size of <60 mm and sieved and then refined (Erlach et al., 2011). Soaked biomass is pumped into the HTC reactor, where it is pressurised to 25 bars by means of steam and heated up to 220 °C (Erlach et al., 2011). Citric acid is added the process of biomass decomposition to commence the dehydration and carbonisation process. The reaction is slightly exorthemic and bio coal paste is formed as the product. Mechanical compression is applied in order to remove 50 % of the water from the cooled-down bio coal paste. Using the waste heat from the HTC process the coal cake is dried to the moisture usually 5 - 25%. Drying process produces pulverised biocoal which is pelletised and stored (Erlach et al., 2011).

6. Conclusion

Conversion of agricultural waste biomass to bio pellets promotes sustainable development through usage of renewable and eco-friendly source if energy for large domestic use. The bio pellets from agricultural waste have high heating values and are produced through easy technological processes mainly processes making them easily adoptable. The adoption of bio pellets does not only provide energy for Africa but also promotes effective waste management.

Acknowledgement

Funding from the National Research Foundation under the Knowledge, Interchange and Collaboration (KIC) is acknowledged.

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DII-2017-028

Recycling of Fibre Reinforced Composites: A Review of Current Technologies

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Abstract

Global trends reveal a general progression and preference for green, energy efficient and sustainable products. This trend, therefore, requires a shift from the dependency on traditional materials such as aluminium and steel to cheaper and more sustainable alternatives such as fibre reinforced composites. These composites are gaining significant application in the construction, medical, automotive, aviation and marine fields. The missing link required to complete the sustainability loop for these composites is recycling at the end-of-life phase. The main objective of this paper is to highlight all recycling technologies available for fibre reinforced composites and their related socioeconomic and environmental implications. Articles cited cover a period from the 1990s to date, capturing the timeframe when the environmental impact of composites, in general, gained global relevance. The outcome of the study reveals that recovery of carbon fibre, glass fibre, energy, fuels, oils and gases from waste composites can be achieved efficiently, economically and with minimal degradation to fibre properties. The findings also suggest that with proper technology, recycling of fibre reinforced composite can be achieved in an environmentally friendly way.

Keywords: fibre reinforced composites, pyrolysis, solvolysis, supercritical fluids, thermoset composites

1. Introduction

The increasing application of fibre reinforced composites in the civil, aerospace, automobile, the wind and marine industries may be attributed its superior properties over traditional materials such as metals and wood. Lightness, corrosion resistance, low cost, and high strength to weight ratio are some of the properties of such composites (Conroy et al., 2006). In 2016, the global market value of thermoset composites was estimated at US$41.98 billion and is expected to increase to US$57.98 billion by 2021 (market and market, 2017). The past decade has seen an annual increase in demand for carbon fibre from 16,000 – 72,000 tonnes, however, this figure is expected to increase to 140,000 tonnes by 2020. La Rosa et al. (2016) also reported that in 2008 the worldwide demand for carbon fibre was 35,000 tonnes, but this figure is expected to increase to 120,000 tonnes by 2020. The increasing demand for carbon fibre in sectors such as the automobile and aerospace will continue. A high percentage of fibre reinforced polymer composite waste generated worldwide end up in landfills which are not

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environmentally friendly and sustainable. The continued preference for thermosetting composites implies that the waste generated will also continue to rise and therefore recycling solutions are a necessity. Aside the environmental impact, stricter regulation and legislation by the European Union (EU) and most developed nations to restrict landfill disposal are leading to several types of research into suitable recycling processes (Oliveux et al., 2015). For example, in the EU's waste hierarchy, innovative recycling is highest ranked while disposal is the least ranked (EuCIA, 2015).

This study attempts to bring to fore the importance of recycling fibre reinforced composite with a focus on the technologies available, mechanical properties of recyclates, socioeconomic impact, environmental impact and applications of recyclate. A study period from the 90s to present is selected to provide a holistic overview while capturing the period when the global importance of recycling fibre reinforced composites received prominence.

1.1 Motivation for Recycling

There are two main incentives associated with recycling composite waste namely; the cost of producing virgin fibres and the environmental problems related to landfill disposal. Therefore, the option of utilising composite waste as a secondary resource for production fibre recyclate is vital since virgin fibres production is very energy intensive and costly. Pimenta and Pinho (2011) reported that the cost of manufacturing 1kg of virgin carbon fibre was GBP£20 to GBP£40 in the UK and the energy consumption was 183 – 286 MJ which 14 times more energy intensive than production of steel. Das (2011) observed that greenhouse emission from the production of virgin carbon fibre is 31 kg CO2 eq/kg and ten (10) times the emissions from steel (3 kg CO2 eq/kg) production. Recycling can, therefore, serve as a solution to waste while providing substantial financial value from recovered carbon fibre. The U.S. standard for corporate average fuel economy (CAFE) has been set at 54.5mpge by 2025 while the EU CO2 emission restrictions have been set to reduce from 130 g of CO2/km to 95 g CO2/km by 2020. These stringent fuel economy standards and CO2 emission laws for vehicles are driving manufacturers towards lightweight materials such as carbon fibre reinforced polymer (CFRP).

The UK has instituted a landfill tax to serve as a financial disincentive aimed at promoting the diversion of composite waste from landfill disposal to alternative treatments like recycling (EC, 2012). The EU's end-of-life (ELV) Directive (2000/53/EC) requires that from 2015, 85% by weight of end-of-life vehicle waste must be reusable or recyclable with a total recovery of 95% including incineration. Therefore, only 5% and 10% of a vehicle are allowed for landfill disposal and energy recovery respectively (EC, 2000; 2012). The EU's Landfill Directive (1999/31/EC) for waste disposal severely restricts the quantity of organic material allowed for landfill disposal. These legislations are making the landfill disposal option an illegality in many countries, and therefore effective and innovative recycling processes are a necessity.

2. Available Recycling Technologies

Fundamentally, there are three (3) primary recycling options currently in use for composite waste management; they include; mechanical, thermal and chemical (Solvolysis) processes as shown in figure 1. However, newer approaches such as utilisation of High voltage fragmentation (HVF) are helping to usher in environmentally sound, efficient and sustainable way for recycling composites.

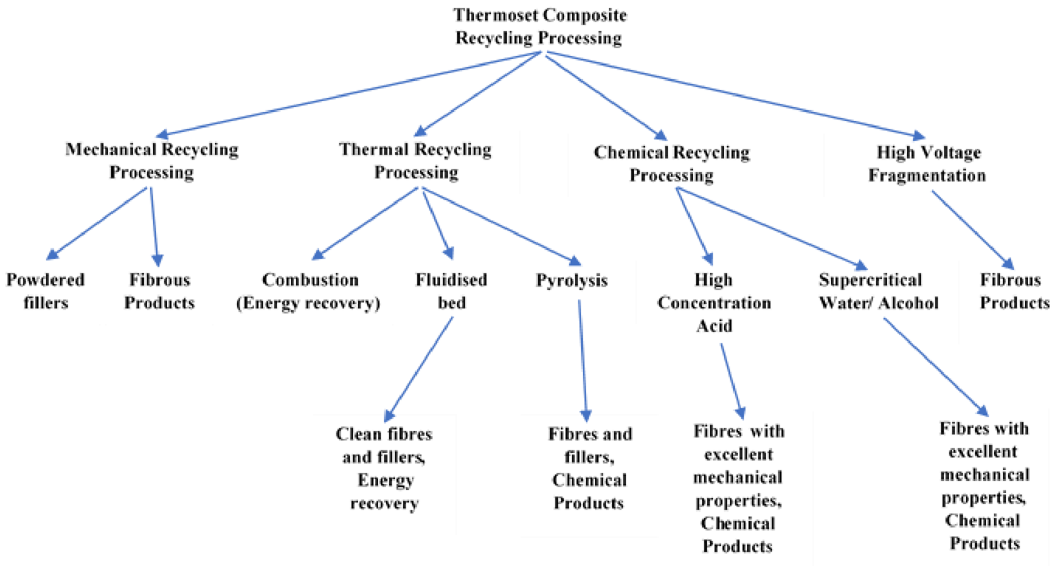

Figure 1: Composite waste recycling technologies

2.1 Mechanical recycling

Mechanical recycling involves size reduction and/or pulverisation by grinding or milling. This recycling process typically requires two (2) stages. Stage one involves a 50 – 100 mm reduction using slow cutting or crushing mills to aid in the removal of metal inserts and transportation, while the second stage, involves a 10 – 50 mm reduction using high-speed mills or hammer mill. Finally, size grading of recyclate into different size fractions is carried out using cyclones and sieves (Scheirs, 1998). The resulting graded fractions could be fine powdered, coarse or fibrous. Finely powdered recyclates can be used as fillers for new sheet moulding compound (SMC), bulk moulding compound (BMC) or dough moulding compounds (DMC) (Palmer et al., 2009). A combination of pressure from legislatures and economic viability of reusing recyclate in BMC of DMC makes it critical to the automotive sector. However, powdered and fibrous recyclates have not received the necessary attention because of their inferior mechanical properties attributed to lack of bonding with polymer and fibres acting as a stress inducing agent (Bledzki et al., 1992). These reported low mechanical properties, led Palmer et al. (2009) to develop a protocol for manufacturing DMCs of equal or superior mechanical integrity that incorporates careful separation and use of the "by-content" reformulation method to ensure intelligent inclusion of recyclate mix (fibres and fillers) and virgin material. Using the optimal mix time of 8 minutes, fine and coarse recyclates were reported to show high flexural modulus and impact strength respectively.

Some successful application of recycled glass fibre includes; furniture manufacture, manhole covers and utility boxes (Job, 2014). Ribeiro et al. (2016a), reports of the use of ground recyclate as filler for the polymer based concrete. Research works by (Castro, 2014; Ribeiro et al., 2016b;) have shown that mechanically recycling GFRPs is viable, sustainable and value-adding. Other applications for coarser recyclates include use as; asphalt reinforcement, an alternative to wood fibre and damping material for noise insulation (GPRMC, 2003; Conroy et al., 2004). Mechanical recycling is the most environmentally friendly because chemicals and toxic gas emissions are absent. It is the only process that is currently utilised on an industrial scale level for commercial processing of recyclates (Palmer et al., 2009).

2.2 Thermal recycling

Thermal recycling processing can be grouped under three (3) main categories namely; Combustion and Fluidised Bed and pyrolysis.

2.2.1 Combustion for energy recovery and application

The Combustion process involves the burning of composite waste in the presence of oxygen. Polymers such as epoxy, phenolics, and polyester all have calorific values of approximately 30,000 kJ/kg, while that of urea formaldehyde is 15,700 kJ/kg. However, the calorific values of glass fibre reinforced composites are dependent on the type and proportion of polymer used (Pickering and Benson, 1991). The recovery of energy from combustion of fibre reinforced composite waste is very viable as presented by (Pickering and Benson, 1993; Nystrom, 2002). The leftovers from incombustible materials may be disposed in landfills or used as fillers for products like cement.

2.2.2 Fibre recovery using fluidised bed

The fluidised bed is used for the recovery of fibre reinforcements like glass and carbon from scrap composites (Pickering et al., 2002; Pickering, 2006). Waste scrap is first reduced to an approximate size of 25mm then fed into a fluidised bed of silica sand fluidised with a current of hot air at velocities of 0.4 – 1.0 m/s and at elevated temperatures ranging 450 – 550 ^{o}C. The high-temperature volatilizes the polymer which frees up the fibres and fillers to suspend in the gas stream. The last stage involves separation and transfer of fibres from the fluidised bed to a secondary chamber where high-temperature combustion ensures full oxidation of polymer. The mechanical properties of recyclate fibres revealed that there was 50% and 20% reduction in tensile strength of glass fibre and carbon fibres respectively. The reduction in strength is attributed to the high temperatures associated with the fluid bed process.

2.2.3 Pyrolysis

During pyrolysis, the composite waste is heated in the absence of oxygen resulting in the polymer degrading into lower molecular weight liquids and gases. Figure 2 is a flow layout for recycling using pyrolysis. Pyrolysis studies for glass and carbon fibre reinforced composites were successfully carried out at processing temperatures of 450^{o}C - 550^{o}C by (Cunliffe, 2003). High temperature causes deterioration in recyclate fibre strength. Therefore Adherent Technologies, Inc. (USA) developed a catalytic pyrolysis process that significantly reduces processing temperature to 200^{o}C and was able to produce epoxy free fibre recyclates having tensile strengths 83 – 99% of virgin fibre (Allred and L. D. Busselle, 2000). Pyrolysis produces oil, gases, char, fibres and fillers.

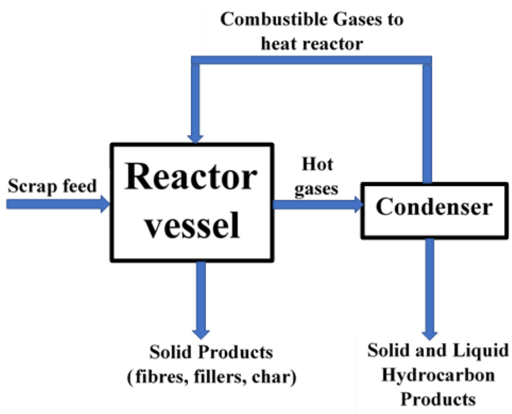

Figure 2: Recycling using pyrolysis (Pickering, 2006)

Microwave assisted pyrolysis

Lester et al. (2004) and Åkesson et al. (2012) experimented on the application of microwaves for heating the composite waste to break down the matrix into gases and oil in an inert atmosphere. Heating with microwaves is found to be advantageous because the waste composites get heated within its core at a fast thermal transfer rate, and therefore ensures some energy savings.

The main drawbacks to thermal recycling processing include difficulty in recovering monomers from resins for reuse and strength and surface degradation of thermally treated fibres. Yang et al., (2015) reported that mechanical properties of composites manufactured from thermally recycled fibre glass were observed to be severely degraded with losses of over 60% in tensile strength, 50% in flexural properties and 70 – 80% in impact strength when compared to virgin fibres. Therefore, further fibre regeneration through chemical treatment to ensure second-life reinforcement reuse is necessary (Yang et al., 2015). The advantage of pyrolysis over mechanical recycling is that it allows for recovery of some products from resins such as gases and oil which may be treated and used as fuels.

2.3 Chemical (solvolysis) recycling

Although there are existing technologies for recycling composites such as mechanical and thermal processing, there are significant challenges to material recovery abilities and their preservation of high-value mechanical properties. Chemical processing seems to be the most suitable and recommended option for ensuring limited damage to fibres after polymer matrix disintegration. Solvolysis or chemical treatment involves the degradation of resin using a solvent. This process has enjoyed major patronage in recycling CFRP for fibre recovery because it is more commercially viable. Water is the most widely used solvent (Pinero-Hernanz et al., 2008a; Oliveux et al., 2012). Water with a co-solvent such as alcohol, phenol and amine (Jiang et al., 2007; Oliveux et al., 2012) have also been successfully used in solvolysis. The alcohols often used in solvolysis include acetone, glycols, methanol, and propanol (Okajima et al., 2012; Xu et al., 2013; Yildirir et al., 2014; Yan et al., 2016). Alkaline catalysts such as sodium hydroxide (NaOH) or potassium hydroxide (KOH) are also predominantly used (Pinero-Hernanz et al., 2008; Nakagawa et al., 2009; Onwudili et al., 2013). Acidic catalysts are only used for highly resistant-to-degradation resins (Yuyan et al., 2009; Feraboli et al., 2012). Meng et al. (2004) used high concentrated nitric acid to effectively break down the polymer resin of carbon fibre reinforced composite at a processing temperature of 90^{o}C and reaction time between 10 and 100 hours to generate fibres that lost only 1.1% of its tensile strength. Etching in combination with post-silanisation is used as chemical treatment for regeneration of degraded glass fibre after thermal recycling by Yang et al., (2015). The chemicals used for etching and pos-silanisation were 48% hydrofluoric acid (HF) and γ-aminopropyltriethoxysilane respectively. A recovery of over 80% of lost tensile strength, 70% of lost flexural properties and 50% of lost impact strength. Glass fibre closed-loop recycling was achieved (Yang et al., 2015).

2.3.1 Supercritical Fluid

When a single component of fluid has its temperature and pressure above its critical temperature and pressure respectively it is said to be supercritical (Debenedetti, 2000). A supercritical fluid is neither a liquid nor vapour. Studies by (Piero-Hernanz, 2008a; Piero-Hernanz, 2008b, Jiang et al., 2009) have shown the suitability of supercritical water for recycling composite waste especially CFRP because of its effective resin degradation capability. Water has temperature and pressure dependent properties which make it an adjustable solvent that is ideal for property manipulation and control. Bai et al. (2010) reported that clean carbon fibre with higher tensile strength in comparison to virgin fibre was recovered using oxygen and supercritical water at a pressure of about 30 MPa and a temperature of approximately 440ºC. Knight (2013), also conducted a study on the recycling of CFRP using supercritical water and observed 99% high cross-linked resin removal while retaining 100% tensile strength and modulus of a single filament. High-temperature solvolysis involves using supercritical fluids such as water and alcohols at temperatures above 374ºC and pressures above 22.1 MPa. Alcohols, however, often have lower critical temperature and pressure than water. Supercritical 1-propanol and water were used to effectively degrade and remove CFRP matrix for fibre recovery at a temperature of 450 ºC at pressures of 25.5 MPa (Alcohol) and 63.3 MPa (water). Yan et al. (2016) also used 1wt% KOH additive and supercritical 1-propanol, to successfully recycle and recover carbon fibres with excellent mechanical properties, clean surface and good thermal stability from an epoxy resin carbon fibre reinforced composite. Phenolic compounds such as isopropyl phenol and cresol are obtained from the degradation of epoxy resins with the following gasses; carbon dioxide, oxygen, hydrogen, ethane, methane and propane (Elghazzaoui, 2012). The main advantage of chemical processing over thermal processes like pyrolysis is that absence of char which tends to contaminate the fibre surface of recyclates. However, the drawback of this method is the high cost of reactors which must be capable of withstanding high temperatures, pressures and corrosion. Supercritical water and alcohols have shown significant potential for chemical processing and are much more environmentally friendly because of low toxicity, readily available and significantly lower processing cost (Salto, 1995).

2.4 High voltage fragmentation (HVF)

High voltage fragmentation (HVF) involves the disintegration of solid materials using repetitive electrical pulse discharges between two (2) electrodes within a short period. The electrical discharge generates a spark channel which produces intense shockwaves at high temperature (> 104K) and pressure (approx. 109 – 1010 Pa) that introduce internal stresses above the tensile strength of material leading to eventual disintegration (Bluhm et al., 2000). A study conducted by Mativenga et al. (2016) observed the following when HVF was compared to the mechanical recycling methods: 1) The characteristics of fibres recovered by HVF were cleaner, lower in resin content retained on fibre, higher in the percentage of fibres, and longer fibre length distribution. 2) As applied electric pulse increased, the residual resin content decreased and 3) The HVF process required a specific energy consumption that was 2.6 times the requirement for mechanical recycling.

3. Discussion

Mechanical processing is the first approach considered and adopted for recycling of composite waste. It is also the most commercially viable. But most literature available has shown that the hindrance to commercialization may be attributed to the use of ground recyclate as cheap fillers that produce inferior products possessing inferior mechanical properties at a slightly lower cost. However, by introducing prudent separation and classification techniques, an optimal and intelligent approach can be developed for using recyclate as both reinforcements and as a filler for manufacturing mechanically superior composites. (Palmer et al., 2009). Mechanical recycling also has the advantage of being the most environmentally friendly technology for recycling as no toxic chemicals and gases are used or emitted.

A lot more recyclates can be obtained from thermal recycling processing such as pyrolysis. Fibres, char, oils and gasses are the possible recyclates which make it more advantages when compared with the mechanical method. It must, however, be stated that recovering monomers from resins is extremely difficult when this method is used. Energy consumption during this process is quite high therefore microwave assisted pyrolysis is helping to decrease energy consumption by reducing the heating time. Due to char contamination, the recyclate fibre produced from pyrolysis also exhibit inferior mechanical properties when compared to virgin fibres. The fluidised bed, however, produces cleaner recyclate fibres but are still inferior to virgin fibres. The mechanical properties of fibre recyclates from pyrolysis can be enhanced significantly by etching in combination with post-silanisation as described by Yang et al., (2015).

The chemical recycling processing is the route with the most space for innovation and achieving an environmentally friendly, sustainable, energy saving and financially rewarding process. The most significant advantage of this process to both mechanical and thermal processes is the quality of recyclate fibre recovered. The mechanical properties of recyclate fibres are close to or in some case the same as virgin fibres. This means that they can be used in the manufacture of new thermoset composites while avoiding the cost associated with the production of virgin fibres. The drawbacks to this process include; the use of chemicals which are toxic and the high cost of reactors.

4. Conclusion

The review has shown that a tremendous amount of research into the provision of a greener, cost effective and sustainable recycling process is essential for coping with composite waste. The motivation and urgency for these technologies are informed by stricter legislation on landfill disposal, CO_2 standards, the high energy input and higher cost of producing virgin fibre. The use of supercritical fluids for fibre recovery can be optimised to achieve high mechanical properties, commercialisation and low environmental impact. Novel approaches such as HVFs are necessary to simplify and reduce the cost of recycling while maintaining high mechanical properties.

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DII-2017-051

Energy Efficiency Enhancement of Off-grid Photovoltaic Power Plant

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Abstract

The sizing of the off-grid PV systems is currently based on a manual approach, i.e. daily load is estimated by identifying commonly used load appliances for modelling system performance. If the system is not properly sized, it may not function according to expectation. The purpose of this paper is to present a conceptual design of an off-grid (autonomous) photovoltaic (PV) power plant, fitted with an efficient power regulating (EPR) management system of solar batteries and an instinctive solar tracking of PV panels. An optimisation model for an Efficient Power Regulating (EPR) system of solar batteries was coupled to a solar tracking device so that the PV panels were constantly in full view of the sun. The objective function of the model was to maximise the efficiency of PV cells through PV battery charge regulation and load control in off-grid PV installations. This study revealed that the effectiveness of the EPR of solar battery (SB) when totally discharged can be realised when the accumulating battery (AB) charge reaches 50%.The study findings were indicative of the effectiveness of the EPR of SB. Hence, the EPR technique and the automatic tracking of PV solar panels proved to be the most effective technique for optimising energy efficiency of autonomous PV power plants.

Keywords: autonomous photovoltaic (PV), energy efficiency, PV solar battery, PV solar panel

1. Introduction

Improvement of off-grid photovoltaic power plants depends primarily on the increased quality of the technical characteristics of power plant sources - solar and the accumulating storage batteries (SB, AB). However, even with the most innovative sources of energy power plants which are currently available, the independent power plant facility may have a compromised power output characteristic due to the irrational usage of their potential capability (Sharma, 2011). Therefore, when designing contemporary and efficient stand-alone PV power plants, it should be undertaken in such a manner that it is able to address two major chores, these are;

- The development and usage of solar cells with increased efficiency and batteries with improved performance.

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- The task of PV system design of power plants with the aim of improving their energy efficiency.

In this paper, the EPR is proposed for solar cells in order to enhance efficiency of PV plants and a technique for PV battery charge regulation and energy load control in off-grid PV plants is presented.

2. Brief Background

The effectiveness of the usage of PV energy sources in their long-term operational cycle, to a large extent depends on the block diagram, design and acknowledged conducts of managing energy sources (Shinyakov, 2007). At present, widely employed are block diagrams of energy systems and plants without the consciousness of the technique of instigating an efficient practice of the regulation of its power (source, n.d.). A number of autonomous PV power plants mostly employ simple controls of current charge and discharge of the AB, which simply cut off the source of energy of SB when the voltage at the AB reaches its limit. However, by reducing the voltage on AB to a certain level such that a solar cell is reconnected again and charging is resumed, voltage on SB is determined by the voltage of AB at a specific given moment, depending on the state of charge of AB. Since EPR management system is not realized, consequently the rate of energy efficiency of such PV power plants is minimal.

3. Methodology

Maximizing the energy efficiency ratio of autonomous PV power plants not less than 30-50% is possible through the following basic means (Shinakov et al., 2010):

- Realizing of the power intake mode at the optimal operating point of the current-voltage characteristics of the solar battery during the life of its exploitation (realizing of the method of efficient regulating of power of solar battery);
- Realizing of a continuous mode of automatic tracking of PV panels for the sun;
- Optimization of the solar battery structure in order to achieve a minimum heating of photocell elements.

3.1 Efficient power regulating management system

The effect of the realization of the EPR of solar batteries depends on a range of variations in the operating temperature of PV panels. Solar batteries of PV stand-alone power plants are used at significantly varying operating conditions. They are strongly influenced by the environment. Their current-voltage (V-I) graph characteristics vary non-linear and unstable (Tobnaghi, Madatov, & Naderi, 2013). V-I characteristics of solar cell sample at 15, 25, 30, 40, and 50 °C temperatures have been shown in Figure 6.

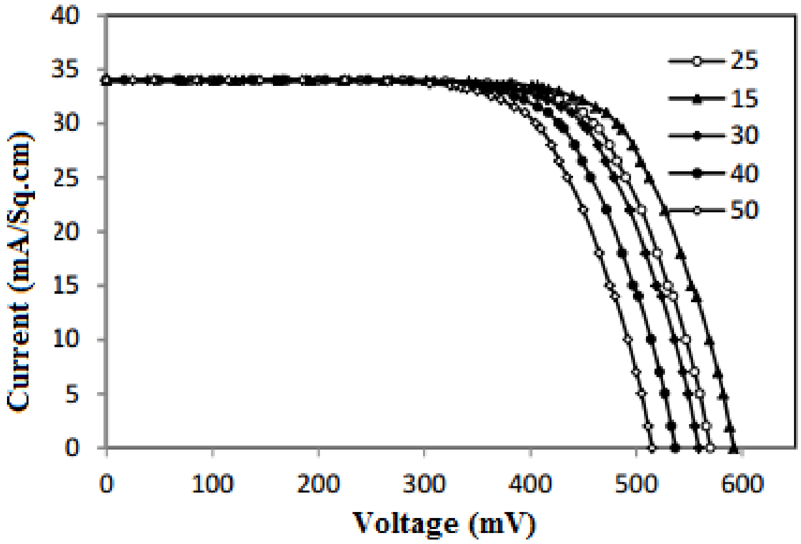

Figure 6: A Sketch of V-I Characteristics of a Solar Cell in different temperatures (Tobnaghi, Madatov, & Naderi, 2013)

It can be realised that V-I characteristics of solar cell vary under different temperatures. Escalations in temperature decrease the band gap of a solar cell, hence affecting the solar cell efficiency (Singh, 2008) (Singh & Ravindra, 2012)

Volt-Watt graph characteristics have a pronounced maximum generated power, the position of which varies considerably from the operating conditions, that is, resources, temperatures, radiance. When it changes operating temperature from +70 to -30 ° C, the voltage of the optimum operating point of the silicon solar battery increases approximately 1.5 times (voltage of a photocell varies within the range 0.5-0.75 V) (Shinakov et al., 2010). The current of a solar battery irrelevantly depends on the operating temperature. Theoretical analysis confirms that in comparison with parallel connection systems SB and AB (operating voltage of a SB, equals to the voltage of AB) energy effectiveness of the realization of the EPR of SB when deeply discharged AB may reach 50% (Shinakov et al., 2010).

3.2 Automatic tracking of the sun by the PV panels

The effect of the realization of the continuous mode of automatic tracking of PV panels for the sun is correspondingly significant. From preliminary investigations undertaken of energy efficiency of automatic tracking systems of PV panels for the sun proves that the effectiveness of the autonomous PV power plant in Mbabane Government Hospital (blood bank) compared to the horizontal arrangement of PV panels is as follows:

- If the solar battery exhibits an angle equal to the latitude of the location, the efficiency is 20%;
- When using single-axis tracking system the sun, the efficiency is 42%;
- The application of dual-axis tracking system of the sun, the efficiency is 51%.

On average for the different locations of off-grid photovoltaic power plants in Swaziland, i.e. Siteki Mzilikazi, Langa and Mbabane, the potential of increasing energy efficiency through the use of tracking systems for the sun rises by 31% for single-axis systems and 46% -for biaxial.

3.3 Impact of the re-design of solar cell structure

The likelihood of improving the design of solar battery structure with the view of increasing the exploitation of the energy efficiency factor results to the high sensitivity photocells elements to temperature. As the temperature increases the efficiency of PV batteries, like most other semiconductor devices is reduced. It is therefore necessary to take all measures to reduce the heat, inevitable under the scorching direct sunlight. Further complicating the situation is that the sensitive surface is rather fragile solar cells covered by the protective glass or transparent plastic. The result is a kind of "greenhouse" aggravating overheating.

Practically no information is available about the work on the investigation of the effectiveness of specific measures and devices that effect cooling of solar batteries of PV solar panels.

4. How the Off-Grid PV Plant Operates

The principal distinctiveness of the designed PV power plant is the;

- Simultaneous use of a stepper motor control method with automatic guidance of PV panels in the direction of the sun,
- EPR of SB and the establishment of an integrated management of power plant control system by dividing its operating period with periods interchanging task between EPR and stepper drives.

The employment of stepping techniques to ascertain maximum power is the most suitable for use in autonomous PV power plants (Hesari, 2016). The coordination of extreme regulator with the charger settings is achieved quite simply by a discrete adjustment feedback in the channel voltage of the solar battery. This method is widely used in photovoltaic power systems of automatic space vehicles (Shinyakov, 2007).

Extreme regulator of any type (analog-digital, digital, and micro-processor) hardly increases the weight of control apparatus, but instead has a low energy consumption and increases the efficiency of the solar battery to 98-100% (Shinyakov et al., 1997) (Shinyakov, 2007).

5. Spontaneous PV Panel Solar Tracking Operations

Figure 7 depicts a sketch of a mechanical system of vertical and horizontal rotations (azimuth and elevation) of solar PV panels. The basic components of the mechanical system of a stand-alone PV power plant presented in Fig. 2 are: the frame with two PV modules GS-S-160 or KSM-180; the non-stationary frame; an immovable frame; rotation regulator in elevation; rotation regulator in azimuth; two stepper motor type SM-5D; two sun position sensors. The fixed immovable frame consists of welded steel frame of the four corners of the core and the tubular elements with four corner supports and one central support in which a rotating shaft is installed. The rotation of the shaft is provided bya stepper motor SD-5D through the worm gear and spur gear. Fixed securely to the lower support frame assembly, wherein rotation of the shaft is provided through the use as a central element of a spherical bearing, and the radial thrust bearings provide the smallest friction connection. The movable frame consists of welded steel frame with fixed thereon driven gear connected to a central shaft and a lower support unit keyed for rotation around the vertical axis installation. The same two arcs fixed frame in which the frame is installed with the axis of rotation KSM-160 modules through the collar and worm gear stepper motor SM-5D for the rotation in elevation. As a law of enforcement mechanisms, to ensure the rotation of the PV system, worm gears with a gear ratio of 1: 250 are used, which allows the use of stepper motors with rated torque load torque - 0.1 Nm. Worm gearboxes allow to exclude spontaneous change of the PV solar panels position relative to the sun under the influence of wind loads.

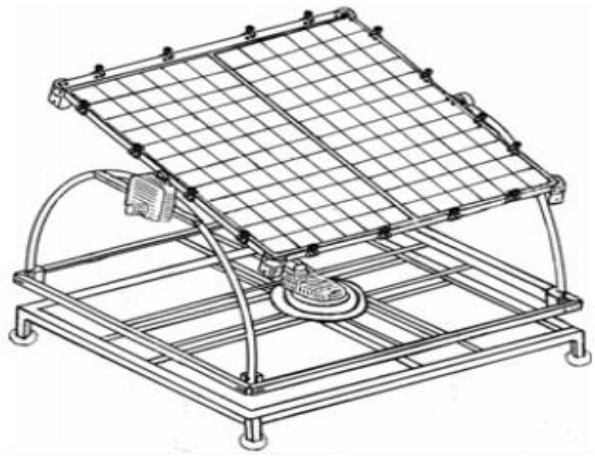

Figure 7: A sketch of the mechanical system of vertical and horizontal rotations of PV panels

6. Designed Off-Grid PV Plant Operations

Fundamental and operational illustration of the off-grid PV power plant is shown in Figure 8. The following symbols are designated as follows: SB is the solar battery; CDCAB - control charge/discharge of AB; I is the inverter; AB1 and AB2 accumulator batteries (storage devices); M1and M2 are stepper motors; R1, R2 are reducers; SMCD1, SMCD2 are stepper motor control drivers; SPS is the sun position sensor; CPS is the control pointer at the sun and LS1 to LS4 are limit switches. This autonomous PV plant system uses an inverter with sinusoidal output TS 1500-224, connected to two series accumulating or storage batteries, type TUDOR T12V 155FT and two solar PV panels of the type KSM 160. In addition, the developed regulator that points at the sun consist of the microcontroller (MC) STM32-F103, the DC-DC Converter, five operational amplifiers, IC, provides connectivity to RS 485 with an external computer through the Converter (I - 7561).

The tracking system for automatic step control, consists of two sensor positions of the sun, the guidance control on the sun, the two stepper motors with gearboxes, two power drivers, stepper motors, and four limit switches, provides two-coordinate mechanical movement of the solar battery, horizontally - not less than 180 degrees and vertically - not less than 70 degrees.

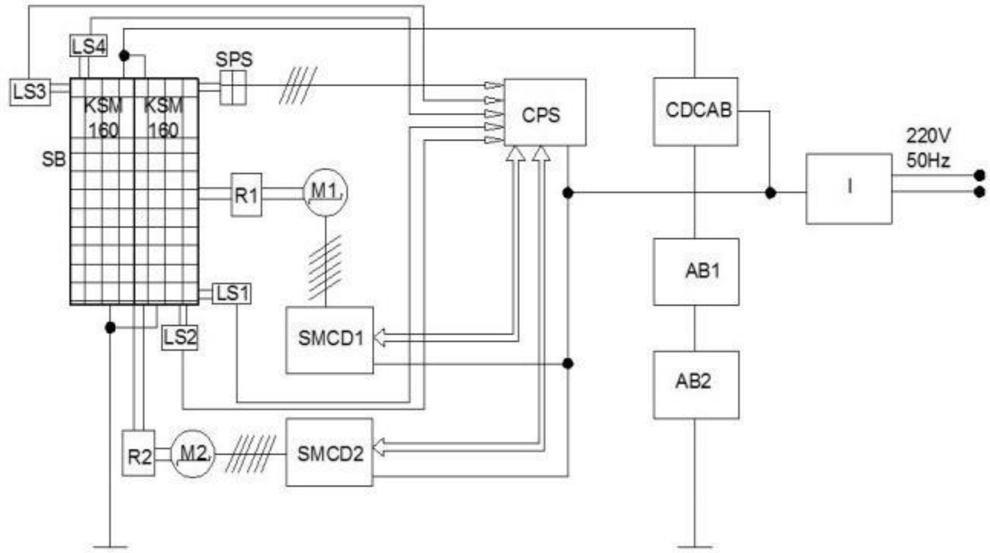

Figure 8: Structural and functional schematic diagram of an autonomous PV power plant

Using the sun position sensor, controller guidance and stepper motor driver provides the PV plant system with rotations about the axis of rotation discretely 1-5 degrees per movement cycle, thus reducing the energy costs of movement when tracking the sun. In the event there is no guidance provided by the stepper motors, no energy is consumed. To reduce jerks and swings by moving the controller for controlling stepper motors using positioning mode, i.e. it is the restriction on the speed and acceleration when moving from one location to another. Limitations of critical rotation angles in both planes is provided by the limit switches (LS1 – LS4), mounted on the immovable frame of the PV plant system and the control pointer at the sun. The controller (CDCAB) uses the charger circuit based on the voltage stepdown converter (SDC), as displayed in Figure 9. The circuit is designed to guarantee the minimum conditions of the power loss. In the study, it is determined that optimal frequency conversion 50 kHz, selected power field transistor IRFPS3810, have a low channel resistance.

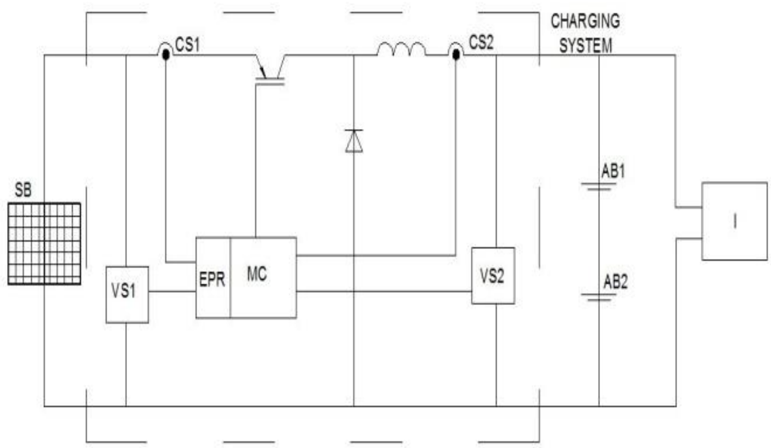

Figure 9: Functional sketch of autonomous PV power plant with recognition functions of EPR of SB

The charging system is controlled by a MC Atmega128, combining the functions of the user interface with the formation of the control action on power transistor (VT1). There are two modes of operation; the first one is the manual mode - a mode of stabilization of the solar battery voltage, where you can set the desired operating point on the constant voltage charge (CVC) of the SB. Second, is the automatic mode - EPR of the SB mode. In this mode, the search for the operating point of the CVC with maximum power output occurs. The operation algorithm feedback of this mode is demonstrated in Figure 10.

7. The Feedback Control Algorithm Process

Before switching on the charging system, the survey of the voltage sensors VS1 and VS2 occurs only in the occasion the open circuit voltage of the SB exceeds the voltage of AB, then the charger is switched on. Another condition is the inclusion of the not fully charged rechargeable battery, which is determined by the voltage AB, which shall not exceed a maximum value.

Afterward is a survey of the mode of operation of the memory, determining a desired feedback mode. In this mode, the sampled current sensor SB (CS1 multiple unit) and the voltage sensor SB (VS1), is considered as SB output. The obtained measured value of the input power P_{SB_NEW} is compared with the power value P_{SB_OLD} measured before the assignation of the control action. In the event P_{SB_NEW} is greater than $P_{SB\_OLD,}$ then the control impact sign (Δγ) does not change, which indicates the correct direction of movement of the operating point for the input voltage ($V_{IN)}$.

However, if there is a reduction of power, that is, P_{SB_NEW} is less thanR_{SB_OLD}, then the operating point is moving down the V_{IN}, the sign changes, SB voltage is reversed Δγ = - Δγ. The property of the algorithm is the continuous movement of the operating point at V_{IN}, which is necessary for the detection of an ultimate V_{IN} and search for a new value when a drift of V_{IN} happens. After the "capture" of the maximum power position of the operating point, the algorithm oscillates in the vicinity of the extreme values.

In the algorithm there is a pause between the introduction of control action and survey, measurement sensors, which is necessary for the completion of transient processes caused by the operating action, and measure the steady-state value. It is obvious that the pause determines the frequency of control actions and, therefore, the search for the uttermost capacity, i.e. performance feedback. Therefore, a factor limiting the performance of the memory is the time of transients in the power converter, determined by inertial smoothing filters connected at its output.

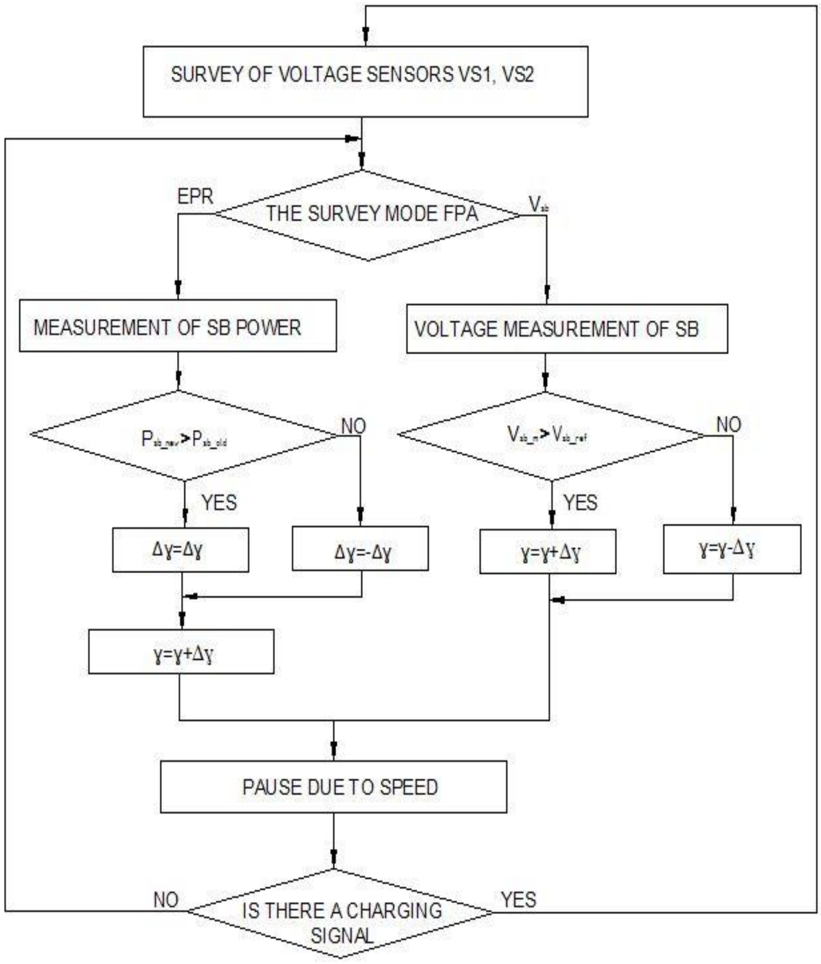

Figure 10: - Feedback Algorithm Process (FAP) ***(Shinyakov et al., 1997)***

8. Conclusion

There is presently no sufficient considerable field data and experimental results available that demonstrates the effectiveness and applicability of EPR and sun tracking of PV panels of off-grid PV power plants. Hence, this paper will assist in realizing the EPR technique and the automatic tracking of PV panels for the sun. The study validated that EPR and sun tracking of PV panels proves to be the most effective method of improving the energy efficiency of autonomous PV power plants.

The PV power plant which is fully autonomous will have a negligible loss of energy due to the provision of guidance mechanism on the sun, (energy costs can be determined at the stage of experimental studies) and optimized to not less than 30-50% energy efficiency.

Furthermore, this work is envisioned to serve as a foundation for additional feasibility and practicability studies into small and large scale application within the manufacturing sector where there is an escalating necessity to produce more off-grid, independent PV power plants.

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DII-2017-046

Protecting Water Delivery Infrastructure from Power Supply Disturbances Damage in Lusaka Urban

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Abstract

This paper presents results of studies and investigations carried out by National Council for Scientific Research (NCSR), at various sites in Lusaka, of causes of water pump and refrigeration motor failures, in the period between 1985 and 2005, with a view of finding solution to this problem. Concerns leading to the investigations were arrived at after reported and observed increased water pump and refrigeration pump failures at different locations in Lusaka. Indications of the causes of motor failure pointed to supply voltage problems. Utilising continuous voltage monitoring and measuring equipment, low voltage on the power supply was measured at several sites. Based on the finding, a pump motor protection circuit was specified, designed, fabricated. The voltage sensor circuit, built to protect against several specified damaging modes is capable of mitigating wide spread water pump motor damages caused by the specified poor power damaging modes. This solution, when implemented, can result in a sustainable water delivery infrastructure that guarantees continuous water delivery to communities; with impact on national economic savings and general social welfare.

Keywords: electronic circuit, load shedding, measurements, pump motor, sustainable

1. Introduction

Water distribution pump motor failure causes are many, and included on the list is poor power quality. Poor power quality disturbances that affect motors are high and low voltage, voltage and current imbalance, voltage surges and spikes, single phasing and phase reversals and harmonics. (Jason, 2015). Other related causes are pump motor overloading, high ambient water temperature and low and very high flow rate of external cooling water. Motor overheating is usually a symptom of problems that can result in motor failure if cause is not eliminated, resulting in extended down times, repeated repairs, and higher maintenance costs. In most cases motor failure is as a result of insulation winding failure leading to shorting (Bryan, J, 2015).

Low voltage on the utility grid was identified to be the main cause of refrigeration equipment failure at Mount Makulu Research centre. While low voltage, surges and short duration dropout were measured on several pump stations of the water supply company in Lusaka.

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To resolve the problem, automated electronic system that senses these aberrations and isolates the motor from the disturbances needs to be installed on the supply lines. However, the natural variability of the supply gives a challenge for close monitoring and control, the problem which is in need of novel solutions and close attention (Jayson, 2015). The designed voltage sensor presented in the paper is capable of both automated monitoring of the power supply and protection of the motor pump by means of isolating the motor from the poor power source. Sensing and protection thus prevents widespread pump motor failures of water delivery infrastructure. Properly implemented, a sustainable water delivery infrastructure is now feasible.

2. Methodology

2.1 Instrumentation failure research in Zambia

The National Council for Scientific Research (NCSR), predecessor of the present National Institute for Scientific and Industrial Research (NISIR) has been the focal point for activities in the field of nuclear sciences and technology in collaboration with the International Atomic Energy Agency (IAEA) in Zambia. These collaborative activities included nuclear instrumentation as applied in agriculture, medicine, industry and general research. This author was the national coordinator of the national instrumentation program. Under these program activates, African member countries frequently met on equipment protection training workshops that addressed issues to do with equipment protection and instrumentation failure. In particular, a regular training program entitled "Power Conditioning, Earthing and Lightning Protection" was organised yearly, both in and outside Africa, where knowledge of instrumentation failure and solutions were shared (IAEA, 2016).

In the period between 1985 and 2005, investigations and studies were carried out on causes of water pump motor and refrigeration pump failures, after concerns of wide spread refrigerator motor failures at one of the NCSR centres in Mount Makulu area and at a later date at a Lusaka based water supply company that experienced an increase in water pump motor failure.

2.2 How pumps get damaged by poor power quality

Pump motors are mostly damaged when the motor winding insulation is destroyed by high temperature. Figure 1 shows theoretical impact of increased temperature on the life of the motor winding insulation system. Inference is that for every increase of 10^0C in motor operating temperature, life expectance is reduced by half and conversely if temperature is reduced by half the life expectancy will be doubled (Bryan, 2015).

Low supply voltage to pumps implies increased current, as stated by the relation P = VI where P is power, V is voltage and I is current. For constant power, reduction in voltage implies increased current I. Resulting from increased current I, I^2R heat losses in the winding resistance causes increased operating temperature which if sustained can result in motor failure. Similar situation results when voltage V goes up causing reduction in current I. However, motor runs faster. Further increase in voltage can however cause saturation in the iron core of the motor which can cause increased current and subsequent heating. *NEMAMG1* standard recommend motors to run at rated +/- 10% while IEC recommend +/- 5%. (Bryan, J, 2015).

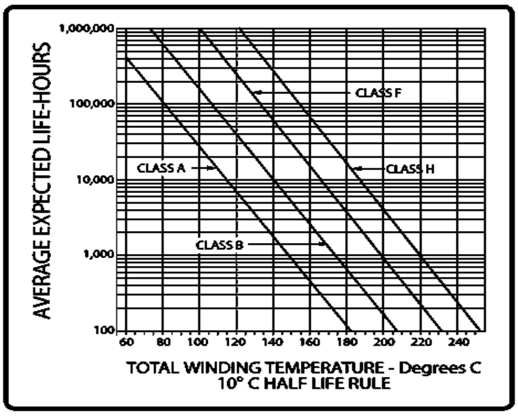

Figure 11*: Total winding temperature - degrees C* ***10^0 half-life rule*** **(Source: Bryan, 2015)**

Voltage imbalance on a three phase supply to the motor will result in increased temperature especially on the phase with the highest voltage. The formula used to estimate the unbalance for both voltage and current is given as:

$$\%\,\mathrm{Un}\,balance = \frac{\max imum - deviation - from - average}{average}$$

NEMAMG1 states that the percentage current unbalance may be 6 to 10 times the percentage voltage unbalance, a condition that calls for accurate voltage measurement within .5% on all phases. (Bryan, J, 2015).

Other damaging modes of concern in Zambia are voltage and current surges brought about by improperly installed load switching events and lightning events. Short duration supply voltage dropout and load shedding are other aberrations harmful to motors (Zesco, 2015).

2.3 Conducted Zesco utility supply studies and measurements

In the late eighties, observation of wide spread failure of research refrigeration compressor pumps at one of NCSR centres in the Chilanga area on the outskirts of Lusaka city, was made. Further, detailed investigations carried out at this centre, using power line voltage measurement equipment, revealed general low voltage on power supply lines. These measurements were done using continuous voltage strip chart recorder, over an extended period of time. It was clear from the results obtained, that low voltages occurred on the grid. It was also established that the low voltages coincided with times when the nearby Chilanga cement factory was in full operation. The resulting near brown out condition that affected refrigerators pumps was conclusively arrived at as caused by the high power demand by the cement factory that shared the local network grid and was the main cause of refrigerator pump failure.

In November and December 2004, water pump installation investigations were conducted at seven pump stations of a local Lusaka water supply company. The company requested checks of various parameters that included earthing systems, wiring and power quality. The request was made after recording several failed pump motors. Fluke power line monitor, strip chart continuous voltage monitors and earth meter were utilised in the measurement exercises.

3. Results

Figure 2 and table1 show the results of the measurements carried out at one of the pump stations. These are selected samples of the many measurements that were made. These results show the most potent disturbances that can damage motors. These include low voltage, surges and short duration power dropouts. The consequential effects of dropouts are similar to load shedding effects. Figure 2 shows the measured utility power supply consistently below the nominal 230Vac while table1 measurements taken from, 9th to 15th November 2004, show eleven transients, and one short duration outage event.

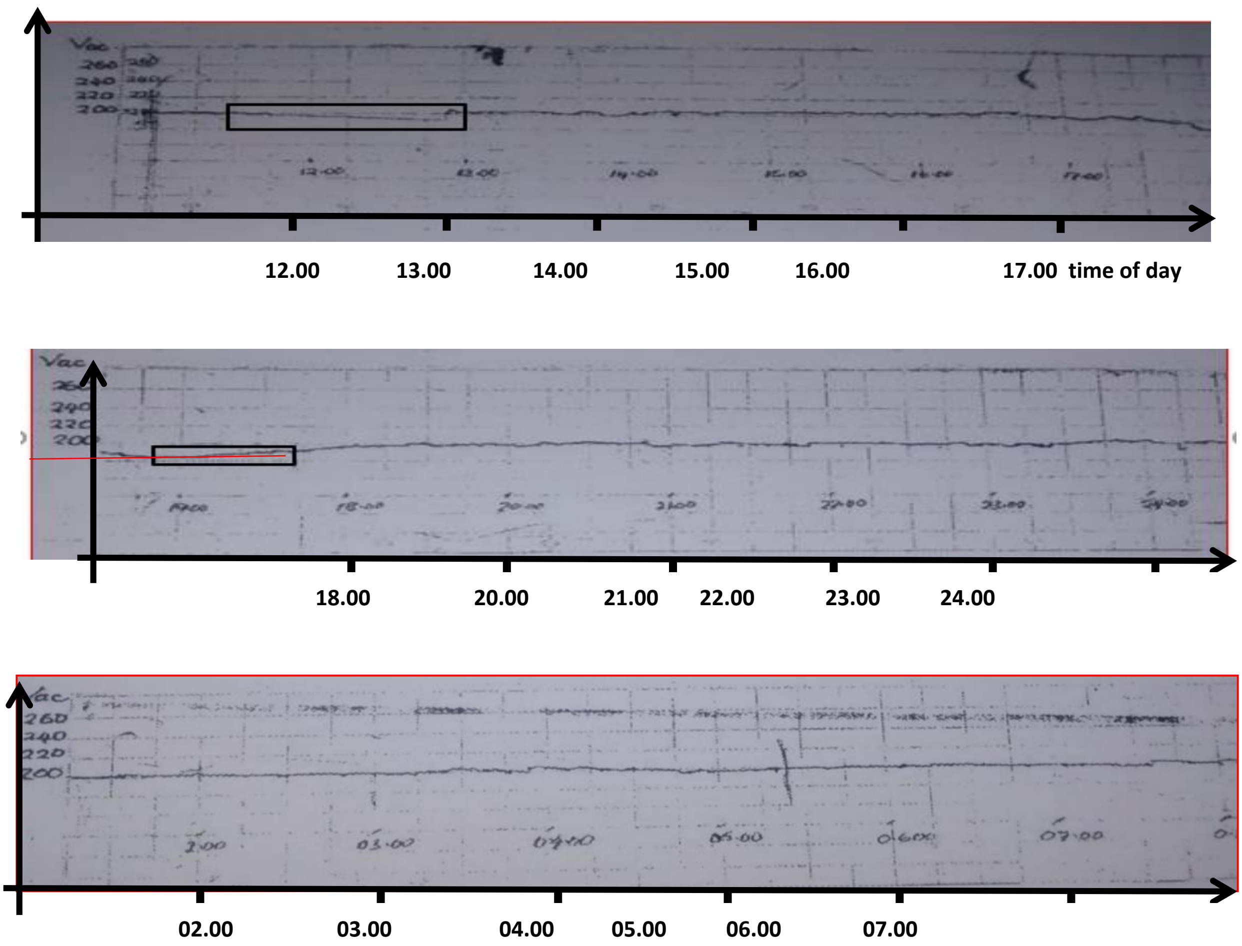

Figure 12: ***Plot of continuous phase voltage measurements using strip chart recorder taken over 20 hours period, showing consistent low voltage.***

Table 1: Summary of power line disturbance measurements

167	11/15/2004 7:00:40 AM	23 N-G Transients	-230 Vp	228°
166	11/15/2004 6:04:48 AM	1 N-G Transient	-140 Vp	31°
165	11/14/2004 3:00:16 PM	1 N-G Transient	+160 Vp	212°
164	11/14/2004 10:12:00 AM	10 N-G Transients	-110 Vp	242°
163	11/14/2004 8:01:04 AM	10 N-G Transients	-190 Vp	212°
162	11/13/2004 6:10:00 AM	1 N-G Transient	+120 Vp	297°
161	11/13/2004 5:52:08 AM	67 N-G Transients	-300 Vp	270°
160	11/13/2004 5:52:08 AM	67 H-N Transients	-260 Vp	270°
159	11/12/2004 5:57:36 AM	45 N-G Transients	-130 Vp	116°
158	11/11/2004 3:50:24 PM	1 N-G Transient	+130 Vp	228°
157	11/9/2004 10:56:08 AM	Outage 0 Vrms	11/11/2004 10:48:40 AM	
156	11/9/2004 10:56:08 AM	1 H-N Transient	+320 Vp	2°

3.1 Design and fabrication of a voltage sensor circuit

Given the problems stated above in terms of damages to pump motors in the country, due to poor power quality problems, local solutions to these problems can be configured to minimise damages to motor pumps. The following section gives a possible remedy to these challenges by way of monitoring changing voltages on the power lines through a voltage sensor and automatically responding to effect protection against all the four stated damaging modes

In conceptualising specifications for the voltage sensor protection circuit, the four damaging modes discussed above were considered.

The block diagram of the protector, highlighting main circuit components is as given in figure 3. The voltage sensor block comprises a potential divider attenuator, a half bridge rectifier and a low pass filter, the comparator, delay timer and output switch. The rectified ac voltage directly senses variations of the utility (220Vac). Comparator block senses two threshold values of low (180Vac) and high (260Vac) utility voltage variations. Safe operation window for pump motors in general is taken between (180Vac) and 260Vac. This implementation is shown in figures 4 and 5 below. The circuit discussed in this paper is for single phase application. Three phase circuit requires integration of three single phase sensors.

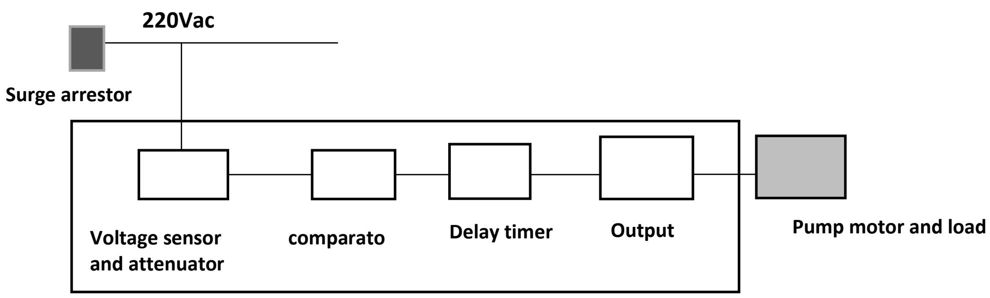

Figure 3: Voltage sensor circuit block diagram

The four protection modes are addressed as follows:

1. When low or high threshold voltages of (180Vac) or (260Vac) are sensed, circuit automatically disconnects the load from power source, thereby isolating the load from the disturbed power source.
2. After good power is restored, the delay component of the circuit delays connecting the load by a predetermined time determined by the RC components time constant. Damages usually occur here at the restoration of power as various loads in the whole community try to come on. Though not visible to the naked eye the power source turns on and off many times before stabilising. Generated transients and other disturbances permeate the grid at this time. A safe estimated period to stable power is about three minutes.
3. Short duration power dropout is also detected by comparator, disconnecting the load which will only be reconnected after the sensor delay time. This feature allows pump motors enough time to synchronise or decompress and start normally.
4. Protection from high energy surges/transients on power lines is done by the surge arrestors. This is not part of the sensor but is on the phase line (Schimanski, 1991; FIPS,1993; DEHN+SOHNE, 2014).

Figure 4 represents the voltage sensor attenator, rectifier and filter circuit. It senses the 220Vac and attenuates it to lower value which is rectified and filtered to give a dc value that is proportional to the line voltage. Figure 5 represents the comparator and the timer circuit. The comparator section is configured to detect the high and low voltage thresholds. The timer circuit determines the timing time of the delay. Figure 6 and 7 show the final fabricated voltage sensor prototypes for pump motor and refrigerator motor protection.

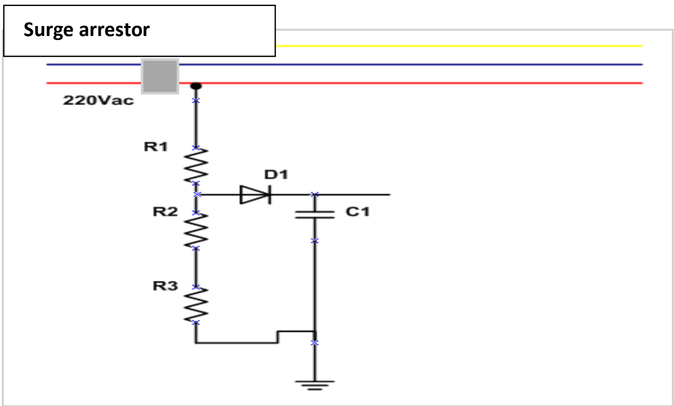

Figure 4: Voltage sensor attenuator, rectifier and filter circuit

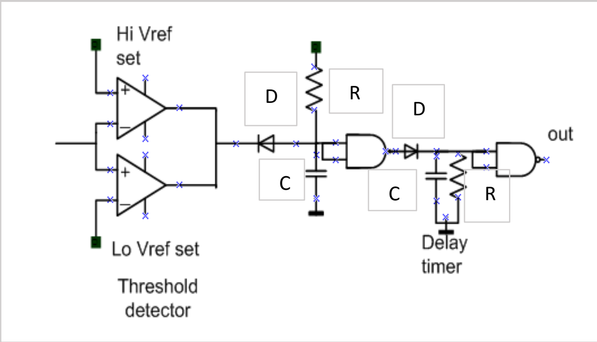

Figure 5: Comparator and the timer circuit

Figure 6: Packaged protection voltage sensor circuit

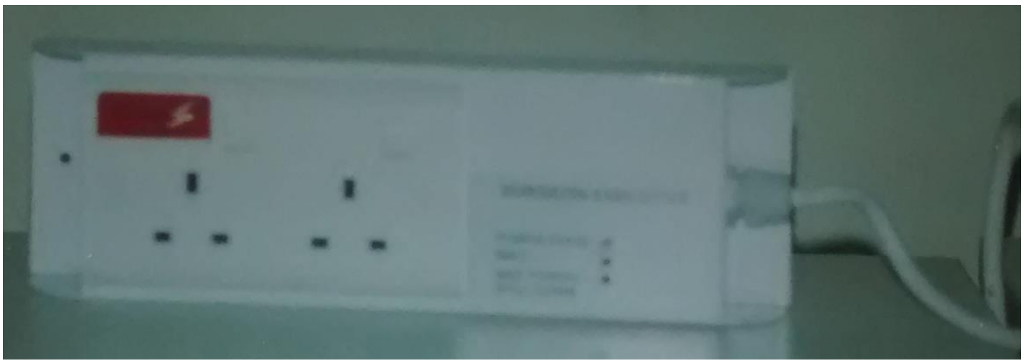

Figure 7: Variation of the voltage sensor used for refrigerator protection

4. Discussion

Water distribution pump motor failure iscaused by poor power quality and other related non power causes. There however seem to be a general agreement that power related issues are the main causes of the motor inductive loads failure due to subsequent overheating and winding insulation failure. Investigations and studies conducted on several Lusaka based water pump station in 2004, revealed low voltage to have been the main cause of the recorded failures as shown in one of the sample measurement results in figure 2. However, figure 3 sample fluke meter power quality measurements reveal presence of surges(transients) and short duration power dropouts which are equally undesirable situations for inductive pump motors.

To protect against these power quality problems, an electronic circuit was specified that would sense the low and high set voltage thresholds, and short duration dropouts. Under these conditions, the circuit would disconnect the pump motor and its load from the poor power source. Restoration of power to the load will only be after power returns to acceptable levels. The delay time before restoration protects against local generated surges and allows for proper synchronisation in case of short duration dropout. External surge arrestors are included on the power line to absorb fast damaging surges from reaching the motor, load and electrical and electronic controls.

As other non-power causes of pump motor damage have symptoms of motor overheating, a temperature transducer can be included and incorporated in the voltage sensor circuit.

Protection of water pumps for water delivery companies that guarantees sustainable water delivery can be improved by conducting power quality audits and the incorporation of voltage sensor circuit to protect against premature water pump motors.

5. Conclusion

This paper has presented the various utility power aberrations that adversely affect water pump motors and has shown that solutions can effectively be configured, designed and produced locally in a cost effective manner. This addresses the question of infrastructure development and sustainability through proven endogenous effort.

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DII 2017-038

An Audit of Embedding Sustainability Elements in Built Environment Education in Zambia

Sambo Zulu[1], Franco Muleya[2]

Abstract

The importance of the construction industry in achieving the nation's sustainable development agenda is recognised and has been a subject of research by many. It can be argued that to some extent that sustainability is seen as a moral challenge to this generation. Several initiatives have been introduced the world over to encourage the construction industry to support the sustainability agenda. Evidence also suggests that many organisations have adopted initiatives to enhance their sustainability credentials. The Zambian construction industry is currently thriving with infrastructure development projects as one of the major sources of construction activities. In addition, the inward foreign direct investment has resulted in precedent demand in the construction industry. The need for a sustainable construction industry should therefore be an important consideration as the industry continues to develop. This study acknowledges the significant role universities can play in driving the sustainability agenda. As such the aim of this research was to evaluate the extent to which sustainability is embedded in Built environment curriculum at a university in Zambia as a case study. A review of literature was conducted to determine the effectiveness of sustainability education models. Interviews were also conducted with heads of departments in the university in order to determine the extent to which sustainability elements are embedded in their curriculum. The responses from these heads of departments were verified by interviewing lecturers teaching relevant modules on the subject matter. Students' projects with sustainability elements were also examined as a verification process. Thereafter, the approaches used in embedding sustainability in Built environment courses were evaluated. The study concluded that all the departments at the University under study were aware and conscious of embedding sustainability elements in the curriculum, however, not all departments had implemented the sustainability embedment in the curriculum. The study further revealed that all the departments had in one way or another included sustainability elements in students' projects and dissertations at undergraduate and post graduate programs. The study recommends full inclusion of sustainability lessons and skills in the entire curriculum, but in conjunction with industry partners and stakeholders, in order to fully meet the sustainable development goals 9, 11 and 12 which addresses Industry, Innovation and Infrastructure; Sustainable Cities and Communities; and Responsible Consumption and Production.

Keywords: audit, built environment, curriculum, education, sustainability

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1. Introduction

Sustainable construction is one of the leading headlines in the global sustainability agenda. This is more so that the construction industry is seen as a major consumer of the bulk of the ever diminishing natural resources such gravel, cement, steel, timber, water, aggregates to mention a few. Further the construction industry is seen to be a contributor to greenhouse gas emissions. This study focuses on the role that universities can play in producing graduates that understand and contribute to the successful achievement of the sustainability agenda through embedding sustainability elements in the curriculum and research projects. The study further acknowledges that universities need to work with industry partners and stakeholders who are one of the major stakeholders in the sustainability cycle. The study further investigated the level of recognition of universities role in the sustainability agenda by key partners and stakeholder in Zambia. The Zambian construction industry has over the last 10 years witnessed a steady increase in construction activity in various sectors including infrastructure, housing and retail. According to the Zambia Development Agency (ZDA) report for 2014, Zambia recorded USD 3.3 billion in foreign direct investment mainly in the construction sector in 2014. Zambia commissioned a number of larger infrastructure projects which were large consumers of natural raw materials which included steel, aggregates for roads, cement for concrete production among others. Other major projects included the link Zambia 8000 kilometres and pave Zambia 2000 kilometres. This included, Copperbelt Province roads, the Mongu-Kalabo road project in the sandy terrain western province of the country. Other projects undertaken included hydro power stations, and schools, among others. Further the National Council for Construction report presented to the 2015 DII conference stated that the number of local and foreign contractors grew from 1,307 in 2005 to 4,627 in 2014. The number of foreign contractors rose from 26 in 2005 to 219 in 2015 representing significant growth in the construction sector. It is therefore important that the sustainability agenda is promoted in the Zambian construction industry taking into account the volume of work that has characterised the country. The higher education sector is seen as key in delivering the sustainability agenda. It is evident, based on a review of literature that universities world over can influence decision makers of tomorrow and as a result, the approaches they use in instilling sustainability skills in students become important. This aim of this study was therefore to provide an audit of the current approaches used in embedding sustainability in built environment education in Zambia. This is a follow up study on Zulu and Muleya (2017) in which they examined the student perceptions on sustainability considerations in construction procurement at the same university.

Within the construction industry, a considerable body of literature (Miyakate, 1996; CIB, 1999; Hill and Bowen, 1997) has identified certain principles for sustainable construction. These principles include:

- resource consumption minimization;
- the maximization of resource reuse;
- use of renewable and recyclable resources;
- the protection of the natural environment;
- creation of healthier and non-toxic environments; and
- the pursuance of quality while creating the built environment

The above principles must be accepted and supported by all stakeholders on built environment projects in order to attain the respective sustainable development goals. The implementation of the principles must be measured against the goals in order to establish compliance of the projects to sustainability.

2. Sustainability and the Role of Education

According to the World Commission on Environment and Developments (WCED, 1987) also known as the Brudtland's report, it defined sustainable development as 'development that meets the needs of the current generation without compromising the ability of future generations to meet their own needs' (WCED 1987). It is generally accepted that this definition is broad and encompasses three strands, namely environmental, social and economic sustainability (Zwinkle et al, 2014; Zeegers and Clark, 2014). Zuofa, T. and Ochieng, E. (2016) however highlights that irrespective of definitions, Atkinson (2008) suggested that the basic intention of sustainability appears to be how replenishing the well-being of living systems can be achieved over time

The Higher Education sector has been viewed as a key stakeholder in the drive for achieving the sustainability agenda. The role of institutions of higher learning in driving the sustainability agenda has been a subject of many studies. Some have, for example argued that universities train leaders of tomorrow and therefore have an influence on future decision makers. As such universities can have a significant part to play in creating a sustainable environment (Cortese 2003); Kalpana et al 2013. The need for incorporating sustainability in university courses, built environment courses inclusive, has been a subject of many studies (Ramirez, 2006). This incorporation can be extended to group and individual course projects, dissertations and course work or assignments.

3. Sustainability Education Approaches

From the discussion above, it is clear that the higher education sector such as universities and other training institutes and schools among others can influence decision makers of tomorrow. In view of this, the approaches that they use in instilling sustainability skills becomes important. This study provides an audit of the effectiveness of current approaches used in embedding sustainability in built environment education in Zambia. This section provides an overview of different methods that can be used to embed sustainability in curriculum. Today, there are more and more efforts to include Education for Sustainable Development (ESD) in engineering education. Many projects relate to the development of learning objectives or strategies for curriculum or course development for inclusion of ESD (Knutson Wedel et al., (2005); Svanstro ̈m et al., (2008); Segala `s et al., (2009); Hargroves and Desha, (2010)

The method used to achieve a higher degree of embedding of ESD at Chalmers University of Technology in Sweden involved the formation of a "resource group" of teachers from many different departments, experienced in ESD. This group was given the task to approach teachers and programme directors at Chalmers with the aim of embedding ESD in educational programmes, Sandstorm et al (2012). In addition, they offered open lectures to incoming undergraduate and graduate students on sustainable development and their role. Additionally, learning about sustainability was integrated into master's level engineering and architecture programmes. All students are required to take one compulsory course in Environment and Sustainable Development. Courses are available in the different disciplines, which allow students choice in how to fill the requirement, Johnson, (2007). According to Fadeeva and Mochizuki (2010) universities play an important role for fostering Education for Sustainable Development 'by addressing sustainability through their major functions of education, research and outreach. In the study by Matthias Barth and Marco Rieckmann (2016), it was concluded that there is a clear need for more research on higher education for sustainable development from non-Western researchers as well as for more research in non-Western countries. Conducting more research in the – so far underrepresented – non-Western regions will help to better understand the relevance of different contexts as well as general drivers and barriers for implementing HESD and will contribute to cross colonial boundaries. This is very important because the application of sustainability will vary based on the region, capacity and technology in a particular area. The embedding of sustainability in the curriculum will vary from region to region depending on the counties specific needs and capacity.

Amadora et al (2015) study confirms the idea that the development of academic staff abilities is an essential prerequisite for a sustainability paradigm shift in higher education. This study shows the importance of having a theoretical framework supporting a set of criteria through which curricular assessment takes place, and provides a clear picture of the manner in which sustainability issues are addressed in different courses. Curricula assessment should also be complemented with research on pedagogical approaches and their effectiveness in delivering sustainability education, and 'educating the educators', as stressed by Lozano and Young (2012). There has been an increasing interest in integrating sustainable development into curricula at all levels, as well as methods to achieve this, particularly in terms of students gaining an understanding of how their own decisions and actions of groups, corporations and states affect the environment and society (Lozano 2012). Poon (2017) research concluded that to effect a successful implementation of incorporating sustainability within the curriculum, it is important to have support from all stakeholders, including academics and students. For the academics, the sharing of their positive personal experiences and good practice with the incorporation of sustainability within the curriculum is a suitable way to encourage their peers to do the same. One of the ways to encourage students to support the incorporation of sustainability into the curriculum is through recognising and rewarding their achievement; for example, awarding badges and prizes to students who have engaged in sustainability.

A study by Lambrechts et al. (2013) within two Belgian Universities indicated that many higher education institutions have integrated SD in competences and curriculum, The analysis pointed out that, despite valuable efforts, the integration of SD in competences showed some deficits: it was too implicit, too fragmented, and incomplete. Ekene and Suleh (2015), concludes from their study that the role of Marist International University College (MIUC's) curricula in contributing to sustainable development in Kenya could not be overemphasised. MIUC's curricula enhance environmental, socioeconomic, political and psycho-spiritual development in her graduates. MIUC provided an environment conducive to teaching and learning. Despite the role of MIUC in enhancing sustainable development in Kenya, it is faced by the challenges of financial constraint, limited programmes, and low enrolment of students, exodus of lecturers and lack of hostels. The study therefore made the following recommendations that Government should acknowledge the role private universities in Kenya are playing for sustainable development and fund them fully as it funds public universities. This is important because government is the owner of major development activities that affect sustainability issues. Lozano and Lozano (2014) states that with a growing interest in sustainability, a number of universities have engaged in educating the future leaders, decision makers, scientists, and engineers on how their decisions can help societies become more sustainable. In this study, the process for developing the Bachelor's degree curriculum in Engineering for Sustainable Development at Tecnológico de Monterrey in Mexico was undertaken. While one approach of introducing sustainable development is embedding sustainable elements in the curriculum, one other way of to develop programs that wholly focus on sustainability in almost all sectors of the university programs to address industry challenges that border on sustainability. Table 1 shows the many sustainability based courses developed in various universities.

Table 1: Examples of Degrees in Engineering and Sustainable Development (Adapted from Organisational Sustainability, 2013 and Lozano and Lozano, 2014)

Degree	**Level Institution**	**Country**
Bachelor of Engineering in Sustainable Electrical Power Engineering	Bachelor University of Greenwich	UK
Bachelor Sustainable Energy	Bachelor	Copenhagen University, College of Engineering Denmark
BSc Chemical Engineering in Sustainable Chemical Technologies	Bachelor	Berlin International College Germany
BSc Environmental Engineering	Bachelor	California Polytechnic State University USA
BSc Environmental Engineering	Bachelor	Cornell University USA
BSc Environmental Engineering	Bachelor	Drexel University USA
BSc Environmental Engineering	Bachelor	Florida State University USA
BSc Environmental Engineering	Bachelor	Johns Hopkins University USA
BSc Environmental Engineering	Bachelor	UBC Canada
BSc in Environment and Energy	Bachelor	Rhine-Waal University of Applied Sciences Germany
BSc in Environmental Engineering	Bachelor	Novia University of Applied Sciences Finland
BSc in Sustainable Electrical Technology	Bachelor	Institute of Technology Blanchardstown Ireland
BSc EnvE Environmental Engineering	Bachelor	Georgia Institute of Technology USA
Business Engineering Sustainable Energy Systems	Bachelor	Hochschule Luzern Switzerland
Civil Engineering: Sustainable Building Engineering	Bachelor	Helsinki Metropolia University of Applied Sciences Finland
Civil, Environmental and Sustainable Engineering and Construction	Bachelor	Arizona State University USA
Engineering (Mechanical and Sustainable Systems	Bachelor	University of South Australia Australia
Engineering (Sustainable Systems Engineering)	Bachelor	Royal Melbourne Institute of Technology Australia
Engineering in Sustainable Energy	Bachelor	Cork Institute of Technology Ireland
Engineering in Sustainable Energy Engineering	Bachelor	University of Adelaide Australia
Engineering Sustainable Energy Systems	Bachelor	Australian National University Australia
Engineering with an Alternative Energy Technology Concentration	Bachelor	Wayne State University, College of Engineering USA
Mechanical and Sustainable Energy	Bachelor	University of Adelaide Australia
Sustainable Design Engineering	Bachelor	Dundalk Institute of Technology Ireland
Sustainable Energy	Bachelor	Cork Institute of Technology Ireland
Sustainable Energy Engineering	Bachelor	Athlone Institute of Technology Ireland
Alternative Energy Technology Master of Science Degree Program	Master	Wayne State University USA
Civil, Environmental and Sustainable Engineering, Master of Science (M.S.)	Master	Arizona State University USA
Clean Energy	Master	UBC Canada
Construction Management and Sustainability	Master	University of Pittsburgh USA
Engineering Sustainable Systems (MSc and MScE)	Master	University of Michigan USA
Mining Engineering, Specialisation in Mining Sustainability and the Environment	Master	UBC Canada
MSc Sustainable Energy Technology	Master	TU Delft The Netherlands
MSc Sustainable Process and Energy Technology	Master	TU Delft The Netherlands
MSc Civil, Environmental and Sustainable Engineering	Master	Arizona State University USA
Sustainable Energy Engineering	Master	Royal Institute of Technology Sweden
Civil, Environmental and Sustainable Engineering and Construction	Master/PhD	Arizona State University USA
Sustainable Urban Planning and Development	Master	University of Johannesburg

Table 1 shows some of the various sustainable related programs at Bachelors, Masters and Doctorate level offered by various Universities world over. The table illustrates that there are many programmes in different disciplines and professions that embrace sustainable development. This signifies the breadth and depth to which teaching and research institutions have gone in embracing sustainability in different fields of study and research.

4. Methodology

In this study a desktop study of literature review on sustainability in the university education curriculum was carried out. The study took a simple audit of the curriculum in the Built Environment School of a University in Zambia as a case study. The university and industry institutions were selected through the case study approach because of the limited availability of built environment schools and regulators in the country. Literature on sustainability in a University in the region was also considered. Interviews were also conducted with 5 heads of departments under the Built Environment School. The purpose of targeting the departmental heads was to get the current status regarding embedding of sustainability skills and knowledge in the curriculum, and students research projects. The responses from heads of department were verified by interviewing lecturers in relevant courses. Students' projects were also examined to verify the embracing of sustainability aspects in their projects. Managers responsible for promoting sustainability at local institutions in the industry were also interviewed in order to establish expectations of sustainability skills and knowledge from graduates in the industry.

5. Results and Discussion

Construction Regulator 1 indicated that despite not enforcing sustainable development in the industry, one of its mandates was to champion sustainable housing, sustainable constriction and suitable designs. The regulator clearly stated that they were looking to research institutions such as universities to play a major role in delivering solutions that hinge on sustainability. It is therefore important for universities to provide leadership and equip students with sustainability skills as they become decision makers.

The Local authority in which the university is located stated that it is aware of the need to become green and sustainable in all the infrastructure projects, however they have no capacity incorporate sustainability elements in development. The authority indicated that they were relying on stakeholders such as research institutions and universities for driving the sustainability agency. Local authorities normally require that the proposed sustainable designs, materials, practices and methods are demonstrated before the authorities before approve and adopting them. Financial constraints and lack of stakeholder commitment were cited as the main reasons for less activity and movement in the sustainability direction of developing the Built environment from a research and application point of view. It is clear that developing countries face similar challenges when it comes matters of sustainability. This account further confirms the role that the university has to play in championing the sustainability agenda in the country hence the need to carry out an audit to establish the level of sustainability in the curriculum

Interviews were conducted in the five heads of department from the five departments in the university's school of the built environment and part of engineering. The departments offer various degree programs including Architecture, Quantity surveying, construction management, urban/regional planning and Real Estate. As discussed above, the purpose of the interviews was to determine the extent to which sustainability has been embedded into the course curriculum. Interviewees were firstly asked to review the extent to which sustainability skills were included in curriculum. Secondly interviewees were asked to evaluate the extent to which sustainability is included in student projects. Table 1 presents a summary of the findings.

Table 2: Sustainability embedment responses at a local university in Zambia

Department	Sustainability lessons and skills included in curriculum	Sustainability lessons and skills included in projects and dissertation.	Plans to formally introduce Sustainability lessons and skills in curriculum in conjunction with industry partners
A	✓	✓	✓
B	✓	✓	✓
C	**X**	✓	✓
D	**X**	✓	✓
E	**X**	✓	**Not Sure**

Results from the interviews indicated that two of the five departments had commenced the process of embedding sustainability lessons and skills in the curriculum. Three other departments had not yet commenced the process. Two of three departments however indicated that they have plans to introduce sustainability aspects in consultation with industry partners while one was not sure. The general response form the departments was that clients, institutional and industry stakeholders do not have an aggressive agenda to embrace substantiality hence slow rate of adopting it in the curriculum. Research projects in the built environment school had done well in addressing some of key elements of sustainability in areas such as land use planning, use of mine waste products as construction raw materials, green leasing and sustainable designs that meet local needs of clients. All the departments in the Built Environment and part of engineering schools exhibited evidence in efforts to address sustainability related aspects through selected student research projects. The challenge lies in the fusing in of sustainability aspects in the program curriculum in consultation with industry stakeholders. Limiting embedding of sustainability elements in research projects alone is not enough to influence good practice where sustainability of the construction industry in concerned. The current curriculum does not contain sustainability elements. Sustainability aspects alongside sustainable development goals are mentioned informally and not necessarily as a major element. This requires serious curriculum review in partnership with industry and other research stakeholders.

6. Conclusion

The study concluded that all departments in the built environment school have sustainability components but only in the research component carried out by students which is a very good indicator. The results show that it is very possible to fully embed sustainability lessons and skills as part of the curriculum because that is already happening at individual and group project level. Depending on the extent of the curriculum review required some changes may require senate approval while some may not. It is worth noting that sustainability skills and lessons in the curriculum cannot be developed or embed without the key stakeholders' involvement such as clients' consultants, local authorities, regulators and relevant government ministries. Much of the industry practice today remains unsustainable in terms of design, practice methods, materials and waste management. The study recommends speedy consideration of fully embracing sustainability lessons in the curriculum in order to meet s the Sustainable Development Goals (SDGs). Further, it has become acceptable practice to embrace sustainability in the education systems in order to develop minds that will always embrace sustainability aspects in industry at all levels. Currently the curriculum has no elements of sustainability in them thereby presenting a major gap in the training process of the students. The formal introduction of sustainability lesson and skills in the Built Environment and Engineering curriculum can play a significant role of influencing sustainable practice in the Zambian industry thereby preserving diminishing natural resources and maintaining a greener environment.

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DII-2017-055

Commercialisation of Bamboo in Ghana: How Sustainable in Infrastructure Development

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Abstract

Bamboo is a multi-purpose composite material with wide industrial applications.The accelerated deterioration of Ghana's forest timber as a result of high demand for its products and unlawful harvesting practices has led to exploitation of other non-forest resources like bamboo The study examined the commercialisation of bamboo as an alternative material to timber, its sustainability to the infrastructure development and effects on rural livelihood in Ghana. The primary data collection was attained through a structured survey study which employed questionnaires, interviews, observations, pictures in the three regions under consideration. Data were analysed using descriptive statistics and regression analysis method from which a total of 300 respondents were involved in the three regions of study. The results show that Eastern region has an average total cash income of 64% with Ashanti having 27% and Western region with only 9%. Bamboo commercialisation in Ghana would boost the economy and infrastructure growth of rural livelihood, provide material for construction industries, reduce the over-dependence on timber for construction and provide the nation with foreign exchange.There is a prospect for sustainable rural income and commercialisation in the construction and wood industries.Though bamboo commercialisation had received little consideration in the wood industries in the past decades, it has been boosted currently with the development of the value chain with effective, sustainable management systems. The development of infrastructure for connecting resource and consumers through awareness creation among producers may boost and improve the availability of the resources.There is a need to enhance a sustainable bamboo cultivation and treatment process by creating a connection between all stakeholders in the commercialisation of Bamboo in Ghana. This will help in realising a sustainable wood and construction industry.

Keywords: bamboo, commercialisation, construction, Ghana, infrastructure, sustainable

1. Introduction

Bamboo a non-timber forest product (NTFP) has been consideredsignificant resources for rural communities and a sustainable use of the natural forest. Bamboo has a high economic and environmentally sustainable development which has received increasing interest among scientific researchers (Wunder et al. 2014). Bamboo is abundance across Ghana's ecosystems, from the

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rainforests to the dry savanna zones which increase the worth of the forest making it an incentive for preservation (Belcher et al. 2005). It is a fast-growing natural plant, renewable, environmentally friendly, cheap and a multipurpose material having several applications (Lobovikov et al. 2011: Perez et al. 2004). Bamboo is the most efficient plant that is used in solving many environmental issues as well as providing socio-economic needs of most rural communities and as a raw material for Ghanaian wood industries (Xuhe, 2003). Bamboo is used at all levels of industrial applications ranging from small to large scale industries such as construction, craftwork and other works (Lobovikov et al. 2011). The significance of bamboo in construction is due to its mechanical properties like high strength to weight ratio, tensile strength and high specific load bearing capacity(Tada et al. 2010; Ghavami 2005). These properties make it an alternative material for the wood and construction industries in Ghana. Its applications in the construction sector include scaffoldings, trusses, bridges and furniture. However, despite its numerous benefits, the major setbacks to bamboo commercialisation in Ghana is the limited capacity of local firms (small and medium scale enterprises) to meet the global competitive value chains standard (Belcher 2007; Oteng-Amoako et al. 2004). The efforts to commercialise bamboo and its products through value addition are still inadequate as most products produce of low-value subsistence due to lack of technological transfer. This study examines the commercialisation of bamboo and its products, its sustainability to the wood and construction industries for a sustainable infrastructure development in Ghana.The commercialisation development can be broadly classified into three interrelated methods such as (a) value chains, (b) sustainable rural income and (c) challenges. The value chain method arose in response to bridge the limitations associated with the commercialisation by complementing the preceding methods (Figure 1), which have a large rural emphasis with weakness in linking the various stakeholders in the process (Jenssen 2009). The sustainable rural income method deals with the understanding of livelihood possessions and revenues mainly at the rural communities (Kanji 2005).

2. Commercialisation

Commercialisation comprises of the incorporation of a product or services into a market economy. The incorporation could be stated as due to improved economic trade value or by the percentage sale to the overall revenue (Nepal and Thapa 2009; Marshall et al. 2006). When the percentage of production ending in the market is higher than the general sustenance sale, the product is mostly considered as commercialised. Similarly, commercialisation can also be described by the form of the value chain strength. When a product or service attracts more demand, a related increase in the value chain length and complexity may be detected. Commercialisation may also occur at the input side, as manifested by the greater use of purchased inputs and management investment in domesticated or wild systems (Lemenih et al. 2011). The commercialisation of a product can be stirred or deterred by factors ranging from household characteristics to wider institutional and policy environments. Product commercialisation can be affected by external factors on infrastructure development, technological change, demand for the product, the extent of land use diversification, the level of input use and intensity of management (Marshall et al. 2006; Nepal and Thapa 2009; Hichaambwa and Thomas 2012). However, bamboo is in Ghana, especially in its industrial form, requires much processing and a modest level of manufacturing technology to realise quality product development and enter into a competitive market. In this study, it can be said that development of technological, product and organisational (entrepreneurial) innovation is crucial to inspire value-added commercialisation of bamboo in Ghana.

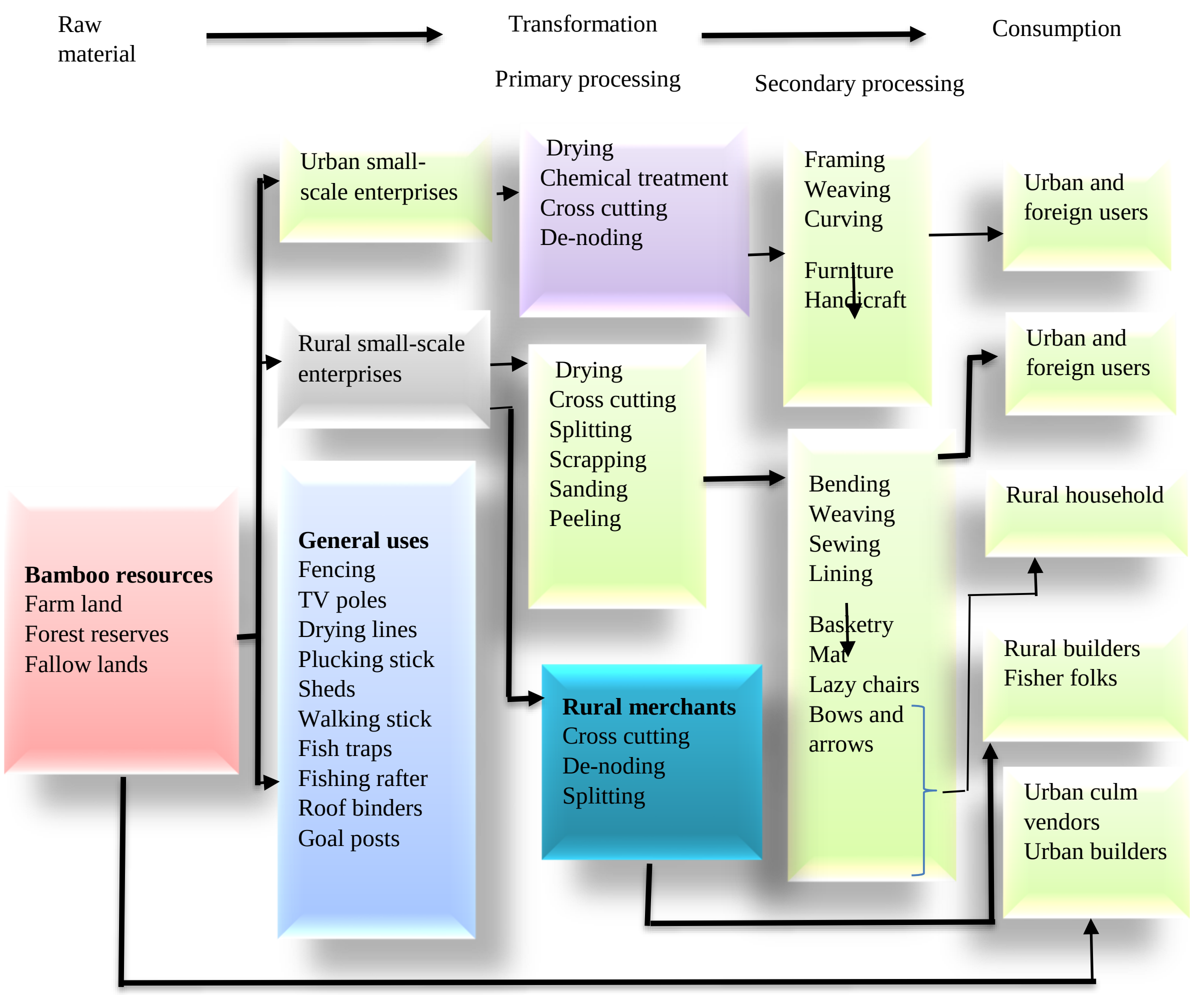

Figure 1: Current bamboo value chain structure of commercialisation in Ghana.

2.1 Bamboo commercialisation globally

There are over 1500 recognised applications of bamboo worldwide(Bystriakova et al. 2004). Globally, it is stated that there are over 2-3 billion people who depend on it for their daily sustenance (Lobovikov et al. 2011). In Asia, bamboo contributes to the highest value of economic returns to most countries with 2 million artisans in India and more than 1000 large processing firms buy millions of bamboo culms from farms in China (Zehui et al. 2012). Bamboo's image is improving from poor-mans-timber to a global commodity (Lobovikov et al. 2007) with a global market value of nearly US$10 Billion (INBAR 2014). Due to its recent growing recognition through improvement of its processes, its worth has been growing steadily (Lobovikov et al. 2011). The industrial production value of bamboo in China has increased from the US$13.1 Billion in 2010 to US$ 19.5billion in 2012 while in Indian it was expected to reach US$ 4.4 billion in 2015, which is a considerable improvement from US$ 35million in 2003 (INBAR 2006). There is a significant increase in the export of higher technology value-added bamboo products (e.g. engineered bamboo panels and others) compare to the traditional products from bamboo (e.g. mats and basket) (INBAR 2014). There is a total of (US$ 1.9 Billion) global market with 29% industrialised products and 25% being woven products (INBAR2014). The three top importers of bamboo and its products in the world include United States, European Union and Japan accounting 72% of the total world imports in 2012. China, Vietnam, Philippines, Singapore, Thailand, Indonesia, Malaysia and Myanmar being leading producing and exporting countries. China is the largest exporter of both traditional and high technology bamboo products (INBAR 2014) with a global market share of over 70% (Hogarth and Belcher 2013). China also has the largest workforce in bamboo research and development with a total of 450 bamboo products and patented technologies, intellectual property rights, as well as over 500 practical techniques on bamboo utilisation developed (Xuhe 2003). Due to China's advancement in bamboo commercialisation, other countries planning to commercialise their bamboo resource often focus on them as a model source of technology and motivation to develop, while they serve as major entry barriers to global industrial bamboo trade. According to previous studies from Latin America and South East Asia (Takahashi 2006), it was found difficult to compete with established Chinese firms. The need to copy Chines technology is seen as a global asset for bamboo commercialisation, while China's excessive domination of the global bamboo production and trade could be a liability for newcomers in the bamboo business.

2.2 Bamboo commercialisation in Africa

In Africa, there are over 50 species of bamboo found naturally distributed in vast areas of more than 4 million hectares. They are spread in the natural forest across the continent. Bamboo has not been given much preference in Africa compare to traditional wood, and its application is widely seen in small crafts, low-cost houses, fencing, partitioning of walls and as a weapon (Obiri and Oteng-Amoako 2007). Moreover, the level of technology for bamboo utilisation in the continent remains largely traditional, and a few processing firms (Zhang et al. 2003). In the few decades past, research has increased in the continent especially within INBAR member countries such as Cameroon, Ghana, Kenya, Nigeria and Togo, on its utilisation, development and policy issues (Zhang et al. 2003). There have also been baseline surveys by INBAR about the production - consumption systems of bamboo in several African countries. They are still limited in scope and are not adequate to bring about bamboo commercialisation in the region. Thus, although the resource is native to this region, Africans bamboo utilisation, product awareness and market integration are far lower than Asian countries (Ingram and Tieguhong 2013). Consequently, technology transfer from Asia to African is considered as a possible option for a technological catch-up and commercial competitiveness.

2.3 Bamboo commercialisation in Ghana

A study conducted by Forestry Research Institute of Ghana (FORIG) and International Network for Bamboo and Rattan stated an estimate of 400, 000 to 600, 000 hectares of bamboo available in Ghana (FAO 2005; INBAR 2006; FORIG 2014) corresponding to approximately 4.3% of the global bamboo supply. Ghana can sustainably produce 3 to 4 million cubic meters of bamboo culms weight annually (INBAR 2006; FORIG 2014) from both native species such as*Bambusa vulgaris, Bambusa v. vittata, and Oxytenanthera abyssinica*and exotic species like *Dendrocalamus strictus, Bambusa arundinacea*. Despite its many potentials, its uses in Ghana are limited to the construction of low-cost houses, furniture, handicrafts and partitioning. The various characteristics associated with bamboo and its availability in the country would enhance the commercial process and help in rural development. It is little, or no research work on bamboo commercialisation in the country and the current state of its marketing needs improvement. The trend of its usage in building and construction industries is increasingly gaining attention for commercialised utilisation in Ghana (Table 1) (Jansen 2000).

Table 1: Some applications of bamboo in the building and construction industries

Applications	Reference
Bamboo floorboards	Xiao et al. (2009)
Bamboo reinforcement	Iyer (2002)
Ceiling	Bandara(1990)
Doors and windows	Gangopadhyay (2003)
Formwork	Recht et al. (2001)
Ladder	Chung et al. (2003)
Landscape	Tekpetey (2006)
Roofing	Shyamasundar (2005)
Scaffolding	Chung et al. (2003); Janssen (2000)

3. Materials and Methods

The study was carried in three selected regions of Ghana which includes Ashanti, Eastern and Western region (Figure 2). The stakeholders include farmers, artisans, harvesters, vendors of culms, workers of wood and construction industries. Bamboo harvest from these regions is mostly extracted from the forest with few hectares being managed by commercial farmers and research institutions. In theses regions, the dominant species of bamboo identify includes *Bambusa vulgaris*, *Bambusa v. vittata* the local species and the exotic species include *Dendrocalamus strictus*, *Bambusa arundinacea*. There are several differences among the study regions regarding socioeconomic, cultural and land tenure systems.

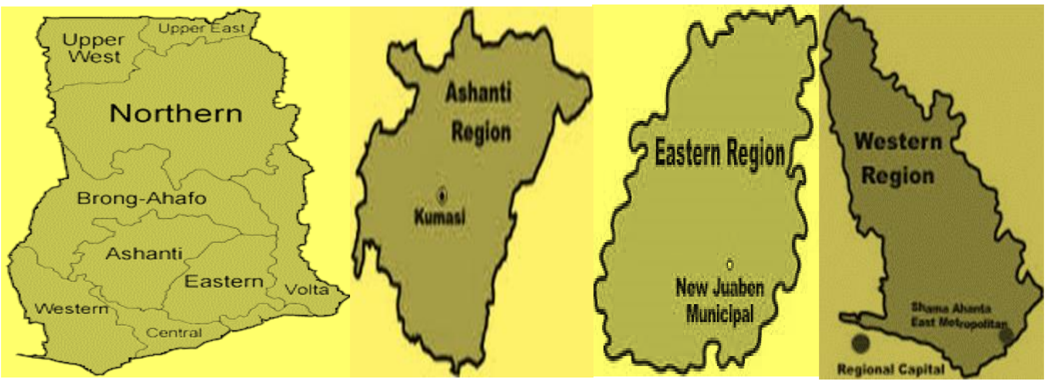

Figure 2: Map of regions for the survey in Ghana.

3.1 Data collection and analysis

3.1.1 Data collection

The data was collected through field survey such as interviews, questionnaires and observations in each of the three regions with stakeholders. The survey further looked at the production-level in each growing areas of the study. The survey questionnaires covered topics such as bamboo cultivation and management system, techniques for harvesting, treatment knowledge, the number of culms consumed and retailed annually, basic bamboo products, prices and income, traditional uses and modern uses.
The data on price and revenue of culms were collected at the various local markets of its products from each region by interviewing stakeholders, the average cost of 200 counts of culms was used in calculating of income and revenue ratios. Sustenance revenue for each region was estimated by assigning cash income equivalents based on the average local bamboo price per culm during the survey and multiplied by the estimated number of bamboo culms consumed by customers annually.

3.1.2 Data analysis

The data collected from the various regions were analysed using descriptive statistics and regression analysis. Data gathered through deliberations with individuals, observation, with small and medium scale workers, and qualitative interviews were analysed qualitatively. Income and commercialisation margins at the producer level of bamboo were analysed using descriptive statistics and regression analysis. Furthermore, income analysis, average prices of culms from each region was used, assumed that data based on price from each area of study is provided. Subsistence equivalents were derived from the selling price of bamboo culms sold in each region under this study. Finally, subsets regression analysis was used as a determinant to analyse bamboo commercialisation in the country with the rate of commercialisation taken as the dependent variable.

4. Results

4.1 Value chain

4.1.1 Bamboo culm production

Bamboo culm value chain starts with the plantations of the plant through its various production processes in each of the regions: the natural bamboo forest in Ashanti, Eastern and Western are managed by the (FORIG) and land owners. The study indicates that the main actors of culms production, harvesting and selling in these study are the landowners, harvesters and farmers. The culms harvest from farmlands, or the forest is sold to vendors who also sell it to wood firms with the remaining for domestic usage. Results show that harvesting culms from commercial farmland are strictly the mature culms. Most of the culms harvest from the rural areas of the regions of study are then transported to the main cities and towns as vendor's retrade them to wood sellers, construction firms, timber companies and artisans. It also came to light that vendors who buy culms in these areas fixed prices through negotiations per 200 counts. Some commercial farmers sell culms directly to industries that process them into useful products such as furniture, curtains, bamboo pellet, bamboo panels and boards.

4.1.2 Bamboo culms processing and consumption

Culms processing starts after harvest through various treatments to final consumption. From the three study areas, similar process practice was identified. The harvesters of culms by rural dwellers, prepare them for temporal household items like furniture, low-cost house constructions, construction of bridges, ladders, scaffolding and equipment for local consumption. It came to light that industrial processing of the culms occurs mostly in the urban areas with the major concentration being in the regional capitals. Some industries primarily produce bicycles, furniture, bamboo boards and floor tiles, pellet and charcoal using the traditional and modern equipment. The rural processors developed skills through internships with other processors. Most processors in the countryside sell their products at centres of production, having no sale centres but those with modern industries add value and export their products. Buyers interest of bamboo products varied with individuals perception with consumers being attracted by cheap products to high-quality products which combine traditional methods with the modern system of designs. Artisans and enterprises produce different types of quality bamboo products for foreign exchange.

4.1.3 Relationships in the value chain systems

In the Ashanti and Eastern regions, the value chain has a broad relationship and more complex as compared to a Western region in this study (Figure 3). This system of value chain was noticed among the stakeholders in the trade of culms in the area. (a) harvested culms are treatments and processed into products and traded to the towns and cities for consumption. (b) raw harvested culms are transported by vendors to major towns and cities in the country by suppliers and processed by wood and construction industries. (c) skilled artisans also use the raw culms for traditional value-added designs and construction of houses in the region after treating the culms from insects and fungi using the traditional method. (d) Small and medium scale enterprises produce furniture, mat, toothpicks, pellets, boards, bicycles, briquette, charcoal, and other products to consumers in the towns and cities and also export to other countries.

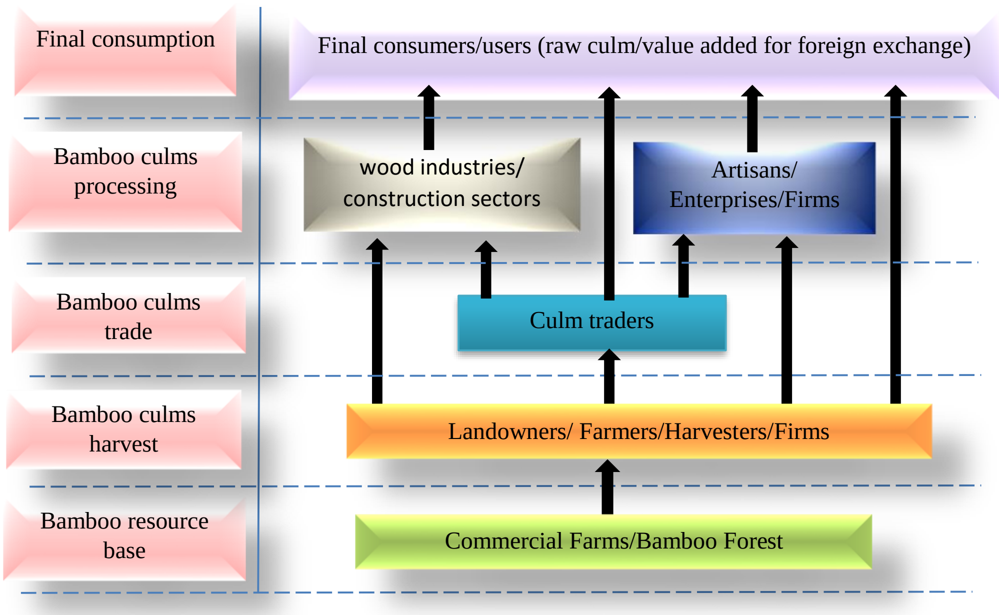

Figure 3:Value chain structure of bamboo commercialisation in Ashanti and Eastern regions.

The Western region, on the other hand, shows that key stakeholders in the chains are harvesters, farmers and consumers being involved in the commercialisation chain (Figure 4). In this region, farmers and harvesters of culms do consume the chunk of the harvested culms for the construction of low-cost houses, temporary structures, fences and for supporting stakes for weak-stemmed crops like banana and plantain. The study also discovered that the buyers of culms fixed the prices for culms per tonnes in this study areas with a low structure of value chain relationships due to the locations and the road networks in this areas.

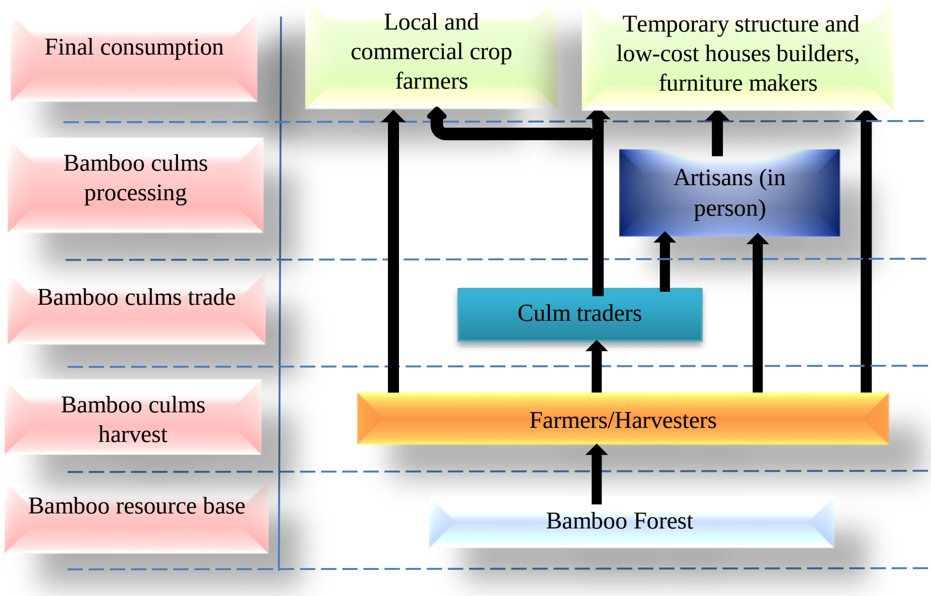

Figure 4: Value chain structure of commercialisation from the Western Region of Ghana.

4.1.4 Income and income ratios

The total average income of bamboo from the study areas was realised to differ from one region to the other with Ashanti and Eastern regions having the highest income ratios. The Eastern region of Ghana has the highest pay for a total of 200 pieces of bamboo culms count due to its nearness to the nation’s capital where the demand is high. From the data collected, an average quantity of 200 hundred pieces of culms costs in a range of GH₵150.00 to GH₵50.00 depending on the size from the region, equivalent to (US$37.5 to US$12.5) for culms harvest from traditional land owners or custodians by a harvester. In the case of commercial farms, a similar quantity of culms harvest costs GH₵100.00 which is equivalent to (US$25). Also for the same number in Ashanti region goes for GH₵50.00, equal to (US$25.00) for culms harvest from traditional land owners or custodians by a harvester. However, Western which has about 60% of the nation's stock has the lowest cost for the same quantity of 200 counts going for GH₵20.00, equivalent to (US$5) for culms harvest from traditional land owners or custodians by the harvester. The Eastern region attained the highest average total cash income of GH₵4742.50, followed by Ashanti region with GH₵11453 and Western region with GH₵1617.9 (Figure 5a). The Eastern region has an average total cash income of 64% with Ashanti having 27% and leaving the Western region with only 9% (Figure 5b). The income ratios between these areas show that stakeholders in Eastern regions make about two times more than those in Ashanti region and seven times those in the Western region. The booming of bamboo trade among interested parties in the Ashanti and Eastern regions of Ghana gives high prospect for the commercialisation of the material in the Ghana. The activeness stakeholders in promoting the bamboo trade in these areas help to commercialised it in Ghana.

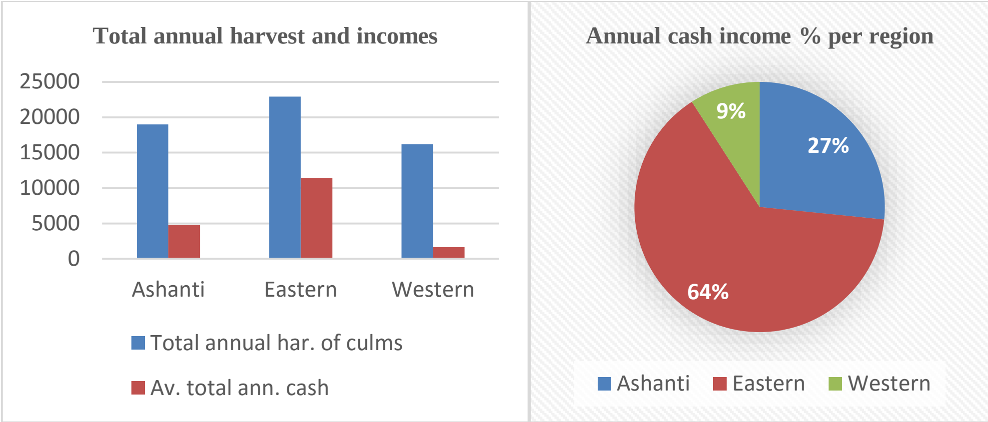

Figure 5: (a) Total annual culms harvest and average cash for each region (b) Percentage annual cash income per each region

4.1.5 Sustainable rural income

From this work, it was realised that over the past few years, bamboo had been a major financial booster to most of the rural youth, farmers and landowners who get into its harvesting for trade. There is a readymarket for its trade, especially in the Ashanti and Eastern region. There are more uses of bamboo, and its commercial value is being appreciated as more rural dwellers are getting involved for their sustainable livelihood. The commercial exploitation of bamboo culms for the production of products like charcoal, bicycles, furniture and boards is helping rural dwellers with sustainable financial income as they engage in its trade. Also, bamboo is used by rural dwellers in these regions of study as a sustainable plant for restoring degraded lands.Bamboo and Rattan Development Program (BARADEP), Ghana are developing a sustainable bamboo sector in the rural areas of study, and this would boost financial incomes of stakeholders. They are distributing high yield bamboo species to the individual, farmers and organisations, which are into its cultivation in these areas as they monitored their growth conditions and adaptability in Ghana. Its aim is to provide adequate planting materials for private and commercial bamboo plantation developers in the country to serves as a booster for sustainable financial stability for the rural dwellers who engages in its trade. Bamboo commercialisation in Ghana would enhance building green economies and also increase the incomes of all stakeholders in its value chain process.

4.1.6 Challenges to bamboo commercialisation in Ghana

The biggest challenges facing bamboo commercialisation in the country include (a) slow stride by the state to support the development of its commercialisation from plantation through processing in the country. (b) unsustainable bamboo resources base, (c) reluctant by financial institutions to provide credit facilities and loans. (d) technological gap is a major hindrance to its commercialisation. (e) Small and medium scales enterprises lack organisational structures. (f) Low-Quality products in the market, (g) inefficient processing of culms, and (h) getting support from stakeholders is difficult.

5. Conclusion

The finding shows that there is an increase in bamboo usage in the country with the three regions as baseline among stakeholders. There is a great prospect for its commercialisation with corresponding high cash and total income from its trade. The study reveals that the proportion of commercial use of bamboo in the country is group into rural and urban utilisation with 60% of total productions being consumed in the major cities. The Western region has 60% of the nation's bamboo resource but, has the least of in its trade due to the remoteness and lack of roads connecting the resource areas. Consequently, the bamboo value chains originating from the Ashanti and Eastern region are longer and denser than that of theWestern region, where only direct harvester and consumer transactions prevail. The distance of resources from cities largely explains the commercial differences among the regionswith the Eastern region having the highest marketing trade. Provision of high-quality species, technology, loan facilities from banking institutions, training to stakeholders and structured organisation of small and medium scale enterprises would promote its commercialisation in Ghana. The government must improve access roads to the resource areas in the regions to boost trade among stakeholders in the value chain for its commercialisation. Finally, publicpolicy towards promoting a sustainable commercialisation development in the country is required for its sustainability.

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DII-2017-021

User Perspectives on Transport Infrastructure in Johannesburg: Challenges and Opportunities for the Public Sector

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Abstract

Cities in developing countries tend to have considerable challenges in creating appropriate levels of urban mobility. A key intervention in alleviating this problem is the development of transport infrastructure. Despite policy interventions, urban mobility remains below average in Johannesburg, South Africa, which can partially be attributed to the deterioration of transport infrastructure. The purpose of this paper is to identify critical areas for public sector intervention to better support the creation of urban mobility in a developing country environment. The study used an opinion poll of over 700 Johannesburg residents to investigate user perspectives on transport infrastructure and its appropriateness in meeting mobility needs. Descriptive statistics were sought using SPSS for Windows version 23. The results showed that Johannesburg residents generally believe that transport infrastructure is underperforming, although some elements are in better condition than others. Taxis, which are the most used form of public transport, are believed to have infrastructure (ranks, stops, etc.) which is in the worst condition, whilst highway infrastructure is considered to be the best. Users believe that potholes, traffic lights and road capacity are the most important issues that need to be addressed in the city. The study showed that, despite policy interventions, the provision of transport infrastructure is lagging. The study also highlighted areas in which specific interventions are required. In addition, it prioritised areas which require policy, planning and physical attention from policy makers. This study provides the only empirical evidence of public sentiment regarding transport infrastructure in the city and is therefore of major value to city planners in attempting to meet the transport infrastructure needs of city's residents.

Keywords: developing economies, mobility, policy, South Africa, urban transport infrastructure

1. Background

A functional transportation system is critical to the efficient and effective functioning of cities. Pinderhughes (2004) states that "Transport is essential to the operation of cities and to the economic and social base of urban areas because it functions to bring raw materials together to create products and services, connects goods and services to markets, and bring workers and others to and from their places of work, school, consumption, and recreation." United Nations Department of Economic and Social Affairs (UNDESA) considers transport in cities from of an accessibility perspective, stating that

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"Transport plays a crucial role in urban development by providing access for people to education, markets, employment, recreation, health care and other key services." (UNDESA, 2011). It is evident from these statements that transport forms the backbone of the movement of people, products and services within the urban environment and that "large cities obviously cannot be supported without a vast and complex transport system" (Rodrigue, 2013). Without adequate transport operations and infrastructure in urban environments, goods and people do not move effectively. Without this mobility, not only is the productivity of the city impacted and the price of goods affected, but also the quality of life within the city.

Despite its importance, creating a functioning transport system within an urban area is uniquely challenging. "Designing corridors, streets and thoroughfares to provide safe movement and access to people and goods, by cost-effective means, involves application of management and technology to resolve many social, economic and political forces." (Kennedy, Miller, Shalaby, Maclean, and Coleman, 2005: 393). Rodrigue (2013) regards some of the major urban transport problems as congestion and parking problems, long commutes, public transport inadequacies, difficulties in non-motorized transport, loss of public space, high maintenance costs, environmental impacts and energy consumption, accidents and safety, land consumption and freight distribution.

These typical urban transport problems tend to be exacerbated in developing countries where the skills, political stability and will, regulatory environment and financial resources are frequently insufficient to address mobility issues within large cities. A German Technical Cooperation Agency (GTZ) report summarizes urban transport problems in developing countries as congestion, fatalities and injuries due to traffic accidents; increasing demand for mineral oil fuels, severe air pollution, increasing noise levels, and a loss of urban liveability and green spaces due to transport activities adversely affects city development; and the high growth of the transport related CO^2 emissions (GTZ SUTP, 2010). "These developments discourage the attractiveness of cities and their economic well-being. From the social point of view the trend towards individual motorisation causes unequal mobility chances and disparities in burdens and advantages…" (GTZ SUTP, 2010: 7). Typically, "Accessible and affordable public transport service and safe infrastructure for non-motorized transport such as cycling and walking are lacking in most developing country cities" (UNDESA, 2011: 1). These types of urban transport problems are evident in many developing countries, with South Africa being no exception.

The Numbeo traffic index (2016) "is a composite index of time consumed in traffic due to job commute, estimation of time consumption dissatisfaction, CO^2 consumption estimation in traffic and overall inefficiencies in the traffic system." According to this index, the major South African cities do not fare particularly well, with Pretoria rated in 15th position, Johannesburg at 25th, Cape Town at 30th and Durban at 56th. Part of this index measures inefficiency, which is an estimation of inefficiencies in the traffic, with high inefficiencies it assumes driving, long commute times, etc. (Numbeo, 2016). According to this index, Pretoria is the most inefficient city in Africa (and the 5th most inefficient globally), followed by (in order) Cairo, Nairobi, Johannesburg, Cape Town and Durban. These figures provide an indication of some of the urban transport mobility issues within the country.

Johannesburg, the largest city in South Africa, is regarded as a developing country city with below average mobility (Little, 2014). Van Dijk and Hitge (2012) argue that getting more people to switch from car travel to public transport requires that compact urban forms be developed, improvements are made to public transport infrastructure, more effective integrated operations are provided and marketing and communications are improved and that these need to happen simultaneously. This is supported by

Kennedy et al. (2005) who argue that there are four pillars to sustainable mobility, i.e. governance, financing, infrastructure and neighbourhoods. To create higher levels of mobility in cities in developing countries, it is thus evident that one of the key focus areas must be transport infrastructure.

South Africa's National Development Plan (National Planning Commission, 2011) requires that "The state will oversee a transport system that takes into consideration the realities of transport in South Africa and thrives to serve the interests of society." This includes, amongst others, "A systematic approach to transport, which puts focus on the total transport network, will improve transport efficiency and accessibility while reducing the overall environmental, social and economic cost" (National Planning Commission, 2011) and places considerable emphasis on improving road infrastructure. The White Paper on National Transport Policy (Department of Transport, 1996) emphasizes the need for appropriate transport infrastructure in its vision statement: "Provide safe, reliable, effective, efficient, and fully integrated transport operations and infrastructure which will best meet the needs of freight and passenger customers at improving levels of service and cost in a fashion which supports government strategies for economic and social development whilst being environmentally and economically sustainable". Considerable emphasis is therefore placed on the development of appropriate transport infrastructure in South Africa, however at present, it is estimated that approximately 30% of Johannesburg's roads (Joburg.org, 2013) and 33% of footpaths (Joburg.org, 2015) are in poor or very poor condition, implying that considerable scope exists for increasing mobility in the city.

2. Research Methodology

The purpose of this article is to establish user perspectives on transport infrastructure in Johannesburg, a city of approximately 4.4 million residents (Statistics South Africa, 2012). This paper is an exploratory study of the user's perspective of transportation infrastructure in the city. A two phased approach was followed in this project. A literature review was conducted to identify typical transport infrastructure issues, firstly, in urban areas; secondly, in urban areas in developing countries and, finally, in Johannesburg in particular. Based on this, University of Johannesburg students worked in groups to develop survey instruments that would most adequately capture opinions on the most pressing infrastructure issues within the city. These questionnaires were used as the basis for a comprehensive survey instrument, which was then tested within a focus group and adjusted to ensure comprehensiveness, robustness as well as user friendliness. A three-page self-administered survey was conducted in 2014 amongst Johannesburg residents from representing five main regions in Johannesburg, i.e. north, south, east, west and central. This survey instrument finally consisted of 71 questions testing aspects in six key areas, i.e. demographic information, familiarity with the responsibility for infrastructure in the city, the perceived state of road infrastructure, the perceived state of non-motorized transport infrastructure, the perceived state of public transport facilities in the city as well as the transport infrastructure priorities. The data was primarily requested using closed-ended questions, with respondents being asked to agree or disagree with statements regarding infrastructure using a five-point Likert-type scale. The response format was anchored from (1) Stronglydisagree to (5) Strongly agree, with a sixth category "Do not know". For questions where respondents were asked to rate the state of infrastructure and 11-point Likert-type scale was used anchored from (0) Completely unacceptable to (10) World class. One open ended question was used to test what respondents believed should be the single most important improvement to transport facilities in their area. A total of 709 usable responses were obtained. Data was analysed using IBM SPSS 23.

3. Research Results

The demographic profile indicated that the majority of respondents (63%) were between the ages of 18 and 35 years of age, reflecting a young profile. Other demographic information that was tested was ethnicity, place of residence within Johannesburg and primary mode of travel. The latter reflected that respondents primarily used private motor vehicles, followed by minibus-taxis (the primary form of "public" transport in South Africa), combinations, buses, trains, walking and other. The demographic information indicated that the age, ethnicity and travel mode profiles approximated that of South African residents in general (Statistics South Africa, 2012; Statistics South Africa, 2013).

Respondents indicated firstly that they believed that there was a focus on highways rather than local streets, with the former being in a far better condition than the latter. Although respondents were equally divided as to whether roads were well maintained in their local areas, the majority of respondents (over 55%) indicated that there were potholes in their local areas, which most (52%) indicated did not get fixed timeously. Over 70% indicated that, where there were potholes, these were not marked, although when actual maintenance was done, warning signs were put into place. Road markings in general, were considered average, although in a later question, this was indicated as one of the key areas requiring future intervention in the city. Speed humps were indicated as not being adequately marked. Traffic lights were considered to be usually in working condition although, when not working, they were not considered to be fixed timeously. Respondents were divided on whether roads were adequately drained. Residents generally (47%) showed an appreciation for the newest investments in highways around the city, but were however fundamentally opposed (76%) to using e-Tolls as a method of financing these improvements. Respondents were relatively neutral about having seen any improvements in the last year, as well as being neutral about the short term prospect for road infrastructure improvements. In general, the residents indicated that they believed the state of the roads and the state of the traffic lights to significantly impact the accident rate and most respondents were neutral or negative when asked whether they believed the city was doing enough to keep the roads well maintained.

Regarding public transport facilities, respondents were overwhelmingly negative regarding all aspects of taxi-related infrastructure, indicating that they believed taxi ranks (terminals) were not user friendly, were badly lit, not clean, unsafe, unattractive and did not cater for people with disabilities. Respondents were neutral regarding whether there had been any improvement in the last five years. Regarding the other next most used form of public transport, buses, respondents were more neutral regarding all aspects outlined above. It is however noted that few (5%) respondents used buses as their main form of public transport and the neutrality could potentially reflect a lack of familiarity with public bus services. This was however mitigated against by providing a "don't know" category. A level of familiarity with bus services was therefore assumed.

Respondents were asked to rate the state of infrastructure in a number of areas believed to be important in the City of Johannesburg. The results are reflected in Figure 1. The results show that in general, respondents believe that highways are in an acceptable condition. Respondents tended to be more neutral about the state of road signs and traffic lights. The same is true for bus stations, although bus stops are not acceptable. The figure also indicates that parking, sidewalks and local roads are not in a state considered to be acceptable by Johannesburg residents. Cycling lanes were not considered to be in an adequate state, although the low rating may reflect the lack of facilities rather than the condition of facilities. Finally, respondents clearly indicated their dissatisfaction with the state of taxi facilities in the city, thereby reflecting earlier results regarding the cleanliness, user-friendliness and safety of taxi facilities.

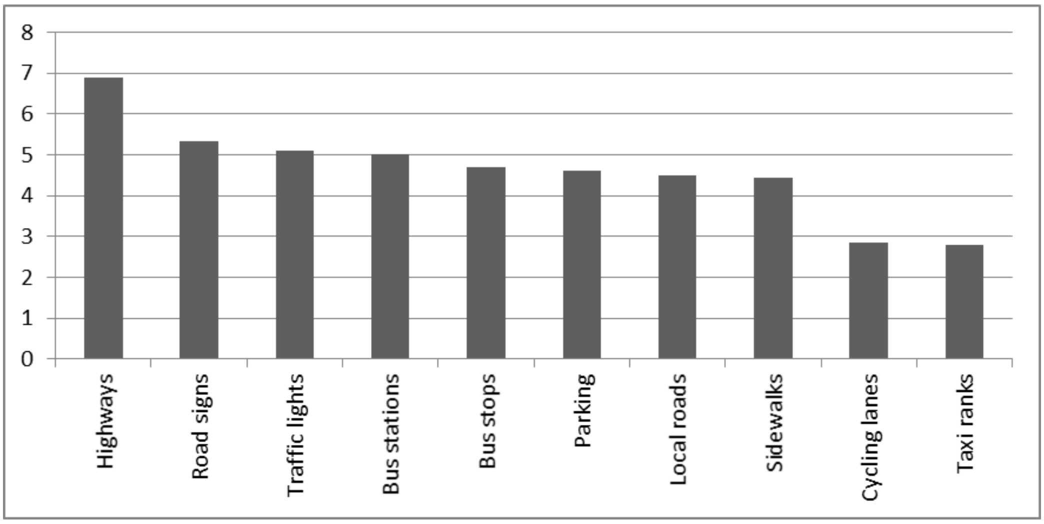

Figure 13: Mean ratings of state of transport infrastructure in Johannesburg (Source: Developed for the purposes of the study)

Respondents were asked to indicate what they believed should be the highest priority issues in transport infrastructure in the city. Although respondents clearly indicated dissatisfaction with the state of taxi facilities, this was not the highest priority issue. These results are shown in Table 1. The table indicates that, although taxi ranks are the 4th highest priority issue for Johannesburg residents, the state of the roads tend to be a much higher concern. Although respondents were also relatively neutral regarding the condition of traffic lights, this was also shown to be a major priority issue. Improving road markings was also important. Adding extra lanes to busy roads, although not necessarily a solution, provides an indication of frustration with congestion levels.

Finally, respondents were asked, in an open ended question, the one area where they would like to see an improvement to transport infrastructure. These results largely mirror the results shown in Table 1, with fixing of potholes/roads being the single greatest cited requirement. This was followed by adding extra lanes/widening roads, improving public transport and related facilities, improving taxi ranks and improving pedestrian infrastructure. Traffic lights, road markings and lighting were also major concerns.

Table 1: Highest passenger transport infrastructure issues in Johannesburg

Highest priority issue	**% of respondents**
Fixing potholes	62.20
Ensure traffic lights work	35.68
Adding extra lanes to busy roads	33.57
Better taxi ranks	15.09
Better road markings	14.53
More working street lights	9.45
Better sidewalks	8.60
Better and more road signs	8.32
Better bus stops and stations	6.63
Dedicated bicycle lanes	6.35
More speed cameras	5.92

Source: Developed for the purposes of the study

4. Conclusion

Appropriate transport infrastructure is critical to the effective functioning of cities. Inadequate transport infrastructure can inhibit mobility and accessibility within a city, but can also impact productivity and costs. In South Africa, in terms of the White Paper on National Transport Policy (1996), the public sector is obliged to provide transport infrastructure that is safe, reliable, effective, efficient, and fully integrated, that best meet the needs of passengers and is environmentally and economically sustainable. User perspectives on the state of current state of transport infrastructure provision are important, as they provide indications of failure of policy implementation and areas for focus for the public sectors future efforts and investments.

Respondents indicated firstly, that they were generally dissatisfied with the state of the roads, in particular potholes and the rate at which problems with road infrastructure were addressed. Although road markings and traffic lights were generally not regarded as major problems in general, when asked to indicate their highest priority issues or the areas in which they felt efforts should be focused, these were considered major areas requiring investment.

Taxi facilities were also considered to be a key priority issue with a large percentage of respondents indicating that they would like to see more investment in this areas. As this is the second highest used mode in the country, after private vehicles, and one which often receives bad press, this result is expected.

Bus facilities received relatively neutral ratings regarding the state of infrastructure, however when asked to identify single most important issues, the third highest mentioned issue was that there should be more formal public transport services and facilities, indicating that, although facilities are regarded as neutral (acceptable), they are insufficient to meet the requirements of the respondents.

Adding extra lanes to busy roads is frequently cited as a high priority issue. Although this may not necessarily be a feasible solution to transport problems in the city, it does provide an indication of the frustration experienced with congestion, thereby supporting the finding that there is insufficient formal public transport in Johannesburg.

The National Household Travel Survey (2013) indicates that over 20% of South African workers walk to work. The need to plan infrastructure for pedestrians is clearly indicated in the open ended question on highest priority, where improving pedestrian infrastructure was the fifth most cited issue.

These results show that although policy clearly describes the ideal state of infrastructure in the country, Johannesburg users indicate that infrastructure is not necessarily experienced as safe, reliable, effective, efficient or integrated. Key focus areas for public sector investment in Johannesburg needs to be the maintenance of roads and related infrastructure (traffic lights, road markings and lighting, upgrading of taxi facilities, improvement of pedestrian infrastructure and the expansion of the formal public transport service offering.

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DII-2017-60

Early Retirement of Construction Workers in South Africa: Case of Occupation Permanent Disability

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Abstract

The purpose of this study is to determine the types of accidents that lead to permanent disability of construction workers resulting in early retirement. The data was obtained from Federated Employer Mutual Assurance (FEM). The types of accidents were analysed from the decade of data from 2007 to 2016. The data were analysed using descriptive and inferential statistics. The analysis established that 7 670 accidents were experienced in the construction industry from 2007 to 2016, of which the major cause of accidents in the construction industry in South Africa was being struck by e.g. object while working. Furthermore, the highest average cost of accident was when a construction worker was electrocuted, the average cost was R214 767.00. The most fatal accidents was caused by motor vehicles. The study further established that there is a 10% chance of a construction worker to be permanently disabled and take early retirement or permanently disabled without taking early retirement when involved in any type of accident while at work. In conclusion construction workers using any work related vehicle, either being transported to site or using the vehicle on site, caution should be adhered to in order to prevent fatalities. The government of South Africa should ensure that strict measures are taken for drivers who do not observe the traffic rules on site and on the public roads. This will ensure the prevention of permanent disability among the construction workers in South Africa. It is also imperative for construction workers to receive training on health and safety when they work on any construction project. This needs to be emphasised daily on site by the construction health and safety practitioners. The authors recommend a further study on the type of injury and ill-health associated with the type of accident that force the construction worker to retire early.

Keyword: accidents, construction industry, pension, permanent disability

1. Introduction

Construction industry is hazardous and dangerous. The hazard and dangerous conditions of the industry are experienced when workers manually handle heavy materials, and are exposed to malfunctioning and vibrating equipment. Furthermore, noise and dust pollution of the work environment and chemicals, exacerbates the dangerous and hazardous conditions on construction site, which might lead to accidents

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and ill health of the workers. Robroek, Schuring, Croezen, Stattin, and Burdorf, (2013) argued that the work environment is important, as physical and psychosocial demands in certain industries can make it hard for workers to work with chronic diseases and ill-health. To buttress this observation, Brenner and Ahern (2000), found that over 677 000 working days were lost due to sickness absence, which were related to workers being absent from work as a result of work related injuries and sickness. Furthermore, they established that over 24 000 potential years of quality working lives were lost due to early retirement on health grounds.

The Health and Safety Executive (HSE, 2016) reported that in 2015, there were 43 fatal injuries among construction workers in Britain. The rate of fatal injury was 1.94 per 100,000 workers, compared to a five-year average of 2.04. In Hong Kong, the construction industry recorded 3 723 industrial accidents in 2015, 7.4 per cent up compared to 3 467 in 2014. Over the same period, the accident rate per 1 000 workers decreased by 6.5 per cent from 41.9 to 39.1. The construction industry recorded the highest number of fatalities and accident rate among all industry sectors in Hong Kong (Labour Department, 2016). The Bureau of Labor Statistics (BLS, 2016) in the US recorded 226 incidents based on construction transportation, 17 incidents of fires and explosion, 364 falls, trips and slips, 138 cases of workers exposed to harmful substances or environment and 159 cases, of workers being in contact with objects and equipment. It can be argued that these incidents have cost implication to the economy.

Waehrer, Dong, Miller, Haile, and Men, (2007), established that the total cost of fatal and non-fatal injuries in the construction industry in the US was estimated at $11.5 billion in 2002, a disproportionately high 15% of the costs for all industries. The average cost per case of fatal or non-fatal injury was $27,000 in construction, almost double the per-case cost of $15,000 for all industries in 2002. In spite of the high economic cost of fatal and non-fatal workplace injuries, there is dearth of research in the type of accident that is prevalent to permanent disability of construction workers, which will push the construction workers to receive pension, therefore leading to early retirement.

It is imperative to prevent work disability pension because of the human and societal costs. Prevention of early retirement as a result of disability is important, because the number of construction workers at risk for early retirement on health grounds is likely to rise in the near future as a result of the ageing population and work force (de Zwart, Frings-Dresen, and van Duivenbooden 1999). A study conducted by Brenner and Ahern (2000) established that the mean annual rate of early retirement of construction workers in Ireland on health grounds was 5.3/1000 workers.

Disability pension is an important means to leave working life into early retirement. In a European study of 4923 older persons, physical and psychosocial demands led to an increased exit from paid employment due to work disability (Robroek, Schuring, Croezen, Stattin, and Burdorf, 2013). Brenner and Ahern (2000) found that in the construction industry in Ireland, cardiovascular disease and musculoskeletal disorders each accounted for nearly one third of the conditions leading to permanent disability on the grounds of which early retirement was granted. Boschman, van der Molen, Sluiter and Frings-Dresen, (2012) indicated that a high prevalence of musculoskeletal disorders (MSD) among construction workers in two different construction-related occupations, bricklayers and supervisors was evident in Netherlands. Chau et al., (2004) also established that the causes of occupational injuries depended on the type of work, and that preventive measures against injuries from moving objects must be taken, more especially for masons, plumbers and electricians. Preventive measures against injuries from construction machinery and devices should be taken for carpenters, roofers, and civil-engineering workers. In Poland Szubert, and Sobala, (2005) suggested that the risk factors for early retirement were the conditions of work i.e. the piecework system, heavy lifting at work, shortage of leisure time, disability, increased rate of sickness absence, and alcohol abuse. A study in Sweden by Falkstedt, et al., (2014), found that women had higher rate of disability pension than men, regardless of diagnosis, whereas men had a steeper increase in disability pension with decrease in educational level. Claessen, Arndt, Drath, and Brenner, (2009), established that moderate overweight among construction workers is not associated with occupational disability. But obesity increases the risk of work disability due to osteoarthritis and cardiovascular disease.

Järvholm, Stattin, Robroek, Janlert, Karlsson, and Burdorf, (2014), indicated that the work environment was a predictor for disability pension among construction workers with those in physically heavy jobs having the highest burden of disability. They found that risk varied considerably among blue-collar workers. For example, rock workers had double the risk of disability pension compared to electricians. However, Arndt (2005) found that the general work force appear to experience a higher risk of disability than the blue collar workers in general. Furthermore, most working years lost due to disability pensions were found among men over 50 years, mainly as a result of musculoskeletal and cardiovascular diseases. Arndt, (2005), affirms the sentiment of Järvholm et al., (2014). Furthermore, it is important to note that, Arndt (2005), calls for further efforts to sustain the health of construction workers in there working life. Based on this discussion and a dearth of research in South Africa on early retirement as a result of permanent disability in the construction industry, this study seeks to fill this gap. In order to fill this gap a number of specific research questions have been stated.

- What type of accident is the major cause of permanent disability of construction workers in South Africa?
- What are the major causes of fatality of construction workers in South Africa?
- What is the probability of an accident leading a construction worker to permanent disability and early retirement or permanent disability without early retirement?

These questions are reviewed in a bid to answer them.

1.1 Type of accidents

According to Agumba and Haupt, (2014) they established that, the frequently experienced accident and injury among small and medium construction workers was, workers being cut while working, struck by falling object and workers falling from height. The injury mostly experienced were wounds. Hinze and McGlothlin (2002) reported that slips, trips and falls accounted for 15% to 20% of all workers' compensation cases; with older workers having higher percentage of falls compared to younger workers.

The collapse of tower cranes leads to accidents. When there is failure of any part of the crane or the load carry systems they can cause serious accidents, with both crane operators, site personnel and general public (Skinner, Watson, Dunklry, and Blackmore, 2006). Occupational Safety and Health Administration (2005) posited that significant and serious injuries of fatality may occur if cranes are not inspected before use and if they are not used properly. Often, these injuries occur when a worker is struck by an overhead load or caught within the crane's swing radius. It therefore implies that, crane accidents are associated with erection or assembling, usage, dismantling and supervision or inspection and are major treat to life of workers on any building site.

Mitra, Cameron, and Gabble (2007) reported that ladder falls or accidents increased significantly in 2001-2005 in Australia, which gave a significant rise in serious injury from ladder falls. This was evident in their investigation of 4553 site workers presented to Victorian Hospital with injuries from ladder fall. Of these, 160 patients were classified as major trauma case. A fall from height, more than one metre, was the most common mechanism of injury accounting for 59% of the total. It was also established that about 20% of ladder-related falls greater that one metre and major trauma cases occurred while people are working on site. It can further be stated that, despite the knowledge of the dangers of falls from ladders, there has been a significant increase in the number of casualties from ladder falls which resulted into broken limb, fracture and bruises on building sites.

In order to overcome some of the causes of injuries and illness among construction workers Chau et al., (2004), suggested that training of young workers when using hand-tools was necessary. Furthermore, the occupational physician could encourage overweight workers to reduce their weight, the workers with hearing disorders or sleep disorders to consult a specialist to solve their problems, and all the workers to practise regularly sporting activities, as they could prevent injuries due to the handling and carrying of objects (Chau et al., 2004).

1.2 Disability and Disability pension

A disability, unlike an impairment, represents the socioeconomic loss that an individual sustains as a result of an injury, illness, or condition. If a worker is injured and as a result cannot return to work, the disability is deemed a very serious one. However, another worker, with precisely the same injury and the same degree of impairment, may be able to return to work quickly with little or no impact on his or her earnings. The injury to that worker would have resulted in a much lower degree of disability (Barth, 2003/2004). Therefore, a permanent impairment need not, but is likely to, result in disability, and the same degree of impairment can result in a vastly different degree of disability for different individuals (Barth, 2003/2004).

Disability pension is a social security benefit given to working age people who have limitations in their working capacity due to occupation disability obtained from accidents or diseases. In Sweden for example the Social Insurance Office records all cases regarding disability pension. In the past ten years in Sweden, the annual inflow in the program has decreased mainly due to tightened eligibility rules (Järvholm et al., 2014).

1.3 Temporary disability

Temporary disability is when a worker is unable to work or cannot do all the work because of an injury or disease, however it is expected that the person will get better. In this case workers can claim for compensation. However, the worker should be put off duty by a medical practitioner for more than three days. The worker is compensated for the duration of time that he or she was unable to work including the first three days (Western Cape Government, 2014, Compensation for Occupational Injuries and Diseases Act, (COIDA, 1997). Barth, (2003/2004) indicated that in the USA, states pay permanent partial disability benefits to workers because they suffer an impairment, a disability, or some combination of the two. Each state's approach to compensating permanent partial disabilities differs, but for convenience the states can use an approach based on impairment, loss of earning capacity, loss of wages, or one that combines features of the other approaches.

In South Africa if a worker is not able to work because of temporary disability, the worker get paid 75% (three-quarters) of the normal monthly or weekly wage. If the worker can only do some of the work, the work will still get paid by your employer. The compensation fund will pay the worker 75% (three-quarters) of the difference between what you got paid and what you would have been paid before the injury. All medical expenses are also paid if the medical accounts are submitted to the Commissioner (Western Cape Government, 2014, COIDA, 1997). A worker can claim compensation for temporary disability for one year. This can be extended to two years, there after the Commissioner may decide that the condition is permanent and grant compensation on the basis of permanent disability (Western Cape Government, 2014).

A review by Mitra, (2009) on temporary and partial disability benefit programs in, Australia, Germany, Great Britain, Japan, the Netherlands, Norway, South Africa, Sweden and the US, posited that in several countries, a focus on time-limited benefits and the design of specific programs for young adults are important recent developments. Time-limited benefits appear to offer some potential in terms of improved return to work and reduced program costs.

1.4 Permanent disability

In South Africa according to the Amended Compensation for Occupational Injuries and Diseases Act, (COIDA, 1997), permanent disability is an injury or illness that the worker will never recover from, for example, loss of hands, an eye etc. The seriousness of the disability determines whether you will never be able to work again or whether the work will be more difficult to undertake (Western Cape Government, 2014). Disabilities are rated from 100% to 1% depending on the seriousness. For example, a 100% would be the loss of both your hands or the loss of your sight. The loss of one small toe is a 1% disability as indicated in the Amended Compensation for Occupational Injuries and Diseases Act, (1997). However, it is imperative that a doctor write a medical report in relation to the disability. The Commissioner and various other doctors will then decide how serious the disability is (Western Cape Government, 2014). Barth, (2003/2004) concurs with the importance of the disability evaluation of the worker by a medical professional. However the assessment should also take some account of the person’s occupation and employment history, education and training, and probably other demographic and labour market variables (Barth, 2003/2004).

If the disability is more than 30% disability, the worker get paid a monthly pension. The amount of pension depends on what your salary was and on the seriousness of the disability. If you have a 100% disability the worker get paid 75% (three-quarters) of the wages. If the disability is less serious, the Commissioner calculates the monthly payment. If the disability is less than a 30% disability, the worker is paid a lump sum. The lump sum payment is a once-off payment. However, the monthly payment will be paid for the rest of the worker's life (Western Cape Government, 2014, COIDA, 1997).

1.5 Death or fatal

In south Africa according to the Amended Compensation for Occupational Injuries and Diseases Act, (COIDA, 1997), if the family member that earns money to support the family (breadwinner) was killed due to an occupational injury or disease, the family can claim from the compensation fund. The amount of compensation that the family members will be paid depends on your relationship to the person who died. The total amount paid to the family cannot be more than the pension the dead worker would have received. The worker's spouse and children under the age of 18 (including illegitimate, adopted and step-children) are entitled for the compensation.

2. Research methodology

The study consisted of a literature review and an analysis of secondary data sourced from Federated Employer's Mutual Assurance Company (FEM). This is the only private workman's compensation insurer registered by the Department of Labour to cater for construction workers accidents. The data presented was on the types of accidents collected during the period 2007 to 2016. This data was comprehensive for analysis and is represented in Table 1. It can be indicated that this information is a record of the actual data recorded by FEM. Hence, the information is reliable and indicative of a high degree of ecological validity (Gill and Johnson, 2010). Due to the nature of the study, ethical approval for the study was not necessary given that no particular party would be harmed by the disclosure of the findings of the study. No data would be traceable to a particular construction enterprise or its personnel. The data was represented using descriptive and inferential statistics, that is, percentages and disjoint and independent probability respectively. Disjoint probability was used to determine if an accident led a construction worker to be permanently disabled, taking early retirement or construction worker was permanently disabled without taking early retirement. On the other hand independent probability was computed to determine if a construction worker was permanently disabled, with early retirement and construction worker was disabled without taking early retirement.

3. Results and Discussion

The data in Table 1, shows that the construction industry is dangerous and hazardous based on the 7 670 accidents that have been experienced from 2007 to 2016. This result is supported by the data obtained from the, Bureau of Labour Statistics in the US in 2017 and from Labour Department (2016) in Hong Kong. These accident still occur despite the promulgation of the construction regulation in health and safety in 2014. Further, the major type of accident that was experienced in the last decade in the South African construction industry was, workers being struck by e.g. an object. In that period a total of 2585 cases were reported out of 7 670 cases. On average in ten years this result translates to approximately 258.5 cases per year. Hence in the US, the BLS (2016) reported that 159 workers were in contact with equipment and objects in 2015. The US report, however did not support the study in South Africa. It can be suggested that more construction workers were injured in South Africa compared to the US per year.

The data in Table 1, further indicates that the major type of accident that engender construction workers to be permanently disabled, was workers being struck by e.g. an object while at work. Of the 806 permanent disablement of construction workers reported in this period, being struck by e.g., an object, contributed 263 cases. Of which two workers were forced to take early retirement as a result of the permanent disability, whereas 261 workers did not take early retirement or receive their pension.

Furthermore, the type of accident that caused fatality among the construction workers in South Africa was motor vehicle accidents. Of the 67 fatal accidents experienced in this period nearly half i.e. 33 of the fatalities were caused by motor vehicle accidents. The Bureau of Labor Statistics (2016) in the US recorded 226 incidents based on construction transportation. However, the report did not suggest if the incidents were fatal or non-fatal. Furthermore, HSE (2016) in Britain indicated that the industry experienced 43 fatal incidents. The HSE report as the case with the BLS (2016) did not separate the type of accident that caused the fatality. However, to buttress the statistics in South Africa, Occupational Safety and Health Administration (2005) posited that significant and serious injuries of fatality may occur if cranes are not inspected before use and if they are not used properly.

Table 1 further, indicates that permanent disabilities not resulting in pension were 796, this suggests that construction workers could have lost an eye, a leg etc., as indicated in Table 1, whereas permanent disabilities resulting in pension were 10. The type of accident that led construction workers to take early retirement was motor vehicle accident, followed by struck by an object. In order for the construction worker to be accorded early retirement they could have lost total eyesight, being totally paralysed, etc. The results in Table 1 connotes that the ratio of construction workers taking early retirement as a result of an accident was 1 out of 767 accidents taking place. Whereas the ratio of an accident not driving a construction worker to early retirement but the construction worker being permanently disabled was 1 out of 9.64 accidents. However, it is interesting to note that statistically analysing the probability of either a worker being permanently disabled and receiving early retirement or permanently disabled without receiving early retirement, using disjoint probability was 0.10 or 10% chance of the occurrence of these situation.

Table 1: Accident data 2007-2016

Cause	Number of accidents	Accidents percentage	Fatal accidents	Lost days	Permanent disabilities not resulting in pension	Permanent disabilities resulting in pension	Average cost per accident (Rand ZAR)	Ranking using number of accidents
Struck by	2585	33.70	9	8572	261	2	19397	1
Striking against	1130	14.73	0	3189	136	0	11971	2
Slip or over-exertion	1007	13.13	1	3298	40	1	18941	3
Fall on to different levels	899	11.72	4	7540	107	1	36566	4
Motor vehicle accident	833	10.86	33	4541	79	4	66424	5
Caught in, on, between	535	6.98	4	3150	89	1	26206	6
Fall on to same level	270	3.52	0	1543	25	0	22453	7
Accident type (Not Elsewhere Classified (N.E.C)) e.g.	139	1.81	6	363	10	1	43010	8
Contact with extreme temperature	117	1.53	4	300	34	0	35973	9
Inhalation absorption, ingestion	105	1.37	1	195	1	0	16190	10
Contact with electric current	48	0.68	5	937	14	0	214767	11
Awaiting information	1	0.01	0	0	0	0	26096	12
Unclassified not sufficient Data	1	0.01	0	8	0	0	18614	13
Total	7670	100	67	33636	796	10	42816	

Source: FEM data 2017

The lost days that could have generated economic gains to the construction industry and South Africa was 33 636 days. This could be translated to approximately 92.15 years. The study of Brenner and Ahern (2000) supports the current study in South Africa. They found that 677 000 working days were lost due to sickness absence related to workers' occupational injuries and illness. Furthermore, they found that over 24 000 potential years of working lives were lost due to early retirement on health grounds. In regard to these statistics, it is imperative that the construction industry stakeholders in South Africa should emphasize the importance of construction Health and safety in their projects.

It is important to note that the number of accidents associated with electrocution were 48 compared to 2585 of accidents associated with struck by e.g. an object etc. The result of data suggested that the total average cost per type of accident was R42 816.00 from 2007 to 2016. However, on average the cost of accident associated with electrocution or being in contact with electricity was the highest at R214 767.00. It can be inferred that on average the cost of electrocution was 11 times higher, compared to the cost of being struck by an object despite the fact that being struck by an object occurred approximately 54 times more than a worker being in contact with electricity.

4. Conclusion and Recommendations

In conclusion, the major type of accident in the construction industry in South Africa in the last decade i.e. from 2007 – 2016 was, workers being struck by e.g. an object while working. Furthermore, being struck by e.g. an object was a major type of accident that led construction workers to be permanently disabled. The study further indicated that there is a 10% chance of construction workers to be permanently disabled and take early retirement or permanently disabled without taking early retirement when involved in an accident while at work. It is therefore recommended that construction workers receive training on health and safety when they work in any project. They should be trained on how to identify hazardous objects. This need to be emphasized on a daily basis on site by the construction health and safety officer, as a result of the number of accidents that have been reported in the last decade by FEM. This will ensure that the workers entrench a health and safety culture in all the construction activities they will be doing and hence avert accidents.

In relation to fatality occurrence, motor vehicle accident was the major cause. Furthermore, construction employees who were involved in motor vehicle accidents were likely to go for early retirement as a result of the accident. It can be stated that when construction workers are using any work related vehicle, either being transported to site or using the vehicle on site, caution should be adhered to in order to prevent accidents. The government of South Africa should ensure that strict measures are taken for drivers who do not observe the traffic rules on site and on the public roads. The vehicle should be roadworthy and be driven by a competent driver. This will ensure the prevention of permanent disability and pre-mature retirement, among the construction workers in South Africa as a result of motor vehicle accidents.

Recommendation for future study is to evaluate the type of injuries and diseases that is occupational among construction workers that, lead to permanent disability but not early retirement and the type of permanent disabilities that lead construction employees to early retirement.

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DII-2017-062

Developing Africa's Future City Engineers

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Abstract

Acknowledging the challenges of urbanisation, globalisation and resource constraints, this paper presents a positive perspective that highlights elements of the potential for development and prosperity in Africa, and particularly for engineering education that ensures that graduates are qualified and equipped to build the future African cities. Engineering education has already begun this transformation in developing local engineering talent in Africa with efforts both on building sound infrastructure and furthering urban sustainability. This paper proposes a future-oriented perspective in re-imagining engineering education for sustainable cities in Africa by identifying essential attributes of Africa's future city engineers in the context of their education, and the skills of Africa's future engineers in professional practice. This study is informed by emerging literature on the opportunities for higher education in Africa, and our interviews with a wide range of universities in Africa, ranging from large public universities with established engineering schools to start-up private universities with alternative learning models, including the integration of online learning capabilities to early developers and users of open courseware in Africa. Some of the examples from across higher education institutions and universities in Africa that were included in this research were summarised to demonstrate innovative strategies that are already in development and in some cases in place. Though engineering education as we know it today, in brick and mortar universities, may not be sufficient, leveraging online capabilities in delivering learning will shape engineering education in the future, with Africa possessing the unique advantage of leapfrogging to advanced technologies.

Keywords: African universities, education, Engineering, online learning, sustainable cities

1. Introduction

The last 100 years witnessed urban populations increase globally from 25% of world population to greater than 50% urbanization. With populations forecasted to boom in Sub-Saharan Africa (SSA), the region is expected to urbanize from less than 30% to more than 70% over the next 75 years (Hoornweg and Pope, 2017; Hoornweg et al., 2014). Multiple research efforts have documented the challenges facing Africa related to the need for new urban infrastructure to support growing populations (e.g. Lwasa, 2012), and the shortage of local engineers to address this growth. From a positive perspective,

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emerging literature highlights some of the potential for development and prosperity in Africa, and for engineering education that ensures that graduates are qualified and equipped to build the future African cities. As one leader puts it,

> *"Higher education is now front and center of the development debate—and with good reason. More than 50 percent of the population of sub-Saharan Africa is younger than 25 years of age, and every year for the next decade, we expect 11 million youth to enter the job market. This so-called demographic dividend offers a tremendous opportunity for Africa to build a valuable base of human capital that will serve as the engine for the economic transformation of our continent… To be more competitive, expand trade, and remove barriers to enter new markets, Africa must expand knowledge and expertise in science and technology. From increased agricultural productivity to higher energy production, from more efficient and broadly available ICT services to better employability around the extractive industries, building human capital in science and technology is critical to empower Africa to take advantage of its strengths. By MakhtarDiop, World Bank's Vice President for the Africa Region, High-level Forum on Higher Education, Science, and Technology in Africa, March 13, 2014, in Kigali* (Blom, Lan and Adil, 2016).

In this paper while recognising Africa's challenges and context we look at the possibilities for developing Africa's future engineers who will build sustainable cities through evidence gathered via interviews with various stakeholders across a number of higher education institutions in the region.

The research team has interacted with wide range of universities in Africa who have expressed interest in our approach to strengthen their engineering programs for designing and building sustainable African cities. The range of these institutions includes:

- **Large public universities with established engineering schools:** Addis Ababa University/Addis Ababa Institute of Technology (Ethiopia), Makerere University (Uganda), University of Lagos (Nigeria), University of Nairobi (Kenya), Kenyatta University (Kenya), University of Rwanda, Kwame Nkrumah University of Science and Technology - KNUST (Ghana), University of Johannesburg (South Africa), and University of Zambia.
- **South African universities with strong capabilities in cities engineering, planning and social studies:** University of Cape Town, Stellenbosch University, Durban University of Technology, and Central University of Technology.
- **Start-up private universities, with philanthropic funding sources and online learning capabilities:** African Leadership University (Mauritius), Kepler (Rwanda), and Ashesi (Ghana).
- **Early developers and users of open courseware in Africa:** African Virtual University (Pan-African)

Against this backdrop, this paper takes a future-oriented perspective and identifies the skills required of African engineering leaders, both in education and in practice, to build Africa's future cities that will accommodate growing populations, and proposes ideas to migrate from the status quo.

2. Beyond the Challenges of Engineering Education and Practice

Well-managed cities can be hubs for innovation and economic growth, and can realize what UN-Habitat terms the "agglomeration advantage", driving more productive and economically diverse environments (UN-Habitat, 2012). However across much of Africa, rapid urbanization has not been accompanied by economic density, partly due to urban planning approaches that do not bring agglomeration benefits to urban areas (World Bank, 2017). Existing city planning approaches rely on comprehensive master plans, largely envisioned by foreign companies or international donors (Watson, 2013). These visions are generally "top-down" in nature, perpetuate Western ideologies, and may fall short of addressing the unique regional challenges or realities on the ground (Watson and Agbola, 2013). Undoubtedly these foreign models have been widely critiqued by researchers (Watson, 2013; Watson and Agbola, 2013), who raise the question to whether they offer long-term solutions in addressing urban infrastructure needs, or worsen the inequalities that already beset African cities.

Local training and capacity building is commonly identified as a solution to addressing the urban planning problem (World Bank, 2017); however, the role of formal education systems in influencing more sustainable pathways has received less attention (Lwasa, 2012). To help fill this gap, this project aims to assist in the transformation of the delivery of engineering education in the region. Current engineering graduates fundamentally lack the tools to understand the complex dynamics of the urban environments they face. While the technical subject matter taught in traditional engineering programmes are important, new graduates remain ill-equipped to tackle the infrastructure-related challenges within their cities. In this respect, African universities will have a growing responsibility to develop the next generation of urban planners and sustainable city innovators.

On a positive note, some countries are addressing the issue by integrating formal planning programmes within their curriculum. For example, the University of Cape Town's African Center for Cities has developed the Association of African Planning Schools (AAPS) that is supporting member universities in the region to enhance their curricula as well as their research and teaching capacity (More information on the AAPS can be found here: http://www.africanplanningschools.org.za/). There is potential to scale-up such initiatives; and in particular, develop new learning models for engineering education using relevant technological tools. For example, using online platforms can be used to deliver interdisciplinary courses that integrate sustainable development and public policy concepts with infrastructure planning and design (e.g. a Small Private Online Course (SPOC) that our team is developing). At the same time, new pedagogical methods and more integrated curriculum can strengthen understanding of complex urban interactions - for example, the interactions between engineered infrastructures and social and natural systems, as these dynamics can ultimately shape sustainability outcomes pertaining to resource management, environmental pollution, climate change, and public health (Ramaswami et al. 2012). Finally, identifying specific regional or city contexts will support the development of local engineering talent, equipped with the knowledge to identify local planning needs, problems and solutions.

3. Envisioning Africa's Future Engineering Leaders for Sustainable Cities

As engineering leadership in universities and educational institutions and associations are exploring the process of developing the engineers of the future, we have attempted to contribute to this line of thought, specifically from an African perspective. There is a substantial recent body of literature on engineering leadership in general, including work by colleagues at the Institute for Leadership Education in Engineering (iLEAD) at the University of Toronto. Engineering educators around the world recently assembled at the Canadian Engineering Education Association conference in Toronto, Canada (CEEA 2017) to generate strategies to build a shared foundation for equipping the "Engineer of 2050" to meet the grand challenges of the data age. In the context of the African continent, African engineers confront the additional challenge prompted by rapid urban population growth, yet have the unique opportunity of leapfrogging to cleaner and more efficient technologies for urban prosperity, both of which have implications for the engineering education and practice communities. Other thought leaders have devised new initiatives such as the "global engineering leader" as the outcome of the framework used as the basis of the development of the Global Engineering Leadership (GEL) Minor at the Georgia Institute of Technology and informed by the National Academy of Engineering's Vision for the Engineer of 2020 advanced in the early 2000s (Amekduzi 2016). Similarly, the "whole new engineer" visualized by Goldberg and Somerville (2015) proposes a revolution in engineering education that shapes educational experiences that are aligned with the creative imperative of the 21st Century.

At the same time, partnerships among academic institutions, policy-makers and industry can ensure sustainable urban outcomes. Also, project collaboration with local governments can allow students to acquire experiential knowledge by working with communities and policymakers (Lwasa, 2012). Africa's future engineers will show success when they follow a two-pronged approach to urbanization, firstly, understanding and aligning innovation initiatives with government priorities, and secondly, supporting global efforts towards urban sustainability.

a) Aligning urban innovation with government priorities

The fact that most of Africa's urban areas are yet to be fully built and serviced with engineered infrastructure presents a window of opportunity to avoid lock-in to unsustainable pathways. Investments in engineered infrastructure will have huge implications for development outcomes in the future (World Bank, 2016). For example, Nairobi's blueprint policy document for urban development, *"Nairobi Metro 2030"*, envisions a "world class African region that is able to create sustainable wealth and offer high quality of life for its residents"(More information on "Nairobi Metro 2030" can be found here: https://fonnap.files.wordpress.com/2011/09/metro2030-strategy.pdf). The document further emphasizes strategies through infrastructure development, urban financing and stakeholder partnerships. In this regard, engineering education and the locus of innovation will benefit through alignment with these strategies to ensure that graduates equipped with the skills to address priorities at both the national and city level.

b) Supporting global efforts towards urban sustainability

The concept "sustainable urban development" has also gained popularity in global development and policy efforts. These efforts have highlighted the synergies between sustainable urban development and other global challenges, particularly mitigating and adapting to climate change. For example, the successful negotiation of the Paris Agreement on climate change, under the United Nations Framework Convention on Climate Change's (UNFCCC) 21st Conference of the Parties, signalled a new area in climate action, and also highlighted the critical role of cities, which are described as "factories of climate change solutions" (WRI, 2015). Also, integrated climate mitigation and adaptation actions are relevant to reducing urban risks and economic development gains. This has been highlighted in the Sendai Framework for Disaster Risk Reduction (UNISDR, 2015). Consistent with this storyline, the new Sustainable Development Goal for cities (SDG 11) aims to make "make cities and human settlements inclusive, safe, resilient and sustainable". Similarly, the outcome document from the Third United Nation's Conference on Housing and Sustainable Urban Development (Habitat III) recognised "environmentally sustainable and resilient urban development" as one of the three transformative commitments for a "New Urban Agenda" (United Nations, 2016). Undoubtedly, meeting the ambitious targets set under these processes requires for scaled-up engineering education and training.

The next two sections below re-imagine attributes of Africa's future engineers in the context of their education, and the skills of Africa's future engineers in professional practice.

3.1 Attributes of "Africa's future city engineers" in education

The skills of future engineers that will be educated to become employable in building Africa's sustainable cities of the future might be a long list if each African city is considered independently. To remain contextually relevant and culturally diverse such skill sets will derive from the higher education landscape and the institutional framework under which engineering schools and accreditation bodies and regulators work. However, intersecting skills that need to be embedded in the Africa's engineering schools include the following list of top considerations:

1. ***Prepare for the unpredictable and equip students with the skills to meet it.*** The future years will entail working within climate uncertainties, which despite the scenarios proposed by organisations such as the IPCC, still remain unpredictable. Engineering curricula that is multi-disciplinary, and builds in sustainability, critical thinking, and communication across the disciplines will be essential to the growth of engineers that can work together across teams and across specializations to tackle global challenges that are more pronounced in Africa.

2. ***Embrace systems thinking and complexity theories.*** The urban built environments include the building blocks that make up cities and include buildings, transportation, water, waste, wastewater and food networks, among others. A systems approach to these building blocks in engineering curricula where students learn about green building design, sustainable transportation, integrated water and wastewater management, etc. will create synergies among the built components of urban environments.

3. ***Address grand challenges by thinking in missions, not disciplines*.** Steering away from the traditional siloes of engineering disciplines, and creating engineering programs that address grand challenges, e.g. poverty, urbanization, food shortage, public health, will give students a better sense of purpose and better chances of employability.

4. ***Adapt to a curriculum that meets the needs of the country and connects with industry.*** The needs of cities (and countries) reflect the political visions for economic growth and urban prosperity, and more often than not, reflect the Sustainable Development Goals (and the Millennium Development Goals previously). Curricula that are cognizant of such country visions for the future produce graduates that are useful to their countries, and have acquired knowledge that is up-to-date with the state of the art, and relevant to industry.

5. ***Learn based on graduate attributes that pertain to competencies for the future.*** Weaving in skills in engineering curricula that emphasize desirable graduate attributes is a way of ensuring that graduates possess the attributes expected of them to continually improve the programs. Inspired by the graduate attributes of the Canadian Engineering Accreditation Board (now known as Engineering Canada Accreditation Board), examples of such graduate attributes include problem analysis, investigation, design, use of engineering tools, individual and teamwork, communication skills, professionalism, impact of engineering on society and the environment, ethics and equity, economics and project management, and lifelong learning.

6. ***Leverage online education.*** Delivering engineering education to students in brick-and-mortar universities pose a challenge for growing populations, online education presents a solution to educate

larger numbers that can tap into global knowledge. As online education is scalable and accessible, female students in engineering will access engineering education that they may not have had otherwise.

3.2 Skills of "Africa's future city engineers" in practice

The characteristics of Africa's future engineers in the workforce will be a result of the higher education system and practical experience throughout the curriculum. Engaging industry and developing local engineering talent will be fundamental to employability. The interaction between universities and industry will have direct bearing on the quality of engineering graduates, while the interaction of the engineering education to align with country priorities will result in employable engineering graduates that have the competencies to contribute to building their future sustainable cities. The characteristics of Africa's future engineers in practice are numerous – the following identifies key characteristics:

1. ***Work in multi-disciplinary teams.*** Engineers that are competent technically need to also be good communicators who can connect with architects, planners, public policy makers, and decision-makers. Engineers will play a large role in public policy to create sustainable solutions.

2. ***Well versed in economic and social implications of large infrastructure projects.*** Many great ideas have fallen short of having the economic and social backing to make them a reality. Building Africa's megacities will involve large infrastructure projects that, when built, cannot be easily erased to start over. Decisions for large infrastructure projects will need to be integrated in the cities' long-term economic and social agendas. This will be the result of a broad-based and comprehensive engineering education.

3. ***Hands-on and practical.*** The engineers of the future will not only be involved in understanding theory, but will be able to contribute to design and practice via a thorough understanding of problem solving and investigation.

4. ***Leapfrog to best practices and locking-in sustainable development.*** Best practices from the east and west may not necessarily be the most relevant practices to the African cities' context, and as such the engineers will have the talents and tools to devise their own best practices and strategies to create and lock-in sustainable development.

5. ***Connect to research and development.***The impact of engineering on society and the environment will be supported by research that goes beyond current practice and is conducive to propelling development. Attracting engineering graduates to pursue graduate education and involving industry partners to finance research, in addition to encouraging a collaborative industry and academic environments are some of the ways that research can aid development.

6. ***Built in lifelong learning.*** Innovations in practice require advancements in knowledge and professional skills, where engineers can recognise they are in a continuous cycle in pursuit of knowledge.

4. Engineering Education Re-imagined

Education at large is being reimagined, and engineering education in particular – through very traditional and conservative in approach – has already begun this transformation in developing local engineering talent in Africa. Pan-African examples from higher education institutions and universities that were among those reviewed in this research to date are summarized below to demonstrate success factors already taking place.

African Virtual University (AVU): With an online presence only (and office headquarters in Nairobi, Kenya and Dakar, Senegal) and operational in Anglophone, Francophone and Lusophone, the AVU offers online courses across 18 countries in Africa. Though not focussed specifically on STEM-related courses, the potential for scalability and access of this model is great in reaching a large number of students.

University of Nairobi: The oldest and largest public university in Nairobi, Kenya is a great example of academic and industry collaborations where African scholars hold positions in the local accreditation body and collaborate with industry by way of finding "practical attachments" (i.e. internship opportunities) for their engineering students. A strong leadership role of the Open and Distance Learning Centre that works across faculties enables and facilitates online education in various capacities for the instructors and students alike.

Makerere University: A large university in Kampala, Uganda with a long history of engineering education is a good example of the practical side of engineering education that goes beyond theory. The virtual labs in the Computer and Electrical Engineering department offers students practical experience, and allows for smaller universities (Busitema University and Mbarara University of Science and Technology) in the country, in addition to the University of Rwanda, to have access to their "ilabs."

Kepler University: A small start up university in Kigali, Rwanda offers an American Bachelor of Arts through a close partnership with Southern New Hampshire University's innovative College for America program. The institution pairs digital content with a team of expert teachers while proving to be an attractive learning model for students. Applications for admissions show a large percentage of applicants with an interest in a STEM-related education, though Kepler has not tapped into STEM-related programs.

University of Rwanda: As the country transitions from French to English, and as six of the local institutions (including the Kigali Institute of Science and Technology – KIST) become amalgamated in what is now known as the University of Rwanda, the transition is a way to combine resources and infrastructure and allow students access to all institutions under one umbrella.

Carnegie Mellon, Rwanda Campus: Carnegie Mellon University (CMU), a world leader in engineering education and research, extended its global reach into Africa in 2012 when it opened the CMU Information and Communication Technology (ICT) Center of Excellence (CoE) in Kigali, Rwanda, in a partnership with the Government of Rwanda. This is an example of bringing world renowned institutions in engineering education and research to Africa and offering students the opportunity to develop real-world ICT solutions with international companies like IBM, Microsoft and Visa.

University of Zambia (UNZA): Zambia's largest and oldest university, and leader in interdisciplinary and policy-oriented research. For example, UNZA's Centre for Urban Research and Planning (CURP) is an interdisciplinary research initiative on the dynamics of Zambia's urbanization and spatial planning. The Centre conducts policy relevant research on sustainable urban planning in Zambia's cities, towns and regions. In advancing this agenda, the Centre has development a number of research partnerships with local communities and governments institutions, including community-led “planning studios” that allow students to engage with local communities living in informal settlements or slums. Overall, the project is influencing policy changes, and has also proven useful in shifting the mindset of industry and government on issues of urban informality, service delivery and poverty (Siame and Muvombo, 2016).

5. Conclusions

The unique opportunity that presents itself in Africa in the face of expanding populations and growing infrastructure demands lies simultaneously in the education for and practice of engineering. Though engineering education as we know it today, in brick and mortar universities in Africa, will not be sufficient, we take a future-oriented perspective of leveraging online capabilities in delivering learning, which we believe will shape engineering education in the future. Migrating from the status quo is not far-fetched, and as such, this paper proposes ideas to influence Africa’s future city engineers by identifying essential attributes in education and skills in the workplace. We set out to explore what it takes to develop Africa’s future city engineers, and used our network of higher education institutions in Africa, in addition to research on reimagining engineering education from like-minded researchers and academics, to inform our paper.

Acknowledgement

Our study “Engineering Education for Sustainable Cities in Africa (EESC-A)” received financial support from the Dean’s Strategic Fund and the Connaught Global Challenge Awards at the University of Toronto. The authors greatly appreciate the information provided by the academic staff and faculty at the African institutions visited and interviewed in 2016.

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DII-2017-037

The Significance of Workers' Involvement in Cultivating a Safety Culture in Zambia's Electricity Industry

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Abstract

Several studies have shown that the link between workers' participation has left a gap in the importance of workers' involvement in the management of organisational safety culture of the electricity industry in Zambia. Shaping culture through change in attitude cannot be enforced by management alone but by involving workers as well. The aim of the study was to examine the importance of involving workers to influence safety culture in the electricity industry of Zambia. The paper also identifies barriers to workers' involvement in safety and health management. The approach for the research was both quantitative and descriptive. The empirical study was a survey using a questionnaire from targeted population of technicians, engineers, elected safety representatives, supervisors and maintenance managers. The convenience sampling method was applied when identifying participants. Statistical analysis was performed using Microsoft Excel. Descriptive statistics was used in compiling results. Semi-structured interviews were also carried out to convolute on the findings amongst union leaders and senior managers. The study yielded positive perceptions and attitudes about involving workers. Workers were found to be responsible in terms of safety for themselves and others and also showed some knowledge about safety procedures in the organisations. The study also found that training, incentive and acknowledgement, improved communication and reporting procedures. In addition, the study identified barriers hindering full involvement including training, reward and recognition, communication, and management participation and motivation. The importance of the study is that it will help managers understand the relevance of involving workers in improving safety culture in the electricity industry.

Keywords: electricity industry, safety culture, workers, Zambia

1. Introduction

There has been significant improvement in the safety performance of the electricity industry even though research in the global electricity safety and competency standards reveals that the industry has still not cracked safety (ASSE, 2011). Additionally, electrical accidents are considered to be erratic in most studies and based on statistics, however majority of them are unreported (Mihai & Sorin, 2010). Nonetheless, the electrical energy sector undergoes accidents and incidents that can be disastrous and a cost to the industry (Mihai & Sorin, 2010). The electricity industry in Zambia considers safety at a high level even if accidents continue to happen. Rutter (2010), nonetheless, postulates that the measures to escalate electrical safety are not effective enough without considering the electricity firms safety cultural aspects. Therefore, to ensure a safe working environment, it is vital for the electricity industry

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to remain at the centre of activities carried out in the perseverance of safety efforts by involving workers in safety and health implementation. Failure to involving workers in influencing safety culture in the electricity industry of Zambia is a missing link to positive and continuous improvement in safety and health management. This study was conducted to add to the existing body of knowledge on the issue of involving workers and the impact it would have once adopted in the electricity industry to sustain positive safety culture.

1.1 The influence of workers' involvement in safety culture

Several studies have shown that there is a link that lies between employee involvement and organisational effectiveness, efficiency and safety performance according to studies undertaken by Raines (2011) and Higbee(2008). Very few studies have been attempted to examine the link between the participation of workers and the inclusive safety culture of the electricity industry in Zambia. Additionally, a study undertaken by Gennard and Judge (2005)indicated that management can generate cultural variations in an establishment by involving workers as practical mean. Raines (2011) informed that the effort of workers involvement and influence among workplace peers can have a positive change on attitude.

1.2 Workers' involvement in the electricity industry

Everyday operations in the electricity industry exposes workers to various risk causing accidents that could be misjudged (ZESCO Limited, 2015). Hence, increased levels of worker engagement in safety activities increases the safety performance as can be seen by the outcome of the actions taken when faced with an incident. According to Wachter and Yario(2014) workers influence over safety management system practices programs and safe work processes by enthusiastically enabling safety approaches and conducts, they are more likely to adopt the value of working safely and encouraging others to do so. Therefore, workers' influence and involvement on safety practices have a strong positive impact on safety culture in the organisation as workers collectively stick to the success of safety programs (Rutter, 2010). Hence, it is imperative to understand the impact of involving workers in influencing safety culture in the implementation of safety and health in the electricity industry (Zou & Sunindijo, 2015). Nonetheless, fatalities continue to occur in the electricity industry regardless of processes and policies guiding the operations of this entity. This can be seen in the 2015 Auditor General's Report (2015), which specified that the electricity industry being the seventh to record 6.9% of fatalities compared with other sectors such as the mining topping at 14.7% followed by the Personal Service and hotels which recorded 13.4% of fatalities in that year as indicated in the table.

The information provided in Table 1 does not however indicate that electrical accidents are low enough to be ignored. As long as they keep occurring even though some of them are not reported implies that it is important to involve workers in influencing the safety performance in the electricity industry. Furthermore, several research in the electricity industry on safety and competency standards have revealed that safety has not yet been cracked (ASSE, 2011). From this statement, it can be said that one of the ways to crack the safety component is underpinning workers' involvement in enhancing safety culture in the electricity industry.

Table 1: Number of fatalities among industries

Industry	2011	2012	2013	2014	Totals	% Totals
Agriculture Forestry, etc.	4	15	14	18	51	13.6
Building Construction	5	18	11	18	52	13.9
Electricity	5	5	7	11	28	11.2
Iron, Steel Industries, etc.	3	6	8	13	30	8
Mining, Quarry Industries	13	10	10	26	59	15.7
Personnel Services, etc.	8	11	15	20	54	14.4
Transport and Communication	4	0	14	11	29	7.7
Total	42	65	79	117	303	

Source: Report from the Auditor General on the Management of Occupational Safety and Health (2015)

2. Safety Culture in the Electricity Industry

Safety culture lies in the heart of effective management of all risks related to the electricity industry such as major accidents and hazards (Olusuyi, 2011) and is understood to be a major pointer to safety performance. Hence most companies have started programs of they can use to improving organisational safety culture to reduce costs and increase performance (Haukelid, 2008). According to Guldenmund (2007), safety culture are aspects of the organisational culture that have eventual impact on attitudes and behavior and values to increase or decrease safety risks. Subsequently, some of the incidents that occur in the electricity industry show that the most of them could have been deterred or reduced through appropriate safe working behaviors by workers as insinuated by Hopkins (2006). Accumulation of errors, questionable decisions, and misguided priorities in management where productivity is placed ahead of safety, results in accidents. Nonetheless, causes of most accidents are accredited to human error and as suggested by many scholars in this knowledge area, 85%- 98% of most injuries that occur at workplaces are caused by unsafe attitudes (Williamsen, 2007). Workers' unsafe acts have been postulated to be the cause of about 88% of industrial accidents and that organisational failures are the underlying factors in individual action oriented errors (Carrillo, 2010). Yule (2003) in one such study indicates that safety culture in an organisation is described in terms of workers perceptions by applying six factors that include personal need for safety, management commitment, blame attitude, rewards and appreciation of risk, control of conflict and supportive environment.

2.1 Workers' involvement and participation

Involvement of workers is an important means by which management can achieve organisational safety cultural change. However, such kind of changes are only attained incrementally after a period of time as it is not possible to change the attitude of individuals at the same time (Gennard & Judge, 2005). To add on, the effects of workers involvement as can be seen by Gifford et al (2005) include enhanced organisational performance, improved employee commitment to changes needed for organisational development and its survival. Workers challenged with hazards and risks have a better understanding on how to improve these risks once this knowledge is exploited. It is opinionated by Raines (2011) that safety changes be made by involving the workers and embracing their input to improve safety performance. The purpose of the study therefore, was to establish the impact that the involvement of workers in influencing safety culture in the management of safety and health in the electricity industry. The problem is that the Zambian electricity industry in managing safety and health focuses only on regulations, policies and processes and does not involve workers in influencing the safety cultural challenges that impact the provisions of the safety and health management system in the industry.

3. Research Methodology

The study adopted a mixed method approach which combined quantitative and qualitative methodology aimed at assessing the impact of worker involvement in influencing safety culture in Zambia's electricity industry. This means that that the procedures could be used at the same time or one after the other in the terms of a single research according to Saunders et al. (2009). The study was inclined to technicians, engineers, elected safety representatives, supervisors, and maintenance managers from electricity companies in Zambia, who were administered with questionnaires. In order to further authenticate and ornate the issues that came from the questionnaire survey responses, semi-structured interviews were conducted on trade union leaders and senior managers. The reason for choosing this group of people was because they were capable of answering the questions raised, thus accentuating the rationale of the variegated method approach.

The sample used was purposive since participants were chosen strategically based on the roles within the industry and relevance to the study. According to Davies (2007), purposive sampling helps the researcher identify and target individuals that will be typical candidates of the population under review. Distributed questionnaires were in total of 250 that were completed, a total of 148 usable responses were received of which 25 were either incomplete or spoiled. The remaining 77 questionnaires were not recovered or answered. The 148 responses account for 59.2% response rate. The qualitative method was adopted to follow up on the common themes emanating from the questionnaire response.

Table 2: Demographic Distribution of Questionnaire Respondents

	Government Company	Private Company	Total
Maintenance Managers	7	2	9
Supervisors	13	6	19
Elected Safety Representatives	19	10	29
Engineers	23	10	31
Technicians	35	23	58
Totals	97	51	148

The semi structured interviews were necessitated by the need to elaborate on the themes that came about from the questionnaire surveys. Two senior managers from a named government owned company and two union representatives were interviewees. The initial proposal of five interviews with extra senior managers was not possible due to unavailability.

4. Results

Themes were created to answer the research questions derived from the research objectives, and these include: practical involvement of workers, relevant factors to successful workers' involvement, other methods of involving workers in safety and health management. Various responses gave a wider range of responses in which all the workers have a role to play. About 20% of the respondents are elected safety representatives. The number of experience in the electricity industry was also asked of which the average years of experience was 12 years even though there were more who worked less.

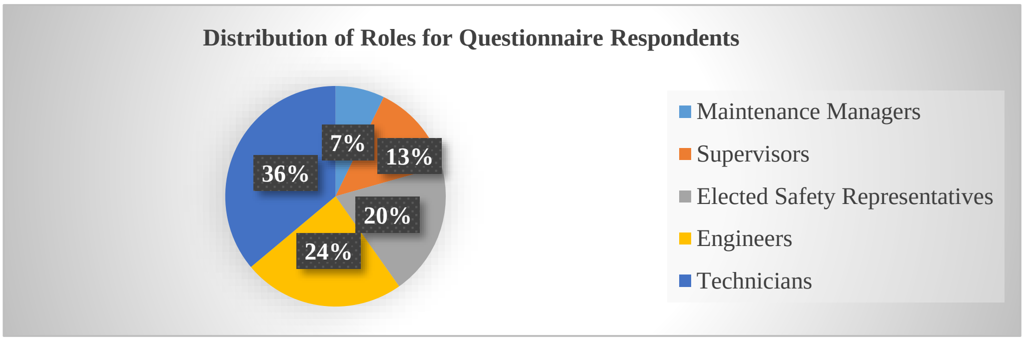

Figure 14: Distribution of Roles for Questionnaire Respondents

4.1 Practical involvement of workers

Respondents' opinion on the practicality of how much workers got involved in the safety and health management was divided into sub-themes. 90% of the respondents felt that there were reputable means of communication from the shop floor to management. About 50% indicated that that there were relevant training sessions that were useful to workers and management, while 71% agreed that they received the needed training and response about their performance. Over 70% of the respondents were found to be involved in making safety related decisions and participate in the safety improvements programs.

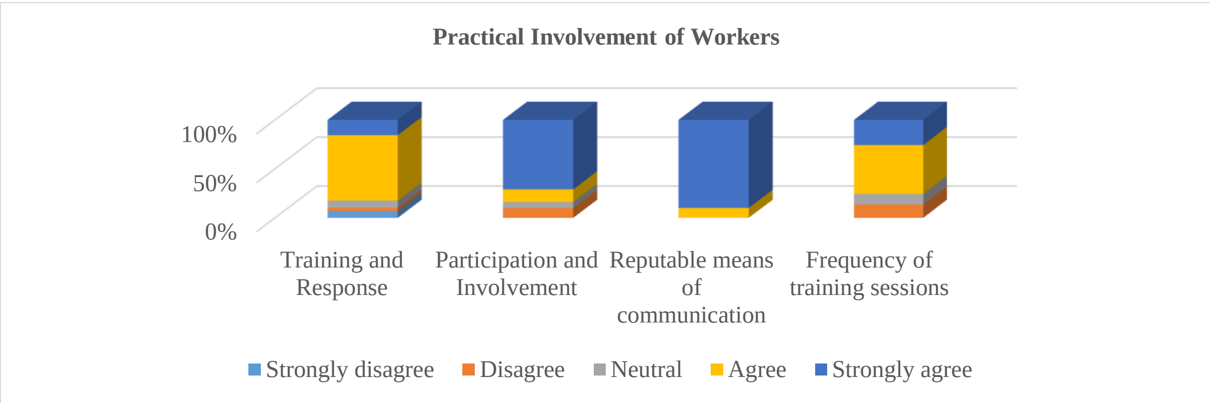

Figure 15: Practical involvement of workers

4.2 Success factors to workers' involvement in safety and health management

Figure 3 indicates the responses to the prevalence of success of employee involvement practices within their work environment. The results showed that 69% felt that the safety suggestions were readily acted upon by management, while 84% of the respondents agreed that the safety trainings being given are effective. Similarly, 78% felt that the approach in safe working are established to follow consultative meetings with the workforce and 58% thought that management and workers works together to tackle safety related issues. 100% agreed that they take responsibility for their safety including the safety of people around them and for 68% of the respondents, felt that the reporting channels of unsafe acts were fair and without fear.

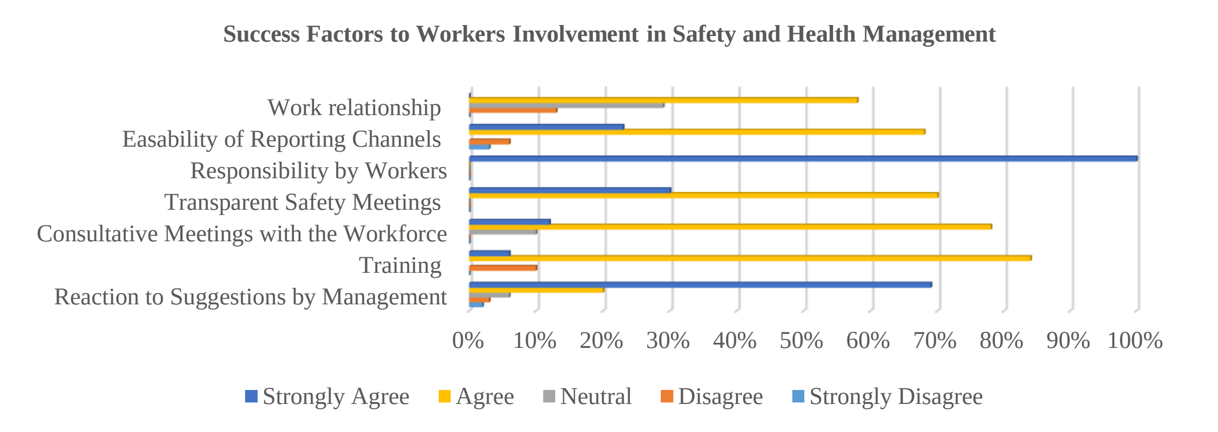

Figure 16: Success Factors to Workers Involvement in Safety and Health Management

4.3 Other methods of involving workers in safety and health management

Respondents were asked to comment on other factors relevant to the success of employee involvement initiatives beside those presented in Figure 3, the various responses clustered into seven classifications and presented in the table below in order of decreasing frequency.

Table 3: Other Methods of Involving Workers in Safety and Health Management

Category	Percentage Frequency
Participation of Management and Motivation	19%
Safety Culture	18%
Recognition and Incentive	17%
Transparent Communication	15%
Understanding and Visibility of Workers Involvement	10%
Participation of Workers and Buy-in/Ownership of	9%
Training on Safety and Health	7%
Others	5%

4.4 Barriers Preventing Workers from being Involved in Safety and Health Management

Over 66% of the respondents disagreed that their supervisors did not do enough to ensure a safe working environment. Additionally, only 50% differed that there is low level of confidence amongst management and frontline staff, while 81% disagreed that safety trainings are too expensive and so should not be done too often. Finally, 87% disagreed that certain procedures on safety and health do not need to be monitored in order to work in a safe environment. This indicates that barriers are predominant at low level and the least likely barrier was the cost of training.

4.5 Influence of trade unions and senior managers' recognition on workers involvement in the management of safety and health

The parameters that were set for this notion was based on acknowledgement, recognition, and understanding of the roles and influence of workers. The study found that over 50% of respondents disagreed that trade unions and senior managers are sufficiently recognised in the industry. Only 47% of the respondents indicated that the role of trade unions and senior managers are well understood in driving safety and health issues efficiently. Additionally, 57% of the respondents indicated that union leaders and the senior managers rarely showed expected levels of influence in the organisation.

5. Discussion

Communication according to Olusuyi(2011) was identified as a key feature of an organisation with positive safety culture in this study. It also indicated that over half of the respondents agreed that there are well established means of communication through the safety toolbox, green area meetings, bulletins, teleconferencing facilities, morning briefs and presentations. In terms of information received, evidence indicates that workers receive information but the quality and quantity of information needed further improvement. Marcella and Pirie (2011) revealed in their study that the flow of information was poor. This indicates that there is need to improve on information sharing and reduce information overload between management and workers in order to reduce confusion and loss of interest. The effectiveness of training was highlighted by Gifford et al (2005) as a process of workers involvement in safety and health management in the electricity industry. In this study, training of workers on safety and health related issues has come out to be very essential in that, if it is not applied, it can lead to barriers toward workers' involvement.

The findings of the study confirmed that integrating information, incentives, knowledge and power is essential for the workers to make the right decisions. Participation of management was cited as an indicator of management commitment relevant in promoting safety as a core value in the industry as was postulated by AICHE (2010). It can then be deduced that management involvement, reassurance and obligation reiterated y the findings of this work are key component in influencing workers in safety culture. It was also mentioned in the semi structured interviews that trade unions were not considered to be influential in safety and health management. Even though a few agreed that the unions and senior management recognition has an inferred influence, only about half support the fact that recognition of trade unions had any influence on involvement of workers. This is attributed to the lack of visibility of trade union role in liaison with senior management in workers' involvement efforts and the absence of such roles.

6. Conclusion and Recommendations

The overarching aim of the research was to determine the workers' involvement in influencing safety culture in the Zambian electricity industry. The results further revealed that although the industry is not completely in the dark with the issue of worker participation, there is room for improvements. Worth mentioning are workers taking more responsibility and ownership, employee participation in safety meetings, management involvement and motivation, communication, positive safety culture, ease of reporting as well as openness and honesty, can be achieved through communication. Affiliation concerning worker involvement and the safety culture of an organisation can be described as a mutualistic.

Nonetheless, the barriers to participation of workers in safety and health management have been highlighted by the study and the majority cited management participation and actions, fear of negative comeback, weak safety culture, inadequate training and low level of trust.

The study recommends a reward scheme to inspire better participation and involvement devoid of encumbering reporting such as award giving. Mechanisms have to be put in place to warrant that workers are rewarded in such a way that they remain motivated and dedicated. It is recommended that management show active involvement and not plain consultation with the workforce. It is recommended that consideration be given to aggregate safety trainings.

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DII-2017-040

A Conceptual Model for Pricing Health and Safety on Construction Projects

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Abstract

The competitive nature of the construction industry (CI) has marginalised health and safety (H&S) on construction projects. Most clients in the CI, if not all, award projects based on price and in most cases to the "cheapest bidder" and not the "safer bidder". Consequently, such practices have compelled contractors to lower their bid price to increase their chances of being awarded projects, whereas in contrast, H&S is marginalised. The study, which was a case study of nine projects of which six were civil engineering projects and three building construction projects, was purposed to conceptualise a model for pricing H&S on construction projects. The findings showed that contractors do price for H&S using an itemised breakdown even though such items are not included as a trade in the Bill of Quantities (BOQs). With regards to expenditure, the actual costs of H&S ranged between 2.9% and 3.98% for projects with a value below R500 million and between 4.08% and 4.90% for projects with a value above R500 million. Health and safety costs were found to be directly proportional to the projects value and indirectly influenced by the client. Previous studies recommended that H&S should be priced as an itemised trade in the BOQs, but such recommendations are yet to be implemented. The lack of a conceptual model for pricing H&S on construction makes accurate and adequate monitoring of H&S costs unlikely. Thus, a standardised pricing model will assist contractors to price adequately for H&S, and clients, to ensure that provision for H&S measures on construction projects is adequate as required by the Construction Regulations (CR) 2014.

Keywords: conceptual model, construction projects, cost drivers, health and safety, pricing

1. Introduction

Poor H&S performance is one of the major problems faced by the CI in South Africa and many other countries worldwide. The number of accidents recorded and the costs implications are still high. In the United Kingdom, the Health and Safety Executive (HSE) reported that in 2013/14, injuries and new cases of ill-health in workers largely from working conditions cost society an estimated £14.3 billion; £9.4 billion from illness and £4.9 billion from injuries (HSE, 2015). In South Africa, a report by the Construction Industry Development Board (CIDB, 2009) recorded that the total cost of accidents direct and indirect amount to R3.5 billion per year which equated to two (2) percent of the project expenditure.

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The International Labour Organisation (ILO) reported that 337 million occupational accidents occur worldwide on a yearly basis and as a result, 2 million and 310 thousand people deceased and 160 million people get injured. The financial loss caused by occupational accident is estimated at 1.2 trillion USD. Occupational accidents cause important financial losses in the workplace (Yilmaz and Çelebi, 2015). According to Rikardsson (2005), these costs can be reduced if accidents can be prevented.

2. Literature Review

2.1. Pricing for health and safety on construction projects

As Motchar and Arditi (2001) stated, the CI is characterised by extreme competitiveness, with high risks and generally low profit margins when compared to other areas of the economy. The competitive nature of the CI hinders H&S performance (Cole, 2003). Sumner and Farrell (2003) remark that such competition has often forced contractors to look for cost savings during the construction phase and such practice leads to H&S being compromised.

As Sumner and Farrell (2003) put it, inadequate and poor H&S do not only affect other project parameters, namely: cost, quality and schedule negatively, but the sustainability of the environment as well. According to Smallwood (1999), the CI is perceived by many to be price driven. Projects are awarded on the lowest tendered price and not enough consideration is given to other factors such as contractors' H&S management proposals, ability to achieve the required quality standards or complete the contract within the required timescale. Elsewhere, López-Alonzo et *al*. (2013) argue that making adequate provisions for H&S on construction projects could yield benefits to both companies and societies as a whole.

In South Africa, The CR (2014) addresses in detail the role of clients with regard to H&S. The client is required to, *inter alia*; prepare a suitable, sufficiently documented and site specific H&S specifications; include H&S specifications in the tender documents (CR, 2014; regulation (f)) and ensure that contractors submitting tenders have made adequate provision for the cost of H&S (Regulation (g); CR, 2014). Based on the above, the scotching question we ask is: how can the client ensure that the contractor has made adequate allowance for H&S measure on the construction project if a standard pricing tool to measure such output is non-existent?

In South Africa, it is common practice to include H&S costs as a line item in the Preliminaries and General (P&Gs) section of BOQ and not as an itemised trade showing a breakdown of H&S costs even though studies by the CIDB (2009), Smallwood and Emuze (2014) and Sumner and Farrell (2009) recommended that H&S costs should be itemised in the BOQ; be laid out using a structured approach and be priced in a special section in the BOQ respectively. It is to note that these recommendations are yet to be implemented in the CI.

The motivation for the study is embedded in the fact that conceptualizing a model for pricing H&S on construction projects will not only assist contractors to make adequate provision for H&S on construction projects or client to ensure that the contractor has made adequate allowance for H&S on said projects but to manage and report on the H&S costs on the said projects. The lack of such pricing model makes the accurate, adequate budgeting and controlling of H&S costs unlikely.

2.2. Drivers of health and safety costs on construction projects

As Bokor (2010) defines it, *cost drivers* are factors which have a cause-effect relationship with costs. These are any factors which cause a change in the costs of work performed in an organisation or in a process. A contextual application of the above definition to the current study, *"H&S cost drivers"* can be defined as *"factors or elements"* that have an impact on the costs of H&S on a given project computed as a sum of all items quantified and costed in accordance to the H&S requirements of the project as outlined in the H&S specifications. These factors or elements can be affected by various inputs *inter alia*: quantity factor (i.e.: number of personnel or equipments required), applicable rates (i.e.: fee scales, labour rates), project duration, etc. As presented in Table 1, 18 elements, referred in the study as "*cost drivers*" were identified from literature.

Table 1: H&S cost drivers identified from literature

Item No.	Cost Drivers	Literature
1	PPEs	HSA (2010)
2	H&S Personnel	CR (2014); Smallwood and Emuze (2014)
3	Safety Equipments (SEs)	Smallwood (1999);Sawasha et *al*. (1999)
4	H&S induction and training	Hinze and Gambatese (2003)
5	H&S Inspections	CR (2014)
6	H&S Audits	CR (2014); Alli (2008)
7	H&S Incentives	Musonda and Pretorius (2015)
8	H&S Meetings	Bizzell (2008:29);CR (2014)
9	Accident investigations and reporting	Kartam et *al*. (2000:177)
10	H&S Medicals	CR (2014:18); HSA (2010)
11	H&S Signage	Sadus and Griffiths (2004)
12	H&S Campaigns	CIDB (2009)
13	First Aid	Wells and Hawkins (2009)
14	H&S Promotions	Hymel et *al*. (2011)
15	H&S Branding	Musonda and Haupt (2011)
16	Security features	Farinyole et *al.* (2013)
17	Emergency Preparedness	Wells and Hawkins (2009)
18	Insurance costs	Babu and Kanchana (2014); COID Act (1993)

3. The Study

The study was a case study of nine projects of which six were civil engineering projects and three building projects which were conducted in two different organisations. A literature review was conducted to identify the various cost elements herein referred to as *cost drivers*. The empirical data were collected through both interviews (Kothari, 2004) and documents analysis (Bowen, 2009). Interviews were purposed to conduct an in-depth investigation on the importance attributed to H&S at both projects and organisations level, evaluate clients' compliance with regards to regulations 5(f) and (g) of the CR 2014 specifically and assess how H&S is priced on construction projects. The five participants that were interviewed, out of which four were H&S Managers and an H&S executive were employed in the 5 large construction companies in South Africa respectively. Their work experience ranged between 10 and 25 years. Documents analysis was conducted to identify the H&S elements priced for on construction projects as well as establish the actual costs of H&S on said projects. Interviews were conducted in 5 different organisations purposely selected based on 2 criteria, namely: H&S records and expertise. It was believed that companies that have good H&S records and have been in the CI for long (i.e.: 5 years and above), will provide the sought information. The choice of projects used in the case study was based on value and type. Considering the fact projects are different in nature and have different requirements, such factors have an impact on H&S costs. With regards to value, the study was limited to a minimum threshold of R30 million. This is justified by the fact that such projects will have good H&S specifications as compared to those of a lesser value.

Data obtained were analysed using descriptive statistics, namely: frequency count (Dawson 2002), percentage ratios (Kumar, 2011) and rankings (Saunders et *al*., 2009). Frequency count was used to identify the most and least frequent H&S cost drivers found on projects (*Figure 1*). Percentiles were used to quantify H&S costs to project expenditure ratios (*Table 3*). Rankings were used to classify various cost drivers based on their FS in descending order.

4. Findings

4.1 Findings from documents analysis

4.1.1 Project characteristics

The project values ranged between R31 million and R687 million. In terms of duration, the shortest project period was 10 months and the longest 27 months (See *Table 2*). Table 2 presents information; namely: type of project, duration, labour content and project budget on the nine projects used for the study. The documents analysis revealed that the actual expenses on H&S elements ranged from R900 thousand for a R30 million project and about R34 million for a 650 million project.

Table 2: Project information

Item No.	Project Names	Scope of work	Duration (months)	Labour (Peak)	Project Budget Expenditure
1	Project A	Civil (Pipeline)	18	260	R 400 000 000.00
2	Project B	Civils (Pipeline)	12	120	R 195 000 000.00
3	Project C	Civils (Roadworks)	12	31	R 31 500 000.00
4	Project D	Civils (Pipeline)	27	600	R 630 000 000.00
5	Project E	Civils (Pipeline)	21	280	R 500 000 000.00
6	Project F	Civils (Pipeline)	18	450	R 687 000 000.00
7	Project G	Building Works	10	375	R86 000 000.00
8	Project H	Building Works	13	250	R72 000 000.00
9	Project I	Building Works	24	850	R372 000 000.00

4.1.2 Expenditure ratios on projects

Table 3 presents H&S costs on the nine projects as well as percentage ratios of H&S costs to project expenditure as used in the study. In terms of the actual expenses on H&S and the project values ratios, it was found that the actual costs ranged between 2.39% and 4.90% (*Table 3*). It was also observed that projects with a value of R500 million and above had a higher H&S expense to project value ratio. These projects had a ratio of 4% and above. Of interest, however, is the R31 million value for project C, which spent about 3% of its projects value on H&S provisions.

Table 3: Health and Safety Expenditure ratios

Item No.	Project Names	Project Budget Expenditure	HSand expenditure	% ratio
1	Project A	R400 000 000.00	R9 553 995.79	2.39%
2	Project B	R195 000 000.00	R5 203 248.74	2.67%
3	Project C	R31 500 000.00	R957 454.78	3.04%
4	Project D	R630 000 000.00	R25 690 909.42	4.08%
5	Project E	R500 000 000.00	R20 688 493.19	4.14%
6	Project F	R687 000 000.00	R33 664 777.73	4.90%
7	Project G	R86 000 000.00	R2 680 986.22	3.12%
8	Project H	R72 000 000.00	R2 410 426.05	3.35%
9	Project I	R372 000 000.00	R14 791 563.62	3.98%

4.1.3 Health and safety expense items

As shown in *Figure 1*, nine elements were found to be the most frequent on the nine projects with a frequency score (FS) of 9. These expense factors included: H&S personnel, PPEs, safety equipments, induction and training, incentives, medicals, signage, first aid and H&S promotions. Incidents and investigations were ranked second with a FR of 8. Security features was ranked third with a FS of 7. Health and safety audits were ranked fourth with a FS of 6. H&S inspection was ranked fifth with a FS of 5. In sixth position were expenses to do with H&S meeting and attained a FS of 4. Four (4) elements were ranked last with a FS of 3. These include; H&S campaigns, H&S branding, emergency preparedness and insurances. Of interest, these were the elements on which expenditure was allocated only for building construction projects, data of which was received from a building contractor. It was surprising that such items were not spent for on civil engineering projects, but perhaps the explanation could be that the head office as opposed to the project provided for these costs.

It is to note that it was surprising to find that H&S meetings were ranked low as compared to other expense elements. To the contrary, literature informed us that H&S meetings can be a useful tools to ensure close follow-ups on H&S targets and milestones set for projects Kikwasi (n.d.) and keep the drum beat with regards to performance monitoring. It can be observed that H&S is still not considered as a priority on construction projects, hence the low FS.

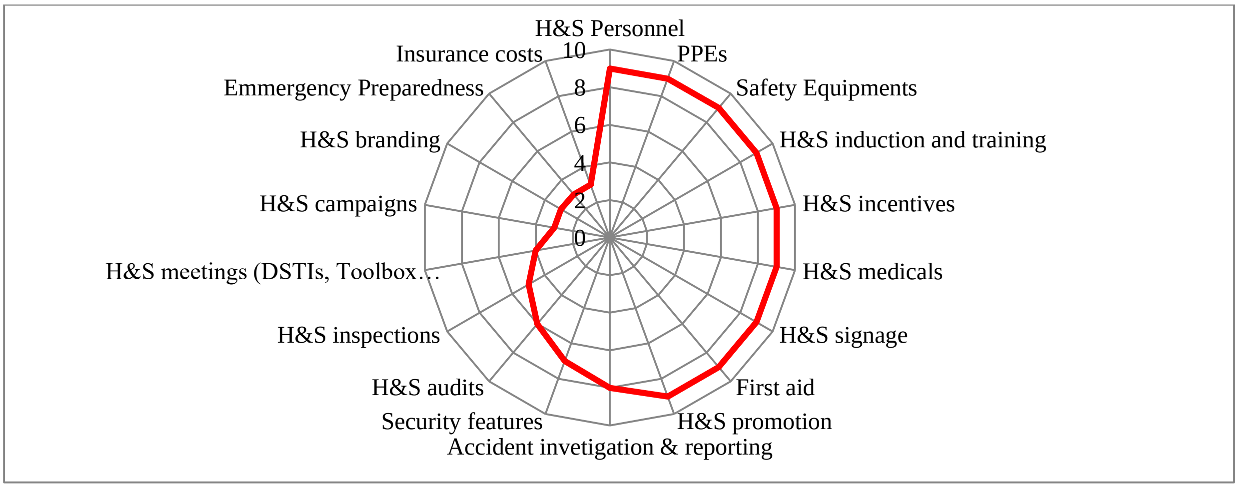

Figure 1: H&S Elements Priced for on construction Projects

The findings of the also revealed that projects with higher values had also a higher H&S expense for the project compared to those with lesser value. H&S costs were found to be directly proportional to the project value. Considering all elements being equal, it was observed that for projects valued below R500 million, the H&S expenses ranged between 2.9% and 3.98% whereas on projects valued above R500 million, the H&S expenses ranges between 4.08% and 4.90%. Thus, the higher the project value, the higher the cost of H&S.

4.1.4 Findings from interviews

The results from interviews portrayed striking similarities between participants with regards to clients' compliance with regulation 5(f) and (g) of the CR 2014 specifically, pricing for H&S on construction projects and H&S specifications. All participants acknowledged that not all clients provide them with H&S specifications on the projects. Secondly, all the participants emphasized that the specifications provided by the clients are very generic and a repeat of the CR 2014 are not site or project specific as required by the CR 2014, which leave them with no choice but to comply with the minimum H&S requirements. Thirdly, they concurred that with the lack of a standardised pricing model, clients in the CI cannot ensure that H&S measures is provided for adequately on construction projects .With regards to pricing, all participants acknowledged that they are using an itemised approach in pricing for H&S on their projects and have deceited from using percentages as such method is considered not accurate. With the use of an itemised costing approach for H&S, better pricing and cost control can be achieved.

5. The Akawi Pricing Model

The Akawi pricing model (APM) was theorised based on the findings in literature and empirical study. The 18 cost drivers as identified in literature (Table 1) were synthetised into a 12 elements model referred in this study as the APM. Preambles and costs components were provided and purposed to serve as pricing guidelines as laid out in Tables 4a and 4b.

Table 4a: The Akawi Pricing Model (Conceptual Model)

Item No.	Category	Preambles	Cost components items	Units
1	PPEs	All PPEs to specifications. Type, size and make to be described as per manufacturer's specifications	Protective footwear, protective clothing, hand protection, eyes and earing protection, head protection, fall arrest/prevention; respiratory protection, reflective wear, special PPEs.	Head count (No.)
2	Induction and Training	All training to be project specific as required by the CR 2014. Special training to be done when required.	PPE ; emergency response; crane/machinery operations; refresher courses; inductions; accidents investigation and reporting; first aid; special training	Head count (No.)
3	SHE personnel	Personnel appointed for various responsibilities	SHE/SHEQ manager; SHE officers (Site based); SHE reps; first aiders; supervisors	Fixed monthly remuneration
4	Medicals	The type of medicals to be undertaken by workers should be fully described and priced.	Entrance, periodicals and exit medicals; medical surveillance; OHP; OH; and OMP.	Head count (No.) time based for consultation with OHP, OH and OMP.
5	Site Security features	Security equipments to specifications. Type, size, shape to be described.	Fencing and site enclosure; security equipment; access cards; lighting protection; site illumination; emergency plan and preparedness.	Item (sum); head count (No.); time based (Cost/hr)
6	Safety Equipments (SEs)	SEs equipment to specifications. Type, size, shape and to be described as per manufacturer's specifications	Fire extinguishers; firefighting equipment harnesses; cones; alarm canisters; flags; speed bumps/humps; breathalysers; portable ladders; scaffolding; lifelines; inspections and maintenance costs.	Item (No.); Cost/hr and item (sum) as applicable
7	Welfare, wellbeing and Environmental	The items in this category should be described in full as laid down in the H&S specifications.	Accommodation; transportation; skips for hazardous waste; drip trays; food security; wheel bins; ablutions; eating area and cooking area; cleaning equipment; disposables; storage facilities; cleaning personnel.	Sum (once off) Cost of consumables (Monthly costs) Maintenance costs Salary for cleaning personnel
8	Signage	H&S signage to specifications. Type, Shape, size and make to be described as per manufacturer's specifications	Warning, information; directional prohibitory signs; mandatory; emergency traffic control signs (i.e.: speed limits, Stops blocks, etc.) signs	Cost per item (No.)
9	SHE Administration and Management	Activities in this category are time related as they are linked to compliance with regulations.	SHE file; Permits approval; Police clearance; Inspection and audits; Stationary (i.e.: paper, files, labels, dividers, etc)	Item costed based on time inputs (i.e.: Cost/hr which is reliant on frequency (i.e.: once-off, fortnight, weekly, monthly, etc).

Table 4b: The Akawi Pricing Model (Conceptual Model) continued

10	Accidents investigations and reporting	Accident investigations – probabilities based on statistics	Direct costs (medical treatment, hospital costs and indirect costs (legal costs; investigation costs, etc)	Provisional sum/allowance
11	Insurances	Ensure project risks are covered; risks transferred to other parties	Contributions for COID, Insurance premiums (motor vehicles, public liabilities); PI cover	Insurance premiums, motor vehicles insurance, COID contribution
12	Sundries and Miscellaneous	Additional items as per client's specifications	H&S awards; H&S branding; incentives (i.e.: monetary, non-monetary tangible, etc.).	Fixed cost (H/O overheads and costs); insurance premiums COID contributions, etc.

6. Conclusions and Recomendations

The study aimed at conceptualizing a model for pricing H&S on construction projects. In order to achieve that, there was need to identify the costs drivers that should be considered when pricing for H&S and how much should be allowed for. H&S cost drivers presented in the findings are regarded as the minimum to be priced for if it all H&S performance can be assured on construction projects.

From the findings, it was evident that contractors itemised the cost of H&S on their projects even though such breakdown is not included as a trade in the BOQs. Since each contractor has its own way of pricing for H&S, it is evident that the lack of a standardised model for pricing H&S on construction projects makes the adequate pricing, monitor and controlling of H&S costs unlikely.

It was also observed that the costs of H&S on projects were directly proportional to the project values. Higher H&S specifications will have an impact on H&S cost compared to projects with lower specifications. Since projects are driven by clients, it was also observed that clients had an indirect impact on H&S cost on projects. An H&S minded client would have higher H&S specifications, thus affecting H&S costs.

It is recommended that a similar study be conducted on a different population and sample size to improve its application and generality. It is to note that the APM as presented in this study was not validated. Recommendations for further study will be to validate the model using a Delphi study Survey and Structural Equation Modelling (SEM).

The APM as presented in this study would be of great benefit to the CI and its stakeholders if endorsed and implemented on construction projects. It can be argued that the implementation of the APM in the CI will ensure that the accurate pricing and adequate monitoring and controlling of H&S costs are achieved.

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DII-2017-004

Effectiveness of Employee Retention Plan as a Strategy for Reducing Labour Turnover in the Zambian Construction Industry

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Abstract

Employee retention is an important component of any organisation's success more so in the construction industry which is labour intensive. The research focused on assessing how retention plans can be used in order to reduce the employee turnover in the Zambian Construction Industry (ZCI). The research adopted an exploratory research approach and a questionnaire survey was used to collect data. The questionnaire comprised closed and open-ended questions. Data was collected from Lusaka and Copperbelt provinces because the two provinces have the highest concentration of construction activities in the country. Research results revealed that the most common employee retention plans involve giving bonuses, rewards and regular salary. Factors that lead to employee turnover were found to be organisational and job related. Major organisational related factors include poor working conditions, poor management and poor relationship with superiors and co-worker while job related factors include job security, poor salaries and inadequate job satisfaction. It was further established that employee turnover affects a project's performance negatively due to the cost and time needed to engage a new worker. Therefore, in order to reduce employee turnover, practitioners in the ZCI must adopt retention plans that go beyond the cash remunerations and focus on the employees' wellbeing. This retention plan has potential to drive appropriate project delivery.

Keywords: construction industry, employee retention, labour turnover, Zambia

1. Introduction

The Zambian Construction Industry (ZCI) has gone through some turbulent times has recovered from a low contribution of GDP of 4.5% in 2000 to 29% in 2014. Statistics furthermore indicate that employment in the construction sector increased from 140,000 in 2000 to over 188,000 in 2014 (BOZ, 2014; NCC, 2004). These statistics show how many employees go into the ZCI through the construction companies (e.g., consultants, contractors and suppliers). NCC (2004) report also notes that lack of qualified staff to execute works has hampered the performance of contractors. On the other hand, many construction companies have not kept up with the changing needs of the workforce causing many

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needed skilled employees to leave. Thus, employee retention is becoming a major issue with most employers (Chipunza and Michael 2009). Furthermore, the ILO (2014) points out that there is a trend of high staff turnover in the ZCI. Skilled staff changes companies frequently as better paying contracts become available, resulting in employers having difficulty finding skilled replacements. The high turnover of skilled staff is therefore an issue facing most firms in the ZCI. Hence, the main objective of this research is to find out factors leading to employee turnover and what construction companies in Zambia do to retain their workforce. The study will contribute to knowledge by coming up with relevant information which can assist construction companies in Zambia understand and reduce the problem of labour turnover.

2. The Zambian Construction Industry and Skills Availability

Shakantu et al. (2000) pointed out that the construction sector in Zambia consists of five main sub-sectors, namely, the design, assembly, manufacturing, supply and clientele. The ZCI deals with the delivery and maintenance of buildings and infrastructure such as roads, railways, airports, bridges, dams and power stations. The production process that facilitates the construction industry involves legal and institutional relationships among clients, architects, engineers, surveyors, planners, contractors, manufacturers and material suppliers (NCC, 2004). Since the early 1970s, construction in Zambia experienced a noticeablyhigh drop in the volume of work in almost all areas (Muya et al. 2014). The effect of reduced investment and workload resulted in loss of valuable experience at every level of the industry (Turner 1995). With very little workload on the market the industry's labourpool gradually moved into the informal local sector. Muya et al (2014) further noted that while there has been a serious decline of skilled workforce on one hand, there has been no sustained replacement with trained artisans. This means that there is no focused industry effort on which the industry can base its planning for future skill requirements. With very little effort to systematically maintain the workforce even at its present levels, the industry is likely to see further decline in its capability to offer services that can compete favourably in the sub-region. Muya et al (2014) suggests that during glut periods, the practice of increasing remuneration as a response to shortages of skilled labour leads to companies head-hunting the little workforce available on the market from each other and consequently raises the cost of construction. The long-term option of establishing training programmes to solve labour shortages are rarely applied (Agapiou et al. 1995). A proportion of the demand for labour can be satisfied from the unemployed construction workers, notwithstanding the losses caused by retirements and movements to other industries during recession. It is, however, unlikely that the construction industry's labour needs will be satisfied from the ranks of those out of employment alone – many no longer possess the necessary skills. Also, numerous skilled operatives leave the industry and fail to return when work becomes available. Such skill losses create serious problems and have a direct impact on the rate of expansion of the industry. Realizing that there is a shortage of skilled labour in the ZCI, retaining those employed must be one of the key considerations for any construction company.

3. Employee Turnover and Retention Plan

Employee turnover is the rotation of workers around the labour market; between firms, jobs and occupations; and between the states of employment and unemployment (Abassi and Hollman. 2000). The term "turnover" is defined by Price (1977) as: the ratio of the number of organisational members who have left during the period being considered divided by the average number of people in that organisation during the period. Each time a position is vacated, either voluntarily or involuntarily, a new employee must be hired and trained. This replacement cycle is known as turnover (Woods1995).

The size of the labour turnover depends upon the proportion that the total number of employees hired during the year bears to the size of the labour force that must be maintained. Companies should take a deep interest in their employee turnover rate because it is a costly part of doing business (Bentalletet al.1999). This is because labour turnover represents a significant direct cost in terms of recruiting, poor production practices and reduced standards as well as high replacement and training costs (Barlett 2009). On the other hand, most organisations have been successful because of the organisation's ability to retain employees (Chipunza and Michael 2009; Luecke 2002). This is because maintaining the same labour helps to ensure consistency in the output of work. However, there is a percentage of labour turn over that is inevitable and normal for business operations. For example, workers who pass away or fall ill must be replaced, or workers who are incompetent and untrainable need to be fired. Employee turnover may be classified into the following five categories:-

a) Functional Vs Dysfunctional Turnover: Functional turnover can be defined as "A turnover in which poor performers leave" an example of this areworkers or employees who are ill, become deceased or incompetent or dismissed (Nkomo 2010 p.23). Dysfunctional turnover can be defined as turnover in which good performers leave (Ibid).

b) Avoidable Vs Unavoidable Turnover: A turnover that happens in avoidable circumstances is called 'Avoidable Turnover', where as a turnover that happens in unavoidable circumstances is called 'Unavoidable Turnover' (Lockwood, 2006) Buhler (2002) points outthat avoidable turnover results from life decisions that extend beyond an employer's control, such as a decision to move to a new area or a job transfer for a spouse. Avoidable turnover is something organisations can prevent by hiring, evaluating and motivating their employees more efficiently. Chiu and Francesco (2003) propose that it is important to evaluate whether the organisation is dealing with voluntary turnover that could have been prevented.

c) Voluntary Vs Involuntary Turnover: This is a situation in which an employee chooses to quit or the employee leaves at their own discretion (Chipunza and Michael 2009). Involuntary turnover on the other hand is a situation in which employees have no choice in their termination; for example, sickness, death, moving abroad or employer's initiated termination (Ibid). Additionally, Staw (2007) states that voluntary employee turnover can be caused by lack of job satisfaction, alternative job opportunities as well as job stress.

d) Internal Vs External Turnover: Internal turnover happens when employees send-off their current position and getting a new position within the same organisation (Huang et al. 2003). It is also internal when employees leave their current assignment and take up new roles or positions within the organisation. This could bring both positive and negative feelings. It is related with the internal recruitment where organisations filling the vacant position by their employee or recruiting within the organisation.

e) Skilled Vs Unskilled Turnover: Untrained, uneducated and unskilled positions often face high turnover rate. Without the organisation or business incurring any loss of performance, employees can generally be replaced. On the other hand, skilled and educated positions may create a risk to the organisation while leaving. Therefore, turnover for skilled and educated professionals incur replacement costs as well as competitive disadvantage of the business.

3.1 Retention Strategies

Employee retention may be defined as a sum of all those activities aimed at increasing organisational commitment of employees, giving them an overall ambitious and myriad of opportunities where they can grow by outperforming others (Bogdanowicz and Bailey, 2002). The following are some strategies that are invaluable in a retention program:

- **Culture and Commitment:** A strong company culture is one that places value on people, fosters teamwork, is forward thinking and encourages open communication. Staw (2007) suggests a successful retention plan must involve all departments and levels of an organisation.

- **Compensation packages:** These should be competitive with other construction firms in the region (Sutherland, 2000). If not, one method to bring them to a more comparable level is to offer bonuses based on performance, quality of work, timely or early project completion or other specified objectives.

- **Non-salary related incentives:** Such as insurance coverage, paid time off or a flexible work schedule – can also be incorporated into a compensation package to make it more enticing.

- **Rewards and recognition:** Long hours and hard work that go unnoticed will leave employees feeling deflated (Mark and Sockel, 2001). Some forms of recognition include service awards, congratulatory/promotion letters signed by top executives and promotion announcement. Further, companies must consider a systematic compensation/bonus program designed to establish milestones and reward top performers (Harris 2002).

Globally, employers admit that one of the most difficult aspects of their jobs is the retention of key employees in their organisations (Litheko, 2008).On the other hand, a poor relationship with a manager is one of the primary reasons people become dissatisfied. One solution is periodic leadership training and retraining directly taught by company leaders (Luecke, 2002). Griffeth et al (2004) asserts that empirical studies have revealed that factors such as competitive salary, good interpersonal relationships, friendly working environment, and job security were reported by employees as key motivational variables that influenced their retention in the organisations. Ongori (2007) cites an example of Mercer Human Resource Consulting who revealed5 key factors influencing employee commitment and motivation with percentage of employees voting for each of the factors as follows: Being treated with respect - 85%, work-life balance - 79%, providing good service to others - 74%, quality of work colleagues - 74% and type of work - 73%.It is therefore important to recognise the commitment of individuals to an organisation, as well as the organisation's need to create an environment in which one would be willing to stay (Harris, 2000). This is important because organisations failing to retain high performers will be left with an understaffed, less qualified workforce that ultimately hinders their ability to remain competitive (Rappaport et al., 2003).

3.2 Turnover and Performance

According to Abbasi et al. (2000) employees are seen as major competitive advantage to be maintained; as such, labour turnover should be discouraged by management. Labour turnover affects both workers and firms. For example, Hall (2007) finds high labour turnover negatively linked to labour productivity. Baron et al. (2001) also noted that labour turnover is disruptive. Further, each time an employee leaves the firm incurs significant cost, both in terms of direct costs (replacement, recruitment and selection, temporary staff, management time), and also in terms of indirect costs morale, pressure on remaining staff, costs of learning, product/service quality, organisational memory) and the loss of social capital (Dess et al. 2001). Harris et al. (2002) theory asserts that high turnover lowers firms' incentives to provide staff training programs and, therefore, reduces productivity. Alternatively, job matching theory postulates that turnover can help employers and employees to avoid being locked in sub-optimal matches permanently, subsequently increases productivity.Morell et al (2004) identifies direct and indirect costs of voluntary turnover as replacement, recruitment and selection, temporary staff, management time, morale, pressure on remaining staffs, costs of learning, product or service quality, organisational memory, and the loss of social capital (Dess et al. 2001). More specifically, what the employees currently are looking for is interesting work, employer flexibility, feeling valued and having training and advancement opportunities which finally, become the major factors influencing their decision to change jobs (Cunningham, 2002). Firms operating in the ZCI are not immune to such effects; hence, the need to assess ways of retaining employees and what can be improved upon is inevitable.

4. Research Design and Methodology

Research design refers to the overall strategy that is chosen to integrate the different components of the study such as data collection and analysis (De Vaus, 2006). This study adopted both qualitative and qualitative methods of data collection and analysis because qualitative methods are able to provide the actual explanation of facts or quantitative data (Saunders et al., 2008).

4.1 Data collection areas and target groups

A questionnaire survey was adopted for this research because it is less costly and allows contact with many responses (Saunders et al. 2008). Data collection was done in Lusaka and the Copperbelt provinces of Zambia due to the heavy presence of construction activities compared to other provinces. Additionally, the two provinces accounts for over 75% of contractor and consultant population in the country. Only contractors involved in building and civil works were considered from grades 1 – 3 using stratified sampling method of proportions as the contractors within a grade have homogeneous characteristics (Greener, 2008; Liu and Fellows, 2008). Using the formula (Greener, 2008):

$$\mathbf{ni = (Ni/N)\ n} \text{ ....}$$

Equation 1. Source: Greener (2008)

Where; Ni = Sample strata,ni = Sample size from strata. n = Sample size, N= population size.

Consultants and construction employees were also targeted and judgmental sampling was used in selecting the samples. 35 questionnaires were distributed to contractors and 17 were answered resulting in a 48.6% response rate from contractors. 31 and 50 were distributed to consultants and construction employees respectively with 8 and 35 being returned respectively resulting in a 25.8% and 70% response rate. The overall response rate for the research was 51.72%.

4.2 Data Analysis

The Relative Importance Index (RII) was calculated for use in the ranking of the factors using the equation 2 (Badu et al. 2013). This was based on the response to questions with Likert scale.

$$RII = \frac{\Sigma w}{A*N}$$

Where W = weighting given to each statement by respondent with a range of 1 – 5, A = highest response given and N = Total

Equation 2. (Badu et al. 2013)

5. Research Findings and Analysis

From the data collected, the findings have been divided into contractor and client response. These have been divided in parts A and B.

5.1 Part A – Contractors' Findings

The following are the findings from the contractors:

Respondent profile

From the responses, 52% had over 10 years of existence while 48% had 5 – 10 years of experience. Duration in construction is an important feature when studying labour turnover. Labour turnover has to be measured over at least a period of a year; therefore, the companies in this survey have been involved in the ZCI for a long period of time to assess this.

Occurrence of Labour Turnover – Has there Been an increase in Labour Turn Over at your Firm?

60% indicated no with 40% indicating yes which shows that there has not been an increase in the number of people leaving. However, this does not mean there is no labour turnover happening. Labour turnover is measure over a longer period of time with regard to the number of workers at the company.

Factors leading to Labour Turnover

Poor working relationships was the highest ranked with Relative Importance Index -RII of 85%. The 2nd factor was poor working conditions at 76%. Poor relationships with co-workers and poor company management with RII of 63% and 61% were ranked 3rd and 4th respectively. Therefore an employee retention plan in the ZCI should seek to improve these two factors which have also been seen to be major factors in other countries (Chipunza and Michael 2009).

The Effect of Labour Turnover on Performance – *How does labour turnover affect the following?*

The respondents ranked increased work load and poor performance as 1st and 2nd respectively. Low productivity and loss of skilled employees were ranked 3rd and 4th respectively with poor customer service being the least. From these findings, employers therefore believe that labour turnover does affect performance as indicated by other findings (Morell et al. 2002). This makes this research even more relevant to the ZCI.

Direct and Indirect Costs

Hiring a new employee was ranked 1st with RII of 88%. The 2nd and 3rd were replacement of old workers and training new employees with RII of 77% and 69% respectively. This results was also similar with findings of Ongori (2007) and Chipunza and Michael (2009). Administrative was ranked 5th while marketing costs was ranked 4th with RII of 54% and 61% respectively. With respect to indirect costs, project overtime and reduced project performance were ranked 1st and 2nd with RII of 89% and 78% respectively. Low product quality with RII of 72% was ranked 3rd while additional work load on employees was ranked 4th with RII of 64%. Decreased employee morale with RII of 52% was 5th. The least ranked was reputation of the company 6th with RII of 41%

Use of Retention Plan By Organisations – Do you have a retention plan?

Realize the effect of labour turnover on a construction project, contractor were asked to indicate if they implement a retention plan or not. 41% indicated that they do have a retention plan while 59% indicated that they do not have one. With the majority indicating that they do not have retention plan, it is; thus, inevitable that contractors are encouraged to put one in place in order to avoid the negative consequences of not having a retention plan. However, the following were given as the common methods or tools used in the retention plan: Giving bonuses, promoting workers and giving breaks after a period of work.

Organisational Factors Leading to Employees staying with the Employer – What improvements would make your employers stay?

Improving working conditions was ranked 1st with RII of 84, whilst improving worker-employer relationship and working relationships with fellow employees were ranked 2nd and 3rd with RII of 70% and 64% respectively. Improving company management was ranked 4th with RII rating of 63%. These findings are in agreement with what other researchers have established (Bogdanowicz and Bailey 2002) Hence, employers have shown that improving working conditions would influence the stay of the employees. This is very important for the construction industry since it involves working in different environments and people. Employers can therefore seek to have a retention plan that has improved working conditions.

What incentives can make employees stay with employer?

In trying to understand what incentives or conditions will make employees stay, the employers were asked to rank factors that employees consider most. From the findings bonus/reward and good salary were ranked 1st and 2nd with RII of 87% and 85% respectively. Regular pay and promotion incentives were ranked 3rd and 4th with the RII rating of 81% and 75%. The least ranked, 6th, was having a pension scheme and job security 5th with RII of 63% and 69% respectively. Essentially these are some of the conditions of service that employers must try to improve if employers are to return their employees and have been acknowledged by other researchers (Staw 2007).

5.2 Part B - Employees Findings

Previous work experience

Respondents were asked if they did quit a job in the last 12 months. 70% of the employees revealed they had quit before while 30% said they had worked for more than 2 years with their current employers. This implies; therefore, that workers are more likely to leave after a period of 2 years. Though in other industries, this has been found to be an average of 6 years (Chipunza and Michael 2009). Further in trying to assess the level of employee turnover, employees were asked if they intend to quit their current job. 68% said no whilst 32% said yes. This shows that there is labour turnover taken place in the industry at all levels whether professional or craftsmen level. The findings further imply that the employer can put everything in place, the choice to leave or intention to leave remains with the employee. This is what can be referred to as dysfunctional turnover and has been experienced in other countries and industries (Ongori 2007; Bogdanowicz and Bailey 2002; Chipunza and Michael 2009).

Labour Turnover and Performance

Employees were asked if labour turnover affected their performance and 66% indicated affirmatively whilst 34% indicated otherwise. This demonstrates that labour turnover does affect the performance of the employee. If turnover does affect performance then turnover should be controlled. However on the employer turnover has a negative impact as earlier shown. When asked how turnover has affected their performance the respondents indicated that besides it being viewed as having a negative effect, they indicated that it helps to give them more skills, acquire more experience, improve co-worker relations and increase their earnings, a much reason why voluntary turnover exists (Ongori 2007).

Organisational Factors That Make Employees Leave

Poor working conditions was the highest ranked factor 1st, with 85% while poor working relationship with employer was ranked 2nd with RII of 80%. Poor relationship with co-workers was ranked 4th with 65% and poor company management was ranked 3rd with 79% RII. The least ranked was harassment at 6th with RII of 40%.

Conditions That Lead To Employees Leaving

Respondents indicated poor salary as the 1st factor or conditions that would lead to them leaving an organisation with the RII o 86%. The 2nd ranked was irregular payments with 70% RII. The 3rd and 4th conditions were job dissatisfaction and job insecurity with RII of 58% and 40% respectively. The 5th ranked was lack of promotion with RII of 35%. The least was job creation ranked 6th with RII of 20%.

6. Conclusion

Employees are an important part of the construction process. It is important that every firm ensures that employees are well maintained if success is to be achievedin the infrastructure delivery process. However, the challenge of employee turnover has continued to affect the construction industry including the ZCI. This has been largely attributed to poor working conditions and employee-employer relation (Bogdanowicz and Bailey 2002; Ongori 2007; Chipunza and Michael 2009). Hence, it is imperative that a strategy to retain employees is put in place realizing that employee turnover affects performance and leads to indirect costs such as lose of morale and the recruitment process. Further, , employee retention strategy must go beyond financial incentives and consider other factors such as job security. Hence, the firms in the ZCI must consider applying both monetary and non-monetary approaches by giving employees bonuses, paying workers regularly and fairly, health benefits, more responsibility, job security and creating an environment that is conducive for working. This is because these factors were noted as leading to labour turnover in the ZCI. However, these findings cannot be generalized due to the fact that the data was not representative of the ZCI since it was collected from two out of ten provinces. Additionally, the use of the questionnaire did not provide a deep understanding of issues surrounding employee retention and in future an interview approach could be utilised to understand employee retention deeply.

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DII 2017-015

Green Building Practices and Principles in the Zambian Construction Industry

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Abstract

Experiences on green buildings projects can encourage people to make the right choices on the green building practices conducted on construction sites and in turn reduce the negative effects on the environment. Understanding the level of awareness, perceptions and attitudes of artisans, communities and professionals on green building practices provides a good baseline on which to disseminate information on green building technology. This paper investigated the level of awareness, attitudes and perceptions of green building practices amongst participants in a green buildings housing project in North-western and Lusaka provinces of Zambia. A qualitative descriptive cross sectional study was used and all the people who were directly involved in the project were interviewed. The findings suggest that amongst the professionals and artisans who were interviewed, the ones who had participated in other sustainability projects showed greater awareness than those who did not. The professionals had attained the knowledge from workshops, media, green building demonstration houses and institutions of higher learning while the artisans had attained it from a previous project on renewable energy. The community members who were aware were few but the few had attained this knowledge from reading and watching documentaries. The results suggest that professionals who spent most time on the green building project demonstrated greater awareness. On the other hand the artisans who spent an equal amount of time on the project seemed not to have gained as much awareness in comparison with the professionals. The professionals showed the highest positive perception and attitude on the Likert scale. All the groups agreed that green building materials could only be affordable if they were locally produced. The study concluded that the best way of training the local community is by demonstrating the use of local materials and practices whereas for the professionals and artisans, the introduction of regulations on green building practices may increase the level of awareness.

Keywords: energy efficiency, green building technology, sustainable construction

1. Introduction

The Zambian construction industry is one of the fastest growing industries in the Sub- Saharan region and the construction sector contributes 27.5% of the Gross Domestic Product (GDP) of which the building industry is a part (Zambia invest. Magazine, 2014). Buildings are responsible for 30% of all

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greenhouse gas emissions, 65% of waste output, 70% of electrical consumption and 12% of water consumption (National Energy Balance, 2009). Buildings which are not built in a green way can affect the health, safety, comfort and productivity of the occupants (Singh et al., 2010). Green building practices emerged to mitigate the effects of the increasing impact on the environment and to improve the building construction process (Diana and Victor, 2012). Sustainable buildings can be a showcase to educate people about environmental issues, possible solutions, partnerships, creativity, and opportunities for reducing environmental impacts in our everyday lives (Diana and Victor, 2012). Green building, or sustainable design, is the practice of increasing the efficiency with which buildings and their sites use energy, water and materials, and of reducing impacts on human health and the environment for the entire lifecycle of a building (Abimbola, 2014).

2. Background

There many reasons behind green building development, some are economic others are ecological. An increase in the awareness of energy inefficiency and global climate change has significantly impacted the building sector in the recent years. More people are aware of the notion of going green as they incur huge energy bills and high building operational cost. 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).

The first line of contact of the building with its users are the professionals in the construction industry and are the best advocates in promotion of green building practices. The lack of expertise's knowledge in green building development creates an environment that lengthens development time frames (Choi, 2009). The rate of success towards sustainability in construction would depend mainly on enhancing awareness, knowledge and understanding of the influences of people action (Usman and Mohd, 2012). The knowledge gained will yield a number of benefits, firstly knowledge does influence attitudes towards positive environmental responses and secondly the people begin to apply this knowledge in their day to day decisions on the use of resources, energy, water and waste. The aim of this paper was to determine how much awareness people gained from green building projects and to understand their attitude and perception on these practices. The projects that were picked were the Larfage green buildings of Lusaka, the Lumwana and Kalumbila projects of North western provinces of Zambia. The projects were initiated by The International Labour Organisation (ILO) through the Zambia Green Jobs Programme (ZGJP) the aim of which was to involve local participation. This local participation involved professionals, artisans and the local communities. After the construction of the houses, there has been no follow up to assess how much awareness on green building technology and practices were gained by the participants of the project.

3. Research Methodology

The objective of this paper was to explore the level of awareness of green building practice, perception and attitudes of participants in a green building demonstration project. This was a descriptive cross sectional study and it used a qualitative method design. The research type was adopted from two similar studies by Usman and Khamidi, "Determined the Level of Green Building Public Awareness" and "Green Buildings: Analysis of State of Knowledge," (2012) by Diana and Victor. The studies carried out surveys to investigate the level of awareness about green building practices.

A focusgroup discussion was held with the Lumwana community business association. These were either suppliers or they participated in the building as bricklayers although they were not included in the category of artisans. The main research instrument used was a well-structured questionnaire containing both closed and open ended questions. Figure 1 shows who the participants were and all the 31 participants who were available were interviewed.

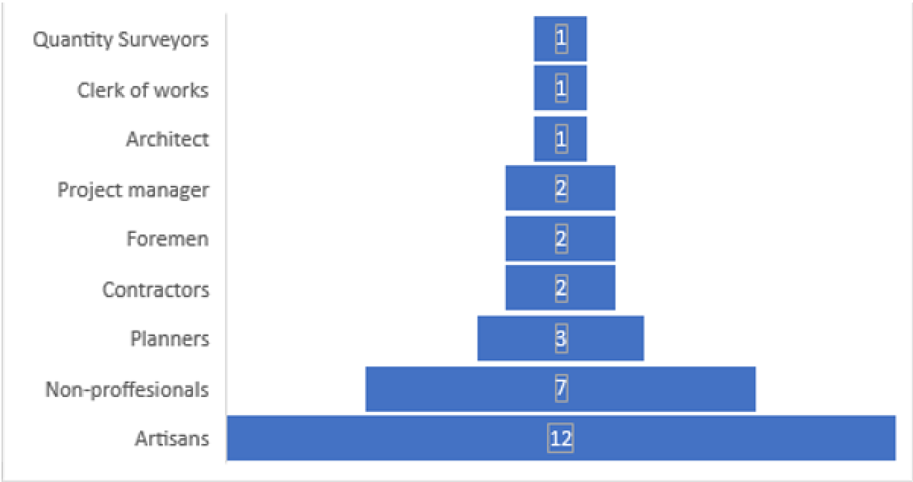

Figure 2: category of the participants of the study

The data gathered was measured on a Likert Scale and analysed qualitatively (scale-type of questions open-ended questions).

The questionnaire had four sections as follows:

a. Part A: respondent's background.
b. Part B: the awareness on green building technology; where the participants were asked to define green building technology, to identify the green building materials and how the technology was applied on the projects
c. Part C: the perception ; they were asked open ended questions whether they agreed with green building practices and asked to explain their answers
d. Part D: the attitude; in there the Likert scale was used to see their level of agreement or disagreement to the green building practices.

3.1 Data analysis

The measure of green building awareness in this paper was based on rankings created on a Likert scale, A 4 point awareness scale was used (1≤very low ,2≤low, 3≤medium, 4≤high). This type of ranking was based on a similar study that was done by Nazirah Z. et al. (2014).The data was generated from the awareness ranking scale that was created and it brought out mean scores for all the groups of participants. The American LEED system standardised concepts of green technology were used as a scoring chart. The following were the themes from which the questions were drawn:

a) Sustainable site planning
b) Safeguarding water and water efficiency

c) Energy efficiency, renewable energy and lower greenhouse gas emissions

d) Conservation and the reuse of materials and resources, and improved health and indoor environmental quality.

The attitudes and perceptions were explored using a thematic analytical technique, where the themes were developed using categories based on participants' responses and the resulting data (Fossey et al., 2002). The perceptions and attitudes helped explain the results that were seen in the awareness scale and these were measured on a Likert scale. The perceptions and the attitudes were scaled with 1- 5, with 1= strongly agree and 5= not sure. A correct answer meant a good attitude for that particular question and the mean average was found for each group to see which group of participants had a good attitude and perception on green building technology.

4. Results and Discussion

Table 3 presents summary results for socio-demographic variables of the study participants. The majority of the respondents were professional males (n=10, 83.3%). This is followed by artisans (n=2, 16.7%). Half of the female respondents were community members (n=6, 40.0%), followed by artisans (n=7, 43.7%) and lastly professionals (n=2, 13.3%). The professionals category has more than three quarters (83.3%) of respondents aged 21 to 30 years whereas the artisan category had slightly more than half (54.5%). The community comprised of those aged above 40 mostly (45.4%) compared to the professionals (27.3%) and artisans (27.3%). For the least number of years of experience, 0 to 5, professionals and artisans were represented by about 44% of the sample each. With regard to the longest experience period, each category only had a single individual with 21 to 30 years of experience.

Table 3: The social demographic characteristics of the participants

	Community		**Professional**		**Artisans**	
	Count	Percent	Count	Percent	Count	Percent
Gender						
Male	0	0.0%	10	83.3%	2	16.7%
Female	7	46.7%	2	13.3%	6	40.0%
Age group						
21-30	1	16.7%	5	83.3%	0	0.0%
31-40	2	18.2%	3	27.3%	6	54.5%
More than 40	5	45.5%	3	27.3%	3	27.3%
Education level						
Primary level	1	16.7%	0	0.0%	5	83.3%
Secondary level	4	44.4%	1	11.1%	4	44.4%
Tertiary	3	23.1%	10	76.9%	0	0.0%
Occupation						
Architect	0	0.0%	3	100.0%	0	0.0%
Quantity surveyor	0	0.0%	1	100.0%	0	0.0%
Engineer	0	0.0%	1	100.0%	0	0.0%
Bricklayer	2	20.0%	0	0.0%	8	80.0%
business man	6	85.7%	1	14.3%	0	0.0%
Contractor	0	0.0%	2	100.0%	0	0.0%
Planner	0	0.0%	2	100.0%	0	0.0%
Carpentry	0	0.0%	1	50.0%	1	50.0%
Years of experience						
0-5	1	11.1%	4	44.4%	4	44.4%
6-10	5	41.7%	3	25.0%	4	33.3%
11-15	1	50.0%	1	50.0%	0	0.0%
16-20	0	0.0%	2	100.0%	0	0.0%
21-30	1	33.3%	1	33.3%	1	33.3%

Figure 1 presents the average awareness scale for professionals. The findings suggest that Architects have the highest level of awareness at 3.7 followed by project managers and clerk of work at 3.5, Quantity surveys at 3.3. Similarly, planners and engineers had medium level of awareness, whereas contractors seemed to be the lowest. When asked were the different professionals had acquired their knowledge from, architects had peril knowledge from the university and they had been involved in a previous green building project. The clerk of works also showed high level of awareness due to his experience on the green building demonstration site. The quantity surveyor showed medium level of awareness and this could be due to the fact that he had been involved in a previous green building project. However, some studies have shown that awareness had been gained from personal interest (Ameh et al., 2007). Amongst the planners the levels of awareness also differed when the study further inquired it was seen that the one who was more aware had more years of experience and had attended courses on green building practices. The contractors seemed to be at the lower end of the scale despite having spent more time on the green building project. Other studies show that the contractors' involvement is limited in the influence of green building practices but they can play a major role in recycling and reusing construction debris, limiting the use of hazardous materials and protecting vegetation (Buys and Hurbissoon, 2011).

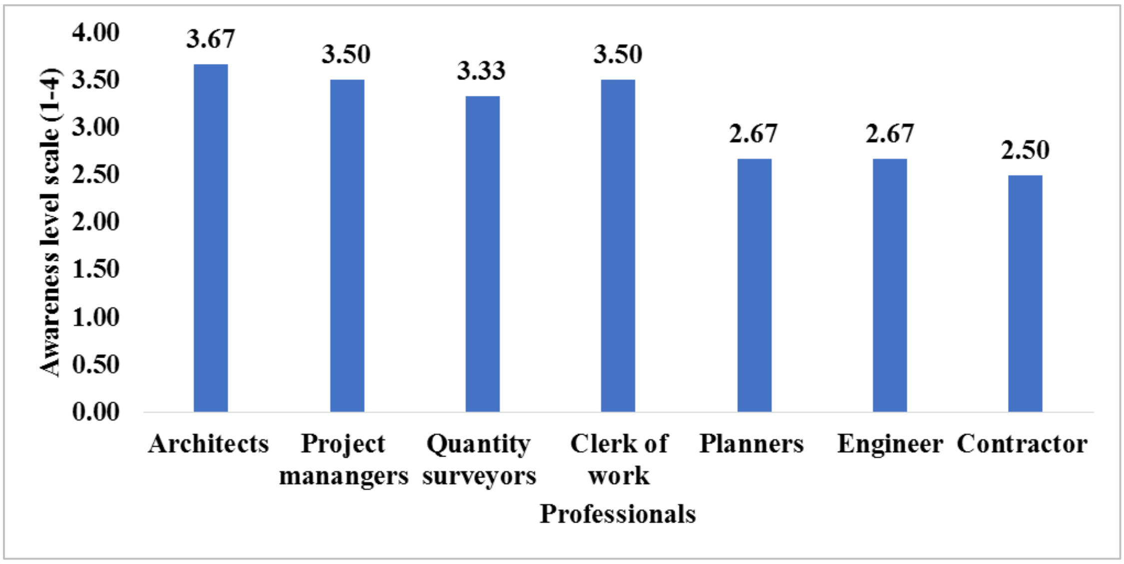

Figure 1: Awareness scale for professionals

In similar studies awareness of the professionals' practitioners in construction industry was 48% and, 30.6% respectively (Nadzirah and Carmen, 2015; Ntshwene et al., 2014), this is lower than the results in this study which found the awareness of the professionals to be at 64% as shown in figure two (2) below. The average community awareness was low at (n= 2, 22%), however two community members showed greater awareness.

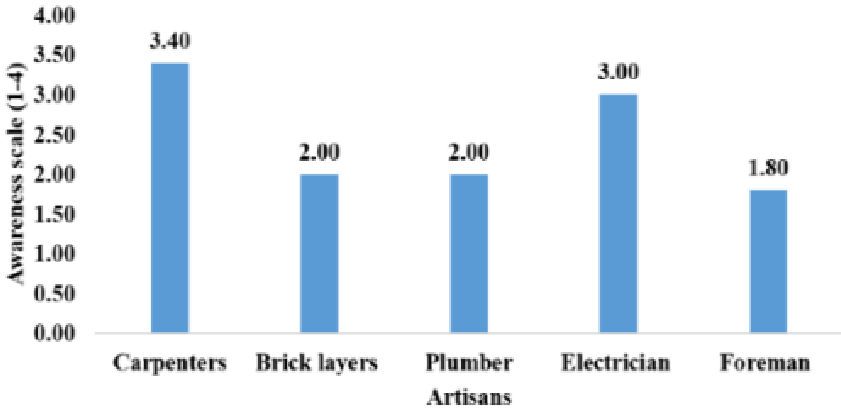

Figure 2: Level of awareness for green building technology

The artisans' awareness was much lower at (n=2, 11%); while on the artisans' scale it seemed that those who had high awareness had a tertiary education and had been involved in a previous energy renewable project. From the results it can be suggested that a high education may encourage interest in green building technology. This is in line with MiladSamari (2013) who showed a significant relation between professional awareness and education level.

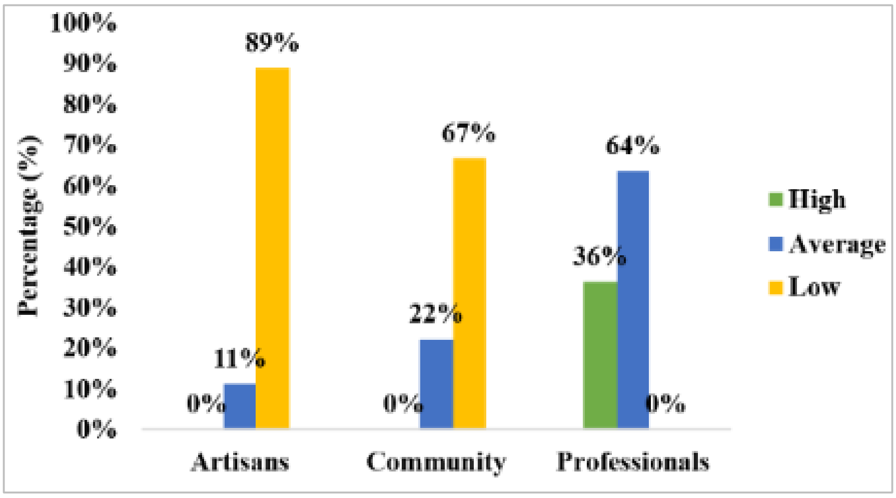

Figure 3: Awareness level scale for artisans

The artisans despite having spent equal amount of time on the demonstration site did not show high level of awareness. This could be attributed to the lack of training and awareness given to them before and during the project. Awareness of green building depends on the understanding of the individual actions, quest for knowledge and absolute involvement and commitment to the principle (Abolore, 2012). From figure four (4) it can be seen that the highest percentage of the participants had less than six (6) years' experience. The professionals despite having less years of experience seemed to show greater awareness compared to the artisans who had spent an equal amount of time on the demonstration site. When the professionals were asked where they had attained the awareness on green buildings as seen from figure five (5), the highest was through training and green building projects while the rest (media, workshop and others) was lower.

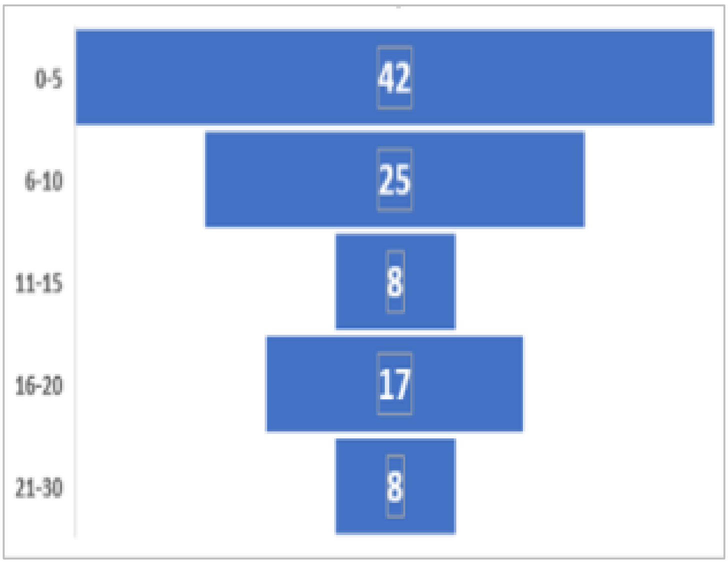

Figure 4: Participants working experience in the Building industry

The sources of information varied across the participants, which suggests that no one strategy could work. Others studies have shown that the awareness was obtained from building regulations, personal research and formal training (Ntshwene et al., 2014), while another study showed that it was obtained from internet, through magazine and Newspapers and through their real estate agent (Usman and Mohd, 2012). In Zambia green building practices have not been incorporated into the building bye laws and if these regulations were available possibly more professionals would access this information.

The study suggested that demonstration houses can be a good source of knowledge for those that take time to learn from it. The perception scales ranged from strongly disagree to strongly agree (5 point Likert scale). The corresponding findings are presented in figure 6. On average, the community and artisans disagreed that the maintenance cost of green buildings compared to conventional buildings is high. Professionals also disagreed but this was further explained that the maintenance cost on green buildings depended on the source of the building materials and the use of materials found within a local setting. Moreover, practically all three — the community, artisans and professionals agreed, with a mean score of about 4, that the benefits of using green building designs are greater compared to conventional ones. Further, only professionals strongly agreed (mean score of about 5) that rain water can be collected and used for domestic purposes whereas artisans agreed and the community were not sure. With respect to green building having sufficient natural lighting, each of the three groups sampled agreed.

Figure 5: Sources of awareness on green buildings

The community perception on the efficient use of energy in green buildings was low. This could be due to their low awareness of what energy efficient meant while the professionals were aware. There was a disparity in the community answers in that even though they disagreed that green buildings were energy efficient they strongly agreed that green buildings have better internal air quality and sufficient natural lighting. The participants were asked if rain water and bathroom and sink water could be reused for bathing and gardening respectively. All the professionals agreed that rainwater could be reused but only 41% of the artisans agreed that bathroom water could be reused for watering, while the community 65% agreed to reusing rainwater. This could suggest that when it comes to reusing rain water the perception for both groups was positive while for the reuse of bathroom water the perception is negative. All the participants agreed that there were more benefits from using green.

The community and professionals had a positive attitude towards the use of green building practices, although some of the professionals mentioned that the house was too small for an average family size. When asked whether the materials were accessible and affordable both the community and the professionals were positive and both also strongly disagreed that the green buildings concept was foreign and would not be accepted. Some explained that if local materials were not used and foreign based materials were introduced then it would be a foreign concept. When asked if they would recommend green building technology all the participants agreed with a mean score of 4.5. When asked whether the demo houses were a good way of learning green building technology 80% agreed that it was, while 10% thought workshops were the best and 10% thought a combination of workshops and demo houses would be the best way to learn.

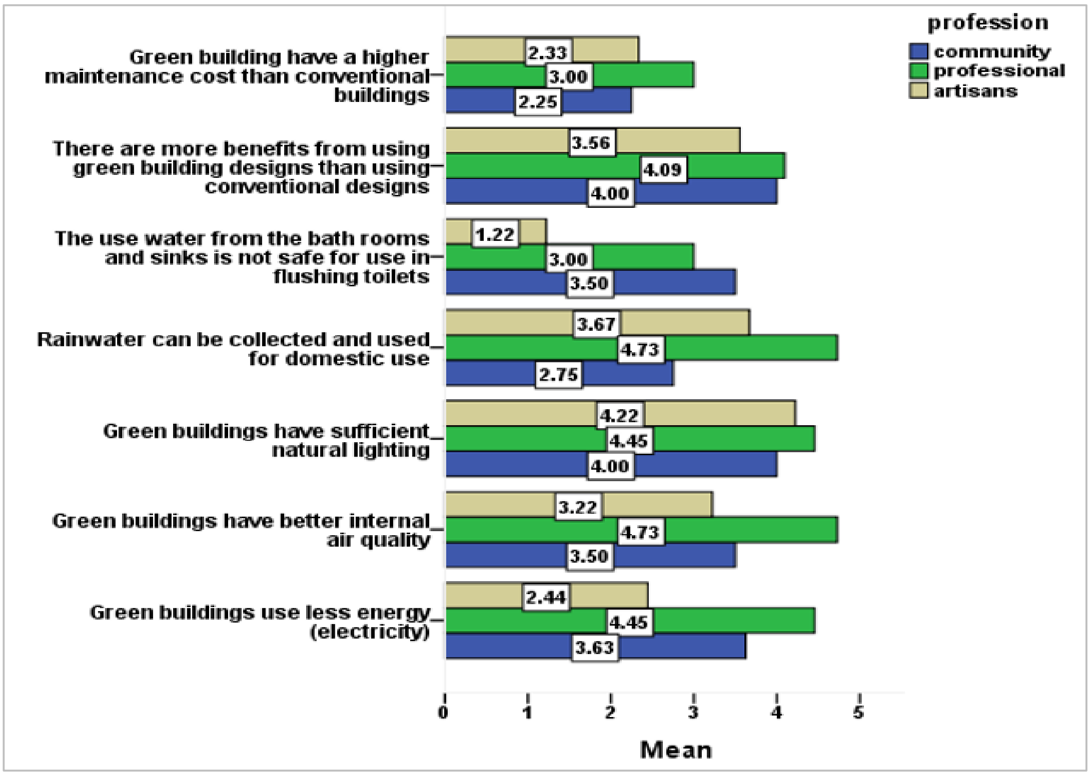

Figure 6: Perception of green buildings technology

5. Conclusion

The study suggests that even though the awareness levels among the artisans and the community was low their attitude and perception of green buildings practices was very positive. There is need to increase awareness among all the participants and the environment should be conducive for the development of green buildings. The introduction of green building practices in the building bye laws will institutionalise the practices. The demonstration houses have aroused a lot of curiosity in the communities where they have been built and introduction of green building technology will be a welcome strategy especially if built upon already existing local technologies. The actors in the building industry should be used as catalysts in the promotion of green building technology. More education is required for the artisans and this should be practical demonstration and not theoretical. The professionals can go through continuous professional development, workshops and involving them in green buildings demonstration projects. The community could have community based education programmes where green building practices are demonstrated.

6. Limitations

The limitations were that this study is not representative of the construction industry and the sample size was very small to make any definite conclusions. It will require further research and a more representative population.

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DII-2017-024

Importance of Transport Infrastructure for Socio-Economic Development: A South African Public Opinion Survey

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Abstract

This paper presents results of an investigation of the importance of transport infrastructure to socio-economic development. It reviews selected areas of transport infrastructure provision which inhibits the achievement of the transport objectives as described by selected policy documents, such as the South African White Paper on National Transport Policy, the National Development Plan and, more recently, the National Transport Masterplan (NATMAP). The results are from four years of the Institute of Transport and Logistics Studies' (Africa) State of Transport Opinion Poll (TOP), an annual survey of 1,000 adults across South Africa, which investigates the public's opinions on certain transport matters, including the importance of transport and the perceived highest transport priorities. Other factors include conditions of transport infrastructure and services, and perceptions on the current and future state of transport.

The findings from the study indicated that the availability and overall condition of transport infrastructure is not delivering transport services which address the needs of the South African public. Major areas of concern for South Africans include mobility, accessibility, affordability and safety. The views from respondents included differences between provinces, indicating disparities in infrastructure provision across the country as well as from an urban/rural perspective, indicating the continuous divide between accessibility levels. Although the sample size could be viewed as a limitation of the study, the individual results over the four-year period provides a comparable representation of public opinion on transport infrastructure matters across South Africa as a whole. This research provides an original contribution to transport research because it is the only annual survey that gauges public opinion regarding transport infrastructure and services in South Africa.

Keywords: infrastructure, public opinion, public transport, TOP South Africa survey, South Africa

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1. The Transport Infrastructure Policy Environment in South Africa

The White Paper on National Transport Policy is South Africa's primary policy paper for the provision of transport in the country (Department of Transport, 1996). The White Paper provides a vision for transport for the country: "Provide safe, reliable, effective, efficient, and fully integrated transport operations and infrastructure which will best meet the needs of freight and passenger customers at improving levels of service and cost in a fashion which supports government strategies for economic and social development whilst being environmentally and economically sustainable" (Department of Transport, 1996, p. 5). The implication for infrastructure is that it needs to be provided and maintained in a manner that supports the vision. The goals of the white paper are more specific:

- To support the goals of the Reconstruction and Development Programme for meeting basic needs, growing the economy, developing human resources and democratising decision making
- To enable customers requiring transport for people or goods to access the transport system in ways which best satisfy their chosen criteria
- To improve the safety, security, reliability, quality and speed of transporting goods and people
- To improve South Africa's competitiveness and that of its transport infrastructure and operations through greater effectiveness and efficiency to better meet the needs of different customer groups, both locally and globally
- To invest in infrastructure or transport systems in ways which satisfy social, economic or strategic investment criteria
- To achieve the above objectives in a manner which is economically and environmentally sustainable and minimises negative side effects (Department of Transport, 1996, pp. 6-9)

Analysis of the White Paper's vision and goals indicate that transport infrastructure, both new and existing, needs to assist in meeting basic mobility needs; it should assist in providing a reasonable level of accessibility; the quality of the infrastructure should be such that the movement of people is not constrained and more particularly, that safety is enhanced rather than jeopardised by infrastructure; that infrastructure should enhance the functioning of the economy and not limit it and that it should prioritise environmentally friendly means such as public transport over less environmentally sensitive transport such as motor vehicles. Transport infrastructure thus needs to support the socio-economic development of the people of South Africa.

The White Paper also makes specific recommendations in respect of transport infrastructure. It provides that as part of the overall long-term vision for the South African transport system, transport infrastructure will, amongst others:

- be structured to encourage public passenger transport and to discourage excessive private passenger transport in urban areas,
- allow for seamless intermodalism,
- provide adequate accessibility together with safety and security within the constraints of social affordability,
- incorporate technological advances which promote and enhance the role of transport in the economy and development, and
- be structured to ensure environmental sustainability and internationally accepted standards (Department of Transport, 1996, p. 17).

The mission for transport infrastructure is described as "To provide an integrated, well-managed, viable and sustainable transport infrastructure meeting national and regional goals into the 21st century, in order to establish a coherent base to promote accessibility and the safe, reliable, effective and efficient movement of people, goods and services" (Department of Transport, 1996, p. 17)

The mission is supported by strategic objectives, including:

- Maintain and develop the transportation infrastructure system, and prioritise its development in terms of sustainable economic and development needs,
- Aid the promotion of a strong, diverse, efficient and competitive transportation industry within the limits of sustainable transport infrastructure,
- Promote environmental protection and resource conservation,
- Enhance the competitiveness of South African industry and the quality of life of its citizens by providing protection of consumers, safety and security, and meeting accessibility, reliability and mobility needs by providing transport infrastructure to serve the purpose,
- Ensure that the transport needs of the country's disabled population are taken into account when new infrastructure is planned and designed (Department of Transport, 1996, p. 18).

The specific principles regarding transport infrastructure, in as far as people movement is concerned, are that infrastructure should provide for an integrated system, which favours public transport. It should be competitive, safe, reliable, affordable, accessible, world class and environmentally sustainable. It should also support socio-economic development, enhance mobility needs and cater for passengers with special requirements.

Transport policy in South Africa is not however only guided by the White Paper on National Transport Policy. More recently, the government issued the National Development Plan (NDP) (National Planning Commission, 2011). Although this plan is aimed at the development of the economy as a whole, it makes specific recommendations regarding transport. In particular, the NDP requires that, by 2030, investments in the transport sector ensure that it serves as a key driver in empowering South Africa and its people, enabling, amongst others:

- Improved access to economic opportunities, social spaces and services by bridging geographic distances affordably, reliably and safely
- Greater mobility of people and goods through transport alternatives that support minimised environmental harm (National Planning Commission, 2011, p. 161).

Crucially, in its executive summary, transport is seen as one of the pillars to increase employment and broaden opportunities (National Planning Commission, 2012). An investment priority is therefore public transport infrastructure and systems, including the renewal of the commuter rail fleet, supported by enhanced links with road based services (National Planning Commission, 2012, p. 56). The plan emphasizes the provision of public transport which is safe, effective, energy efficient and affordable and is part of an overall strategy to alleviate poverty. Transport should also be reliable and there should be better coordination between modes. Transport costs should be reduced as a means of reducing the cost of living for low-income households. The National Development Plan thus largely focusses investments in public transport infrastructure on the need to provide affordable, high quality public transport to those who need it most.

A more recent development in transport policy in South Africa is the National Transport Masterplan (NATMAP 2050), a plan that guides transport policy to the year 2050. The NATMAP 2050 vision is that transport is the heartbeat of the economy and the fabric of the country's socio-economic development as well as its alignment with key policy, legislation and planning frameworks recently developed. NATMAP 2050 therefore aims to achieve an integrated, smart and efficient transport system supporting a thriving economy that promotes sustainable economic growth, supports a healthier life style, provides safe and accessible mobility options, socially includes all communities and preserves the environment (Department of Transport, 2015, pp. 0-3). In this document road infrastructure interventions, as they affect passenger transport, are largely aimed at reducing congestion by developing freeway bypass systems for urban areas and reducing passenger volumes. As far as passenger rail infrastructure is concerned, it is envisaged that by 2050 all metropolitan areas, and high density and income district centres, will have a rail commuter system. Based on modal threshold specifications, residential areas will connect with CBDs (central business districts). Similarly, linkages and integration of various passenger transport systems and modes will be implemented by means of transfer facilities and ticketing systems (Department of Transport, 2015, pp. 6-18). In essence, transport infrastructure investment needs to support the strategic themes, of which, the relevant ones are outlined as:

- Is well planned, integrated and aligned across sectors
- Is responsive to growing passenger and freight customer needs
- Is well maintained and preserved and further developed to advance developmental challenges
- Offers safe, affordable and accessible modal options for passengers
- Preserves the environment
- Is innovative / adaptive and reflect emerging priorities
- Is sustainably funded (Department of Transport, 2015, pp. 0-3).

Analysis of the policy documents indicates that, although the policy is described in a variety of documents, common themes emerge. Transport infrastructure needs to be developed in such a way that it prioritises the needs of passengers. As such principles that must be taken into account when investing in infrastructure for passenger transport are:

- Safety
- Affordability
- Mobility
- Accessibility
- Integration
- Choice
- Socio-economic development
- Inclusivity
- Environmental sustainability
- Responsive to people's needs

Whilst the policies are clearly outlined in terms of the above stated objectives, the repetition of the same policy objectives in various documents over the past 21 years provides an indication that policy objectives are not being met and transport infrastructure remains of an insufficient standard to meet the needs of the South African commuting public. This is further illustrated by the numerous public transport service delivery protests at any given time in South Africa (Africa News Agency, 2016; Herman, 2016; Motlhale, 2016; Tswanya, 2016). This suggests that the current public transport service offering does not meet commuters expectations and this can partly be attributed to the fact that infrastructure constrains, rather than enhances, service delivery.

This research aims at determining public opinion on public transport infrastructure and seeks to determine whether it has an impact of public transport services in the country and whether the imperatives, as described by the various policies regarding transport infrastructure are being met.

2. Research Methodology

The objective of the annual ITLS (Africa) State of Transport Opinion Poll South Africa (TOPSA) is to assess the South African public opinion on a broad range of transport related issues, including public passenger transport, toll roads, and transport usage. It is also the intent of TOPSA is to gain an indication of community confidence regarding transport in South Africa. TOPSA is a telephone survey of 1,000 South Africans citizens, over the age of 18 years, and representative of all the South African provinces. The first TOPSA survey was conducted in 2012 and has been conducted for four consecutive years (Heyns and Luke, 2016; Luke and Heyns, 2013). The purpose of this paper is to evaluate the results of the four TOPSA surveys to reveal the prevailing public opinion on transport matters, and to examine the importance of transport infrastructure to socio-economic development through any shifts in public perception.

The TOPSA surveys was conducted using a two-phased approach. During the first phase, an initial list of prospective respondents were randomly chosen from database of valid subscriber phone numbers which is representative of the geographical and socio-demographic (ethnicity, location and employment status) characteristics of the population in South Africa. During the second phase, respondents were chosen at random from the predetermined list to participate in a computer aided telephonic interview (CATI). Through the quota and random sampling approach, a total of at least 1,000 willing South Africans participated annually in the TOPSA surveys. Trained interviewers from two different market research companies was used to conduct the annual telephonic surveys. Although the sample size could be viewed as a limitation of the study and while a larger sample would lessen the sampling error, the selected sampling size signifies a trade-off with the costs of conducting these surveys.

The research instrument requested demographic information such as locality, age, gender and employment status from the respondents to ensure that the sampling is representative of the geographical and social-demographic diversity of the South African population. The gender split of the sample population over the four-year period is, 58.9% are males and 41.1% are females. For the first three surveys the majority of the respondents (53.8%) were between the age of 25 and 45 years. In the 2015 survey the age group periods were reduced to five categories and indicated that the majority of the respondents (64.5%) were between the ages of 31 and 50.

Across the four TOPSA surveys the majority of the respondents, on average, lived in metropolitan areas (36.2%), followed closely by respondents in towns/villages (29.2%). The rest of the respondents resided in small cities (16.6%) and rural areas (14.5%). The majority of the respondents across the four surveys (69.7%), were employed in some capacity, compared to the 20.7% who were unemployed.

As depicted in Figure 1, the demographic profile from the annual TOPSA surveys approximated a fairly accurate reflection of the South African demographic profile (Statistics South Africa, 2012).

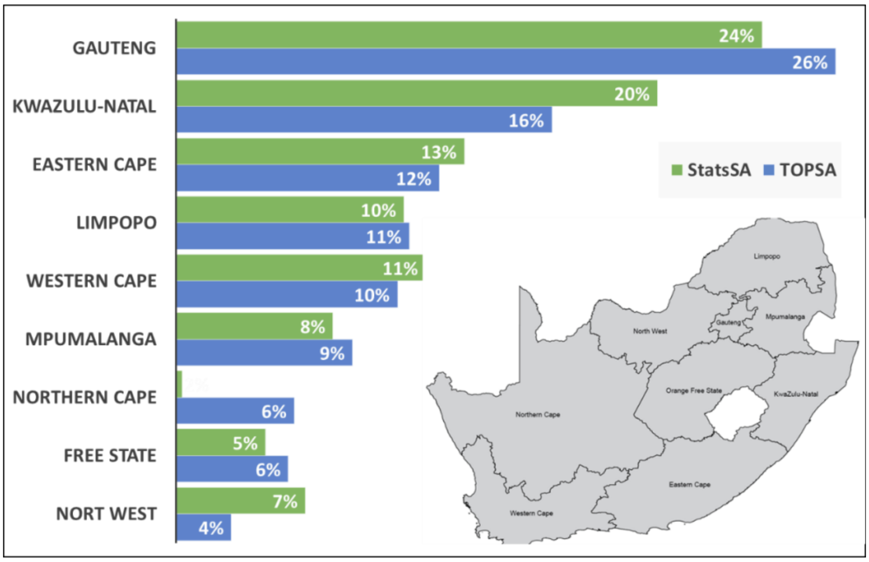

Figure 1: Respondents' geographical location

While the survey sample size may possibly be viewed as a limitation, the authors believe that it is sufficiently large to indicate public opinion on transport matters in South Africa. The Roper Centre for Public Opinion Research (Cornell University, n.d.), states that if a random sample size is increased to 1,000, given a 95% confidence level, the statistical error drops to 3%.

3. Research Results

Respondents were requested to indicate what they thought were the most critical issues facing South Africa. Most of the TOPSA participants are of the opinion that education is the top priority in the country, shadowed closely by health and transport, signifying that transport is one of the most crucial issues facing South Africans today.

The TOPSA surveys indicated, for four consecutive years, that *education* was the highest priority issue in South Africa. It appears that concerns around the state of education has increased significantly with 79% of the respondents nominating it as priority issue in 2015, compared to 56% and 64% in 2012 and 2014 respectively. *Health*, *transport* and *safety and security* are identified as the other main areas of importance. In 2015, for the fourth year in a row, *transport* was identified as the third highest priority issue in South Africa, nominated by 74% of South Africans. This has increased significantly from 47% in 2012 and 57% in 2014, clearly indicating growing concerns. The maintained presence of transport in the top 3 priority list further suggests that, despite certain investments in transport infrastructure and possible improvements in transport services, there are still a growing concern amongst South Africans that the current state of transport is insufficient in providing the required mobility and accessibility. Over the four year period, *infrastructure* as a broad priority area, was identified as the tenth highest priority concern in South Africa, with 50% of the respondents nominating it as a very high priority issue.

When asked to indicate what they believed to be the highest transport priorities in the country, respondents stated, consistently over the four year review period, that the state of public transport is the highest transport priority issue in South Africa. This is depicted in Figure 2. Specific responses regarding public transport reveal that respondents are of the opinion that there are insufficient levels of public transport (i.e. unsatisfactory frequencies and operating hours); poor service quality and inadequate public transport service availability (i.e. service coverage). Although only a major issue in Gauteng and the Western Cape, concerns regarding the e-tolling system seems to have lessened in importance since its peak in 2013. Reasons for this could be attributed to waning media coverage, the reassessing of e-toll pricing, or other associated factors. The cost of transport, irrespective if it is public or private, remains a key concern for South Africans. Although generally perceived as being high by all respondents, transport costs are of far higher concern to unemployed and younger respondents.

Generally, these results reveal that the transport priorities highlighted by South Africans have not significantly changed over the past few years, perhaps indicating that these issues have not been adequately addressed by policy intervention focussing on service improvements and infrastructure developments at all levels of government.

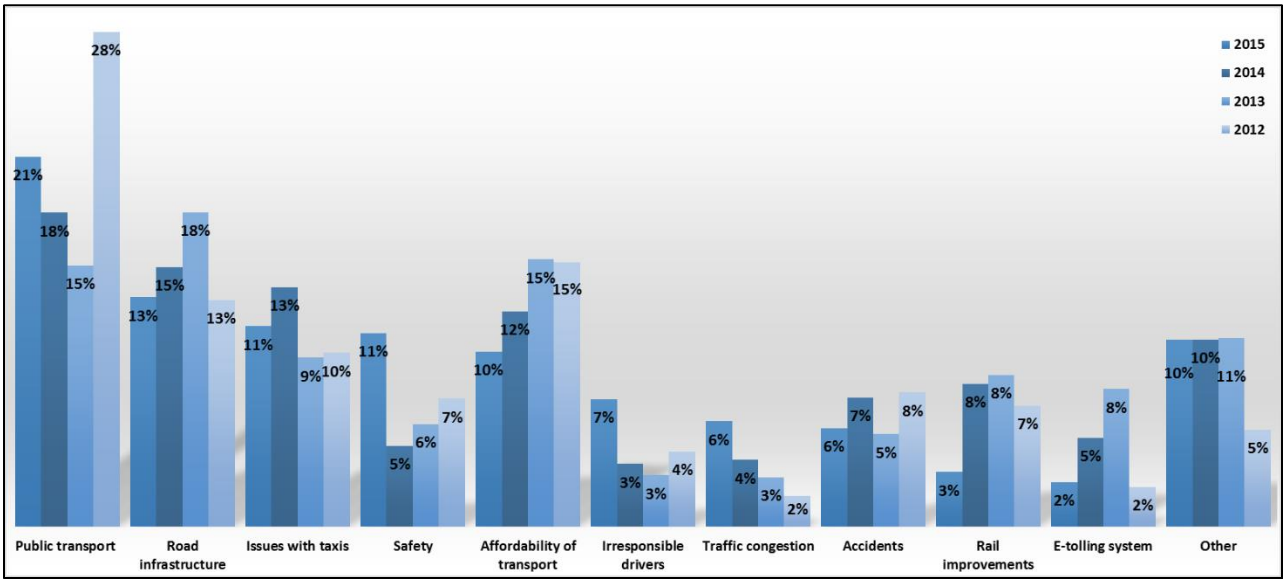

Figure 2: Highest transport issues (2012-2015)

Respondents further highlighted road infrastructure, taxi-related issues, safety and the affordability of transport as high priority issues. Road infrastructure related issues has been the second highest priority issue for most of the four year review period. Specific responses regarding road infrastructure indicate the poor state road infrastructure (i.e. potholes); lack of maintenance and insufficient road infrastructure (i.e. require more roads, traffic lights not working).

At a provincial level, the combined data indicated that public transport is the major transport issue for all provinces. Road infrastructure is the second highest priority for most of the provinces. This is illustrated in Figure 3. The provinces that indicated relatively higher than average concerns regarding road infrastructure are: Limpopo, North West, Free State and the Eastern Cape.

Noticeably, the results further indicate that road infrastructure issues are less of a concern for respondents from urban areas than rural areas. This can largely be ascribed to road building and maintenance programmes being directed on high volume traffic areas in metropolitan areas and cities. Road infrastructure priorities (e.g. fixing potholes) are also more of an issue to older than for younger respondents.

Since 2013, a number of specific transport issues were surveyed to gauge whether respondents believed the services or issues were generally good or poor. As the purpose of this enquiry was only to establish the respondents' general impressions of specific issues, no specific service characteristics were explicitly tested. These are illustrated in Figure 4.

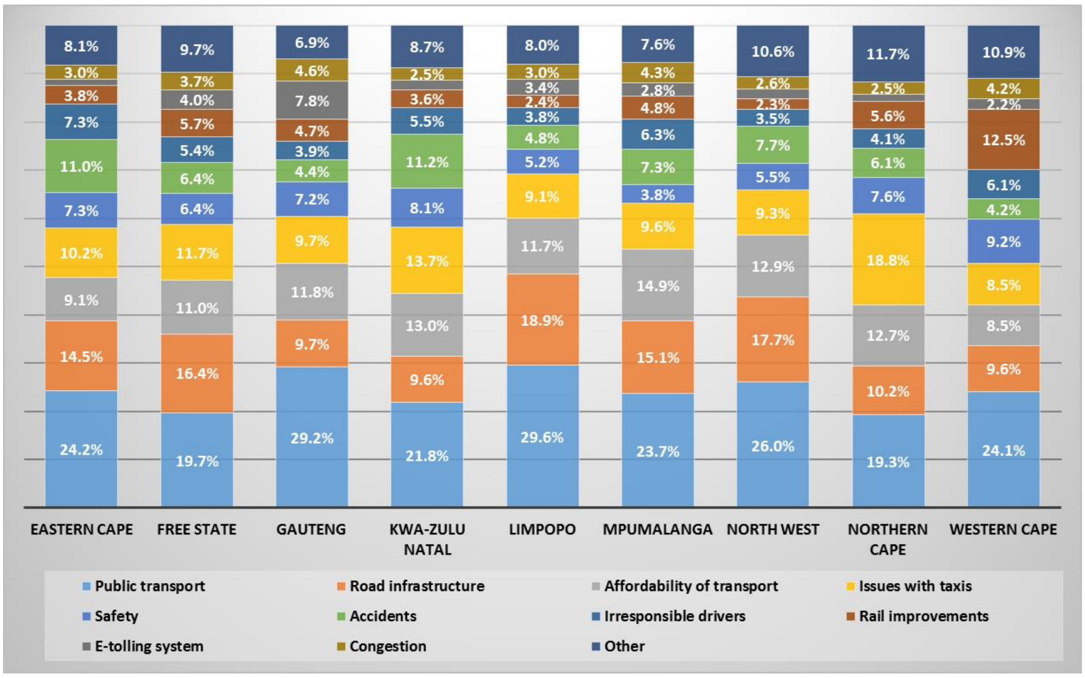

Figure 3: Highest transport issues per province

Transport issue	2013	2014	2015	Very Poor 0-30	Indifferent 40-60	Excellent 70-100
Bus Rapid Transit	58.6	57.9	62.0	17%	30%	53%
Bus services	56.2	55.9	58.1	19%	36%	45%
Minibus taxis	57.9	54.8	55.3	25%	35%	40%
Condition of roads	50.2	50.1	52.2	27%	38%	35%
Passenger rail services	50.2	49.2	49.3	29%	40%	31%
Road congestion	50.9	49.8	48.5	32%	41%	28%

Figure 4: Rating of specific transport issues

Respondents indicated that the significant infrastructure investments in BRT services in many of the metropolitan areas have generally been positively received, with 69% of Western Cape residents and 68% of Gauteng residents rating their respective BRT systems as very good. On the contrary, attitudes towards road conditions, bus services and passenger rail services have worsened.

Generally, the respondents from Gauteng, KwaZulu Natal and the Western Cape are positive about of the quality of their roads, however respondents from all the other provinces indicated that the conditions of their road infrastructure is very poor and gave it their lowest or second lowest rating. Figure 5 below indicates the perceptions of the state of the various transport features per province from the 2015 results. Green and red shading is used to indicate the most positive or negative impression of the transport features within each province.

Transport Issue	Eastern Cape	Free State	Gauteng	Kwa-Zulu Natal	Limpopo	Mpumalanga	North West	Northern Cape	Western Cape
Condition of roads	45.8	37.2	58.3	58.3	44.5	53.7	47.0	38.5	56.7
Road congestion	51.9	41.7	44.2	54.6	56.1	56.4	43.5	47.2	37.2
Passenger rail services	56.4	55.2	49.6	54.3	45.0	58.1	47.8	50.4	34.2
Bus services	53.1	57.0	57.1	58.9	58.4	65.8	67.0	50.7	60.4
Bus Rapid Transit	55.6	56.1	67.9	56.9	56.1	66.5	55.0	55.1	69.0
Minibus taxis	59.9	45.4	53.9	58.2	59.3	64.8	70.0	47.5	42.7

Figure 5: State of various transport features by province

Respondents were also asked to indicate the current state of local transport. A noticeable decline in community confidence regarding local transport services and conditions is measured. In 2015 only 37% of South Africans were of the opinion that transport in their local area is better now than a year ago, contrary to the 42% in 2012. The respondents that suggested that transport in their local area was worse or slightly worse than a year ago, gave a broad range of reasons for this, as depicted in Figure 6 below.

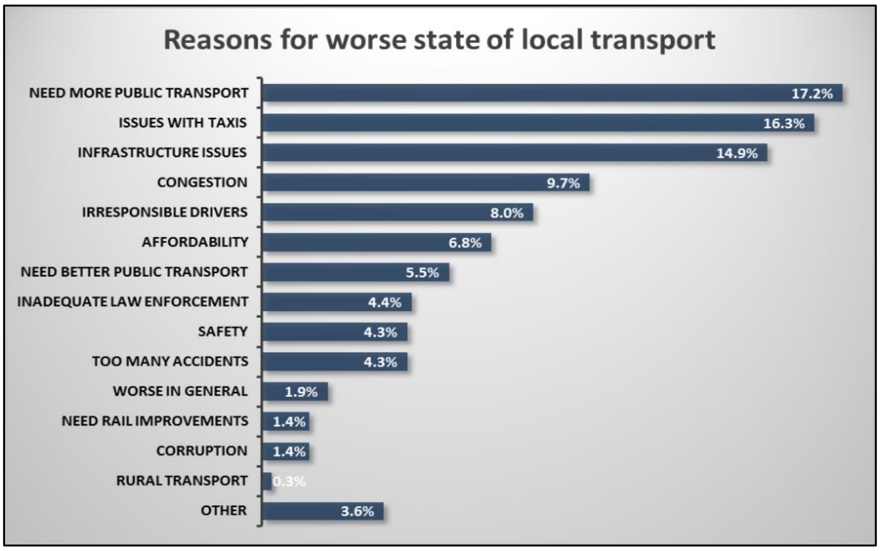

Figure 6: Reasons given for the worsening state of transport

Respondents mostly mentioned reasons related to a lack of adequate of public transport, concerns with taxis (both as road users and as public transport service providers), infrastructure issues (notably potholes), congestion (both insufficient supply of road space and the excessive demand during peak periods), irresponsible drivers and high transport costs.

When questioned on the broad outlook on transport over the next five years, the majority (53.1%) of the 2015 respondents revealed that they are of the opinion that transport prospects would be worse or they were indifferent. This is contradictory to the 2012 results which showed that the majority (67.1%) of respondents believed that transport would be much better in five years' time. It seems that the respondents' outlooks on the general state of local transport has remained mostly unchanged over the review period, however South Africans seemed to be far less enthusiastic on the state of national transport.

4. Conclusion

The aim of the ITLS (Africa) State of Transport Opinion Poll South Africa (TOPSA) is to gauge public opinion on a broad range of transport related issues in South Africa. The results from the last four TOPSA surveys have provided the basis for this assessment of public opinion on transport infrastructure and services and trends. In general, it if found that transport is found to be one of the most critical priority issues in the country and infrastructure in general also being one of the ten top priorities, indicating that transport infrastructure is not of an appropriate standard to meet the needs of South Africans, and needs to be prioritised in future investment and other government interventions. In as far as specific transport issues are concerned, the results indicate that transport infrastructure is almost consistently the second highest transport priority, indicating that South Africans consider this critical to the delivery of an appropriate transportation service. Typically, lack of appropriate infrastructure also has a knock-on effect on the other highlighted issues such as public transport, safety, accidents and affordability, as well as being directly associated with other highlighted issues such as rail improvements and e-tolling. It is thus evident that South Africans believe that transport infrastructure is not at the level aspired to in the policy documents. Some provinces also indicate higher levels of concerns than others, suggesting an inconsistent application of the policy aspirations. Of note is that, when government does invest in appropriate infrastructure such as the Bus Rapid Transit system, it is very positively received by respondents. The general dissatisfaction with other infrastructure such as taxi facilities, roads, buses and rail suggests that the levels of investment are insufficient to meet the policy promises and the quality of the available infrastructure therefore remains below the required standard. It is of interest that, for a large percentage of respondents, the deterioration of transport services and the quality of transport in the country is largely attributable to infrastructure issues. The results reflect that respondents believe that inadequate levels of investment in transport infrastructure has had a direct impact on safety, affordability and choice. Resultantly, mobility, accessibility, inclusivity and therefore socio-economic development are negatively impacted. The results show that, until such time as investment in transport infrastructure reaches appropriate levels, the system will be unable to meet a core aim of the various policy documents, i.e. being responsive to people's needs. Environmental sustainability is also unachievable without investment in transport infrastructure, thereby suggesting that key requirements such as the reduction of congestion cannot be achieved. For government to achieve its minimum transport policy objectives, it is imperative that transport investment be increased and aimed at reducing the mobility and accessibility constraints currently inherent to the system. It is suggested that further research be aimed at expanding the current annual survey figures of 1000 to ensure that views are truly representative of the general population, and that the survey be expanded to determine the specific infrastructure investment interventions that are most likely to enhance mobility and accessibility and meet the requirements of enhancing socio-economic development in the country.

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DII-2017-059

Environmental Influences on Sustainability Dimensions in the South African Construction Industry

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Abstract

The construction industry contributes significantly to the economic growth of developing countries including South Africa. The industry adds value to the quality of life of its citizen through the provision of necessary infrastructures. Notwithstanding its importance and contributions, the industry has been recognised as one of the largest environmental polluters. Its activities have significant impact on the quality of life of people and the environment. As such, sustainable development was recognised as prominent element for the improvement of quality of life through the maximisation and efficient use of natural resources to address issue related to social, economic and environment. Thus, this paper investigates the environmental sustainability dimensions that can influence the promotion of sustainable construction ideas in the South African construction industry. The participants were selected through non-probability convenience sampling techniques. Data were collected through the use of questionnaire design. The targeted respondents were construction professionals in the Gauteng Province of South Africa. A total number of 111 questionnaires were obtained and frequency analysis of the raw data were carried out using the Statistical Package for Social Sciences (SPSS). Mean values was obtained for each of the identified variables and the level at which each factor promotes the idea of sustainability in the SA construction industry was determined. The study reveals seven environmental dimensions that can promotes sustainable ideas in SA construction industry. These factors include reduction in potential environmental pollution, efficient use of water during construction (such as designing project for efficient water use and eliminating water wastage), encouraging the use of renewable building materials, lower energy use, increase in value management practitioners, encourages construction waste management and increased costs associated with disposal of waste. It is very important that various construction stakeholders have good knowledge and adequate awareness of these environment factors. This will not only reveal the benefits associated with sustainable construction practices, but encourage greater procurement of sustainable building and infrastructures.

Keywords: construction industry, environmental factors, sustainability, South Africa

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1. Introduction

Sustainable development has become important subject worldwide. As a result, the concept is receiving an increasing attention in different facet of human activities including construction (Ugwu and Haupt, 2007; Okoye and Okolie, 2013; Saleh and Alalouch, 2015; Elmualim and Alp, 2016). Notwithstanding, the increased attention and importance placed on sustainable development globally, the implementation of its concept remains a challenge in South Africa (Emuze et al., 2015). Over the last few decades, there has been a significant increase in the global environmental awareness (Elmualim and Alp, 2016). The global environmental awareness arises from the emergennce of environmental problems including climate change, water problem, global warming, energy problem, habitats loss, deforestation, degradation, pollution, ozone layer depletion among others. These problems have resulted in the global call for radical shift towards environmental responsiveness (Emuze et al., 2015; Asif, 2016). In order to alleviate the impact of these environmental problems, sustainability was identified as an important concept which should be incorporated in all human activities (Sourani and Sohail, 2005; Asif, 2016).

In line with this call, several countries around the globe have long embraced the concept of sustainability. For instance, the United Kingdom (UK) construction industry promoted the understanding and awareness of sustainable construction. They had strategies in place which support more sustainable development especially sustainable construction (ICE, 2015). In addition, the construction industry is expected to play a very significant role in the mitigation of environmental problems. This is because the building and construction sector accounts for more than 40% of energy and material consumption and also generates a huge amount of waste from its activities (Elmualim and Alp, 2016; Oke et al., 2017). In fact, the built environment industry is found to be mostly responsible for the environmental pollution (OECD, 2013). Unfortunately, the form of construction development in the past ignored the reality of natural resources and environmental issues (Emuze et al., 2015). This neglect results in a lot of consequences inform of environmental degradation, economic downturn, pollution etc and these consequences have significant impact on the environment and the quality of life of people. All these points attention to the urgency of environmental sustainability interventions.

While there have been remarkable advances towards the achievement of sustainable development in South Africa, the reality is that there is still much to be attained (Department of Environmental Affairs and Tourism, 2008). In addition, the implementation of sustainable construction still faces a lot of challenges in South Africa (Emuze et al., 2015). Thus, in line with the urgent need to promote the concepts and implementation of sustainability in South Africa, this study investigates the environmental sustainability dimensions that can influence the promotion of sustainable construction ideas in the South African construction industry.

2. Environmental Challenges and Need for Environmental Sustainability Dimensions in South Africa

Globally, the construction industry carries out a vast number of construction activities yearly. The industry uses a lot of natural resources including energy, raw materials, land and water in the operation of its activities (Elmualim and Alp, 2016). The industry similarly consumes a huge volume of natural and non-renewable resources which engender wastes that are potentially hazardous and cause environmental pollution (Asif, 2016; Nwokoro and Onukwube, 2011). Thus, the construction industry has been unarguably recognised as the largest pollutants, most hazardous industry and destroyer of natural environment (Okoye, Okolie, 2013; Wallbaum and Buerkin, 2003; Wooley, 2000). Literature reveals, that both the building and the construction sector contribute significantly to global warming which happen to be one of the major challenges facing the entire world today (Asif, 2016). Moreover, there are carbon emissions from the construction activities. This carbon emission further added to the rapidly increasing global warming and weather variations (Kolev, 2009). All these pose serious threats to the global ecosystem and also it also has serious impacts on human life, the environment and socio-economic development (Oke et al., 2017; Muneer et al., 2008). These negative impacts have become an issue of serious challenge to the global environment. Unfortunately, the traditional procurement practices are observed to be deficient in providing the needed solution to these serious challenges. As a result, several researchers have stressed the need for grave attention being given to resources consumption through radical shift in human practices (Asif, 2016). Thus, the call for sustainable development in construction has been loud and clear worldwide (Hussin et al., 2013). Ofori (2007) emphasised the need for the global construction sector to be familiar with sustainable development and transforming its traditional structures into modern sustainable construction. For this to be achieved, there is need to first identify the prevailing situation within a particular community and best approach to providing a sustainable building environment. At the 2002 World Summit on Sustainable Development (WSSD), it was agreed that the greatest challenge facing South Africa was dealing with poverty. As such, social equity, intergenerational equity, efficient use of resources, human welfare and sustainable living were the core of the implementation plan during the summit. In order to promote the sustainability thinking in South Africa, this study investigates the environmental factors that can promote the sustainability ideas in the South African construction industry.

3. Environmental Sustainability Elements

According to Yilmaz and Bakis (2015), environmental sustainability signifies handling of natural resources to future generation without destruction. It involves protecting ecological balance and saving in consumption of unrenewable resources. For this to be achieved, some researchers have emphasised the need to start utilising sustainable building practices on construction projects procurement (Koranteng, 2010; Asif, 2016). Ashiboe-Mensah *et al*. (2011) as well as Koranteng (2010) point out the need for the adoption of energy efficiency and sustainable materials. In line with these, Yilmaz and Bakis (2015) likewise noted that environmental sustainability requires sensitivity and should focus on subjects which include: (i) protection of aliveness and diversity on the earth; (ii) conservation of live-support system; (iii) sustainable usage of renewable resources; (iv) being saving in using unrenewable resources; (v) minimising harm to the environment and living things; and (vi) protection of cultural and historical environment. The importance of environmental sustainability cannot be over emphasised as such, several tools to promote sustainable building practice, in the area of design and construction, have been developed throughout the world. In South Africa, government has made effort to establish policy in support of environmental sustainability. A notable one is the establishment of SANS 204 which sets out the general requirements for achieving energy efficiency in all types of new buildings, both for naturally ventilated buildings and for artificially ventilated buildings. Several researchers have examined different elements\dimensions which environmental sustainability should cover. Sourani and Sohail (2005) provided an extensive review of the criteria underpinning the environmental dimensions of sustainable construction through a synthesis of the relevant literature. According to them, environmental sustainability cut across different dimensions including: energy, water, land and material conservation; resource utilisation; minimisation of water, land and air pollution; encouraging renewable energy; preserving and enhancing bio-diversity; creating a healthy, non-toxic environment – including high indoor air quality; protecting and enhancing sensitive landscapes including scenic, cultural, historical and architectural, re- use existing built assets; waste minimisation and management; environmental impact; visual impact and transport – including provision of public transport. In order to give the world to future generation without destruction, adequate attention needed to be given to all these environmental elements. It is on this basis that this study focus on investigating the environmental sustainability dimensions that can actually influence the promotion of sustainable construction ideas in SA.

4. Research Methodology

This study employed a quantitative research method. The research was conducted in the Gauteng Province of South Africa (SA). The Gauteng province was selected because it is widely recognised for its dynamic economic and social circumstances. For example, it is the only province which contributes (34%) more than one third of total Gross Domestic Product (GDP) of South Africa in 2014. Thus, the province has long been recognised as the fastest growing and richest province of SA (The Real Economic Bulletin, 2016). The targeted respondents were the construction professionals within the Gauteng province and they were selected through convenience sampling techniques. These respondents as shown in Table 1 are construction professionals including quantity surveyors, construction/project managers, architects and engineers that are usually involved in construction projects within Gauteng province. Table 1 indicates the demographic analysis of the respondents. The analysis revealed that the respondents have considerable experience within the construction industry and are involved at both private and public construction sectors. They also worked in consulting firms, contracting firms as well as in government establishment. Within the past three years, 39.6% of the respondents were involved in 1-4 projects, 22.5% were involved in 5-6 projects, while 17.1% were involved in 7-8 projects and 20.7% were involved in more than 8 projects. The objectives of this study were achieved using questionnaire survey which attracted one hundred and eleven (111) responses. A thorough review of the relevant literature was carried out to identify the environmental factors that have great potential of influencing the sustainability ideas in the construction industry. A total of seven factors were highlighted and documented in Tables 2. These factors were presented in questionnaire form which attracted (111) one hundred and eleven responses. There are two main parts within the questionnaires. The first part was the introductory section while the second section deals with the ranking of the identified environmental factors. The professionals were requested to rank their perception of the factors on a 5 point Likert scale comprising effect level of strongly disagree =1, disagree = 2, neutral = 3, agree = 4 and strongly agree 5. The mean score (MS) for each variable was established and ranked from highest to the lowest as shown in Table 2. An hypothesised mean of 3.0 was used as relevant level determinant as used in some earlier studies (Coakes and Steed, 2001). This was determined by adopting the mid-point value of the index (1+2+3+4+5/5=3). This implies that all scores above 3 are significant while scores below 3 are insignificant Thus, a factor is considered relevant if it has a mean item score of 3.0 or more.

Table 4: Demographic data of the respondent

	Frequency	Percentage %
Profession of the respondents		
Engineers	24	21.60
Quantity surveyors	29	26.10
Construction/project managers	36	32.40
Architects	22	19.90
Working experiences		
1-5 years	30	27.10
6-15 years	45	40.50
Above 16 years	36	32,40
Construction Industry Sector		
Private	23	19.82
Public	14	11.71
Consultants	34	29.79
Contractors	24	21.62
Government	19	17.12

5. Results and Discussion

Sustainability is a multi-dimensional concept (Sourani and Sohail, 2005). Due to its complex nature it has been viewed in different dimensions as revealed under the literature review section (Sourani and Sohail, 2005; Nwokoro and Onulwube, 2011). This paper as aforementioned mainly focused on the environmental dimension. Seven environmental dimensional factors that can influence the promotion of sustainable construction thinking in the South Africa construction Industry were extracted from literature as depicted in Table 2. Based on factors identified from the review of literature, the respondents were asked to rank these potential environmental sustainability dimension factors. The mean item score technique was adopted in this study. The ratings given by each of the respondents were calculated to arrive at a mean score for each of the listed factors. The mean scores were ranked from highest to the lowest and was used to determine whether the respondents considered a particular factor to be potential sustainability influencing factor or otherwise. In order to provide a clearer picture of the respondents' perceptions, the mean ranking of each factor is also shown in tabular form in Tables 2.

Table 2: Environmental dimension impacting sustainable construction practices in construction project execution

ENVIRONMENTAL DIMENSIONS	MIS	SD	RANK
Reduction of potential pollution	4.24	0.834	1
Efficient use of water during construction	4.23	0.774	2
Encouraging the use of renewable building materials	4.23	0.735	2
Lower energy use	4.22	0.756	3
Increase in value management practitioners	4.20	0.724	4
Encourages construction waste management	4.18	0.777	5
Increased costs associated with disposal	4.12	0.806	6

From findings as shown in Table 2, all the identified factors have great potential to influence the sustainability ideas in SA as all the factors have mean score above the hypothesised mean score of 3.0.

Based on the ranking, reduction of potential pollution with a mean score (MS) of 4.24, efficient use the use of water during construction with a mean score of 4.23 and encouraging the use of renewable building materials with a mean score of 4.23 ranked the three most important environmental factors that can promote the sustainability idea in South Africa. This finding is very interesting and it is agreement with some previous work on sustainability environmental dimensions. For instance, the construction industry is considered the major user of natural resources (Oke et al., 2017). Its activities have significant consequences on the environment. These consequences come in the form of environment degradation, air and environmental pollution, energy problem, habitats loss, deforestation, ozone layer depletion just to name a few. Regrettably, the traditional procurement practices are noted to be deficient in providing the needed solution to these environmental challenges (Asif, 2016). Moreover, most people are not serious about environmental protection on construction site (Chan, 2000). Thus, several of the construction activities result in serious air pollution. As such the industry becomes the main source of an urban air pollutants (Chan, 2000). Recognising, the fact that sustainable development can enhance better environment and lead to reduction in the environmental pollutions is actually capable of promoting sustainable construction ideas within SA. Hussin et al. (2013) noted that developing a new building involve quarrying to provide aggregates, extensive use of water in the production process and the wide use of toxic and chemical materials. All these accumulate and disrupt our environment, thus it is very important to reduce material intensive through the substitution technology and this is main purpose of environmental sustainability. Examining further into the findings in this study, maximizing the sustainable use of renewable resources was found to be of great import because it will lead to material efficiency. Material efficiency could be achieved by reducing the material demand for non-renewable goods and embracing the principles of 3R which are reduce, reuse and recycle. Other factors which are considered important to promote sustainability dimension in SA include lower energy use, increase in value management practitioners, encourages construction waste management, and increased costs associated with disposal. Emuze et al. (2015) has noted that the initial cost of procurement associated with sustainable construction is a significant barrier to its implementation in South Africa. Notwithstanding, the knowledge that the sustainable construction has a lot of benefits including, reduction in the cost of waste management and also the reduction in the increased cost which is associated with waste disposal can make some construction stakeholders to rethink and embrace sustainable construction.

It is essential to recognise that, although the order in which the seven identified environmental dimension factors are evaluated by the respondents indicate priorities on the level at which they promote sustainable ideas, the mean score of each of the factors shows that all the identified factors are significant. This is because all the identified factors have very high mean scores and the mean scores are close to each other. This implies that environmental dimensions that can influence and promote sustainability ideas in the SA construction industry is a combination of all these identified factors. Thus, all the seven environmental factors identified in this paper are perceived by the professionals to be very important in promoting sustainable construction in South Africa. It is necessary to note that for any country to implement sustainable construction successfully, awareness creation is very important. This awareness must be thorough and adequate. The importance and benefits of sustainable construction must be made known to all construction stakeholders as well as the general public. The concept must be clearly stated and adequate explanation should be provided for proper understanding by the public. Thus, interactions with all the construction industry professionals to discuss the need to adopt more sustainable approaches within the industry practices need to be stressed. Taking into consideration all the key sustainability dimensions that influence the promotion of sustainable construction thinking and how it affects quality of lives of people and environment. Professionals should be made aware of consequences of continuing in the traditional way of procurement and how not practicing sustainable construction could affect the national and economic development of a country.

6. Conclusion

The concept of sustainable development has become vitally important subject worldwide and is gaining wider attention in the built environment. Notwithstanding, the implementation and application of its concept is still a challenge in South Africa. Thus, this paper investigated the important environmental factors that can influence the promotion of sustainable construction ideas in the South African construction industry. Seven factors were identified from the literature and were investigated. From the obtained results, all the identified factors were found to be important. These factors include, reduction of potential pollution, efficient use of water during construction, encouraging the use of renewable building materials, lower energy use, increase in value management practitioners, encourages construction waste management, and increased costs associated with disposal. It is very important that various construction stakeholders have good knowledge and adequate awareness of these environment factors. This will not only reveal the benefits associated with sustainable construction practices, but encourage greater procurement of sustainable building and infrastructures. Thus, there is need for the construction industry, policy makers and all other relevant stakeholders to take note of all the identified environment factors that can impact sustainability ideas and embrace them in order to advance the concept of sustainability and sustainable development in SA.

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DII-2017-058

Towards Optimising the use of Quarry Dust in Concrete Production in Zambia

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Abstract

Over the years, the construction industry in Zambia has been rapidly growing and this has resulted in shortages of some construction materials. One such material is River Sand, which is used as a fine aggregate in concrete production. This has resulted increased use of quarry dust as a substitute to river sand, as a fine aggregate. However, no guidelines exist on the replacement of River Sand in concrete production. There is a clear depletion of river sand sources and degrading of river banks. This in turn has led to river bank erosion, triggering environmental problems such deepening of the river beds, loss of vegetation on the river banks, disturbance of aquatic life and agricultural activities, as well as posing a danger to river crossing infrastructure such as culverts and bridges. Two studies were conducted at the University of Zambia: a*Comparative Study of Concretes Produced by Natural Fine Aggregate and Quarry Dust*, and, *Partial Substitution of Quarry Dust as a Fine Aggregate in Concrete Production in Zambia*. The first study aimed at making recommendations on the full replacement of river sand with quarry dust in concrete production whilst the second focused at determining suitable partial substitution of quarry dust in the production of concrete. It was established that Quarry Dust offered some advantages such as; better gradation and higher rate of compressive strength gain compared with river sand. This can offer advantages like speeding up repair and maintenance works. Further, from the second study, a 50% substitution of river sand in the fine aggregate produced the best results.

Keywords: compressive strength, concrete, quarry dust, river sand

1. Introduction

Concrete is made up of three basic components; water, aggregate (fine aggregate or sand, crushed rock, or gravel) and Portland cement. Cement, usually in powder form, acts as a binding agent when mixed with water and aggregates. A chemical reaction known as hydration follows and the concrete hardening process continues over a long period of time. However, most of the hardening takes places over 28 days. The properties of both the wet and dry concrete depend on a number of factors: properties of constituent materials, mixing proportions and consistency of mixing, curing conditions, and testing methods and procedures. Additives may be added to wet concrete in order to impart certain properties. River sand, mostly obtained from river banks, has traditionally been used as fine aggregate in Zambia. Since river sand is subjected to years of abrasion and washing, its particle shape is more or less rounded and smooth. It tends to have a low silt and clay contents thus improving concrete properties such as workability while reducing the water demand during the mixing process to produce concrete (Richardson 2005). With increasing cement concrete construction activities, Zambia has been experiencing an increased

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use quarry dust rather than of river sand as fine aggregate. The traditional use of river sand has led to the depletion of river sand sources and degrading of river banks. This in turn leads to river bank erosion, triggering environmental problems like deepening of the river beds, loss of vegetation on the river banks, disturbance to the aquatic life as well as agriculture due to lowering the water table in the well and others. As noted by Muhammad et al. (2011), physical impacts of sand mining include reduction of water quality and destabilization of the stream bed and banks, disruption of sediment supply and channel form (incision and sedimentation). Channel instability and sedimentation can lead to damage to public infrastructure such as bridges, pipelines, and other utility lines. Biological impacts may lead to removal of infauna, epifauna, and some benthic fishes and alteration of the available substrate.

Balamurugan and Perumai (2013), in their research, have also recognised the need for developing countries to conduct extensive search to identify alternative materials to replace the demand for river sand. Therefore, many construction industries of developing countries have identified Quarry dust as a suitable substitute for fine aggregate in concrete production, hence the need to optimise its use in concrete production. Quarry dust is a by-product of stone crushing units. In terms of grading, it is generally material passing the 4.00 to 4.75mm sieves. Although in some cases it may be considered a waste product, it is actually a resource in the production of concrete. Quarry dust has been used for different activities in the construction industry such as road construction and manufacture of building materials such as light weight aggregates, bricks, pavours, and tiles. Lohani et al. (2012) have indicated that crushed rock aggregates are more suitable for production of high strength concrete compared to natural gravel and sand.

In Zambia, there has been an increase in the use of quarry dust in concrete production, but limited research on the optimisation of the use quarry dust, to help in establishing guidelines on the use of quarry dust in concrete. Due to this lack of guidance on the use of quarry dust, two studies were conducted at the University of Zambia on the substitution of river sand with quarry dust as the fine aggregate in concrete. The first study was aimed at making recommendations on the full replacement of river sand with quarry dust in concrete production (Silungwe, 2015). The second was aimed at determining suitable partial substitution of quarry dust in the production of concrete (Hamaundu, 2016). Silungwe's (2015) and Hamaundu's (2016) studies were conducted in Lusaka, where most concrete construction activities take place. In Lusaka, there are several quarries established to produce aggregates for various applications and quarry dust is produced as a by- product. The production at these quarries is all year round. On the other hand, the main source of River Sand is Kafue, located about 60 km south of Lusaka. River sand mining is centred on the Kafue River and the supply of river sand gets constrained especially during the rainy season. This is due to the transportation challenges by trucks as trucks get stuck in accessing the Kafue River bank. Although the study was conducted in Lusaka, similar situations are being experienced in most industrial cities of Zambia.

2. Literature Review

2.1 Research around the world

Production of massive quantities quarry dust is worldwide. According to Patel and Shah (2015), about 20 to 25 per cent of the total production in each crusher unit is left out as the waste material-quarry waste. The quarry waste is in form of powder, of size below than 90 micron. In India, annual production of quarry waste is 20 Million Tonnes (Patel and Shah, 2015). Tables 1 and 2, respectively, summarise typical physical and chemical properties of quarry dust.

Table 1: Physical properties of quarry waste

Property	Value
Specific Gravity	2.54
Bulk Density	1735 kg/m^3
Water absorption	1.2 %
Moisture Content	0.0 %
Fineness Modulus (FM) and Zone	2.5, Zone 2

Source: Patel and Shah (2015)

Table 2: Chemical properties of quarry waste

Property	Percentage (%)
Silica	62.80
Aluminium Dioxide	18.72
Ferric Oxide	6.54
Magnesium Dioxide	2.56
Calcium Dioxide	4.83
Sodium Oxide	0.00
Pottasium Oxide	3.18

Source: Patel and Shah (2015)

2.2 Summary of literature review

Extensive research on partial substitution of river sand with quarry dust has been conducted, especially in India. The research indicated gain in concrete compressive flexural, split tensile strengths with increased quarry dist content, to a maximum of 50%. Beyond 50%, reductions in strength and workability have been recorded. It has been demonstrated that the use of quarry dust brings about desirable effects, in terms economic and environmental issues. However, maximising on the desirable properties requires specific in depth research on the particular quarry dust. In Zambia limited studies have been conducted establish some of the properties of quarry dust and to determine how suitable they are to enable it to be used as partial replacement for sand in concrete production. Standards and guidelines on the use of quarry dust have not yet been developed. Tables 3a and 3b summarise selected literature review of research on replacement of river sand in concrete production, India and elsewhere.

3. Experimental Work in Zambia

3.1 Full substitution of fine aggregate with quarry dust

This study made comparisons on the properties of concretes produced by natural fine aggregates and quarry dust in C20 and C25 grade concretes. Various tests on the constituent materials were conducted and they included: Aggregate Crushing Value (ACV), fineness modulus, organic content, sieve analysis, specific gravity, water content, and water absorption. The concrete mixes were designed and produced in the laboratory. The fresh and hardened concrete was tested for workability and compressive strength, respectively.

It was found that the full replacement of river sand with quarry dust gave slightly better results. The study concluded that if full replacement of river sand with quarry dust for C25 and C20 grade concretes was done, the produced concrete had better workability, strength and rate of strength gain at various ages of curing. It also showed a better correlation between compressive strength and density. However, further studies on natural fine aggregate substitution with quarry dust for various concrete grades is required.

Table 3: Summary of research findings on replacement of sand by quarry dust

Author and Country	Percentage replacement	Major findings
G Balamurgan and P Perumal (2013), India	10, 20, 30 and 100%	At 20% and 30% replacement, the 28 day compressive strength increases were 8.01 and 13.99%, respectively. When tested at 100ºC after 28 days, at 10, 20 and 30%, the corresponding increases in compressive strength were 0.53%, 3.61 % at and 4.18%, respectively.
Ashish B. Ghogare and P. P. Saklecha (2015), India	0%-50%	Quarry dust at 25% replacement increased compressive strength but beyond 35% strength and workability decreased. 10% substitution resulted in increased compressive, flexural strength and durability
Maina Simon Karanja (2010), Kenya	25, 50, 75 and 100%	Compressive strength gain for quarry dust replacement up to about 25% Beyond 25% to 100% replacement, strength decrease at both for 7 and 28 days. At 75% replacement, compressive strength ≈ 0% replacement
Manguriu, G.N et al (2013), Kenya	20, 40, 60, 80 and 100% on C20 Concrete	Natural sand (RS) replacement of 20, 40, 60, 80 and 100 % resulted in compressive strength gain of 4.89, 0.0, -9.33, -15.11 and -37.33%, respectively. Best results at 20 % replacement.
Aginam C. H. et al (2016), India	0-25%	Quarry dust up to 25% for one brand cement and up to 15% for another brand, resulted in increased compressive strengths.
Rajapaksha and H P Sooriyaarachchi (2009), Sri lanka	10-30%	Replacement of 10-30% with quarry dust consistently increased compressive strength, but lowered the workability of the mixes.
Martins Pilegis, (2014), UK	Plasticised and non-plasticised concrete mixes	MFA gradings containing 5-7 % fines optimal for handling, placing and finishing of MFA concrete, in the abscence of clay particles. Adequate concrete could be produced with 100% MFA as sole fine aggregate
R. Ilangovana, N. Mahendrana and K. Nagamanib (2008), India	100% for M20, M30 and M40	Increases in the 28day compressive strength of 11.26%, 11.36% and 3.63%, respectively.
Mohammad Iqbal Malik et al (2015)	0-40%	Increase in 28day compressive strength, decrease in workability. Optimal strength at 30%.
Ephraim M. E.1 and Rowland-Lato E. O. (2015), Nigeria	20% on Concrete Grades 20, 30 and 40	With 20% sand replacement, 28d, compressive strength increased by 10 to 12
Lalit Kumar and Arvinder Singh (2015)	25, 50, 75 and 100% substitution on M25 and M30 Concrete.	Gain in compressive, flexural and slit cylinder strength. For 25 and 50%, gain in compressive strength of 8 to 10%.

3.2 Partial substitution of fine aggregate with quarry dust

This was a follow up study to the previous cited study. Various substitutions of river sand and concrete grades were explored. Tables 4 to 8 summarise aggregate properties and concrete mixes.

Table 4: Fine Aggregates Sources

Material Type	Source
River sand	Kafue
Quarry dust	Lions quarries
Quarry dust	United quarries
Quarry dust	Oriental quarries

Table 5: Cement and Coarse Aggregate Sources

Material Type	Source
Cement (Mphavu)	Lafarge
Coarse aggregate	United quarries

Table 6: Physical properties of coarse and fine aggregates

Material	Specific Gravity	Fineness Modulus	Moisture Content (%)	Water Absorption (%)
Lions quarry dust	2.62	2.85	0.5	1.2
Oriental quarry dust	2.65	2.79	0.54	1.3
United quarry dust	2.64	3.24	0.56	1.3
River sand	2.66	3.11	0.61	1.4
United Quarries (Coarse aggregate)	2.41	-	0.45	0.8
Acceptable Limits	2.3-2.9 (ASTM C33)	2.3-3.1 (ASTM C33)	-	0.5-4.0 (ASTM C33)

Table 7: Organic Content of Aggregates

Sample	Average Volume titrated mg/l (or ppm)
Blank	20.8
River Sand	19.6
Quarry Dust	21.35

Table 8: Concrete Mix ratios

Grade of concrete	Concrete mix ratio
M25	1: 2.4: 3.1: 0.65
M20	1:2.8:3.54:0.65
M15	1: 3.1: 4.1: 0.65

Figure 1 shows the grading characteristics for the fine aggregates, whilst Figures 2 to 4 show the variation of compressive strength with substitution of river sand for concrete grades 15, 20 and 25, respectively. Figure 5 shows the variation of workability with substitution of river sand for the various concrete grades.

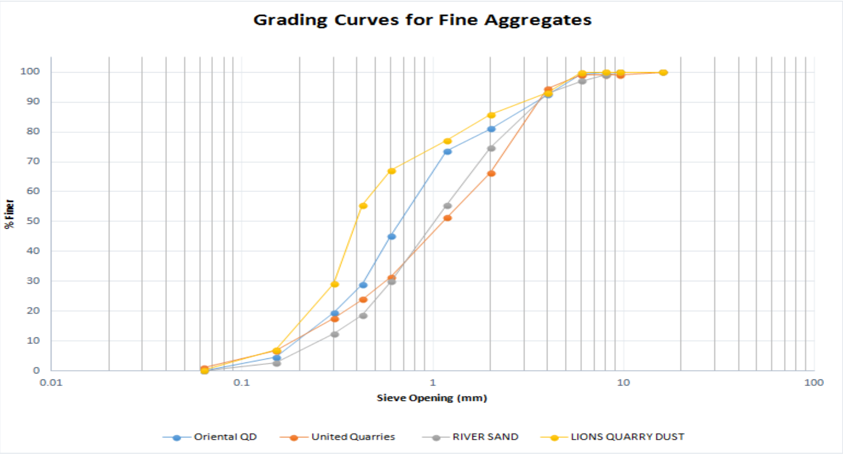

Figure 1: Particle size distribution of aggregates from various sources

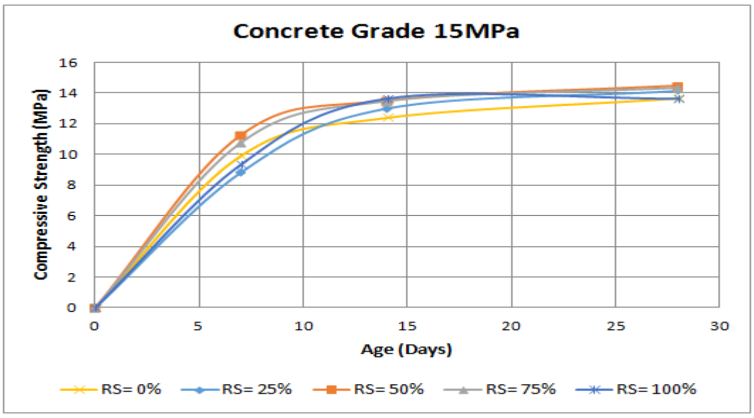

Figure 2: Grade 15 concrete strength with age percentage substitution

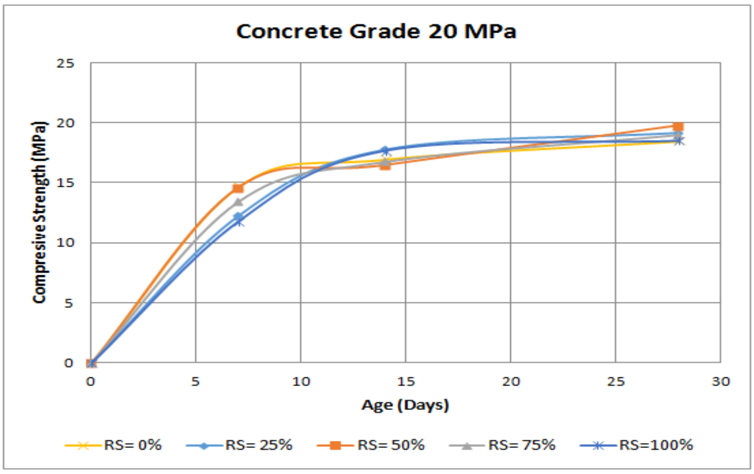

Figure 3: Grade 20 Concrete Strength with Age Percentage Substitution

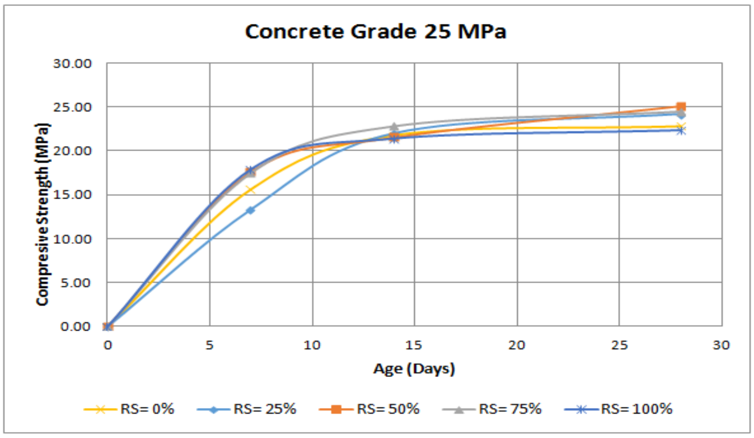

Figure 4: Grade 25 Concrete Strength with Age Percentage Substitution

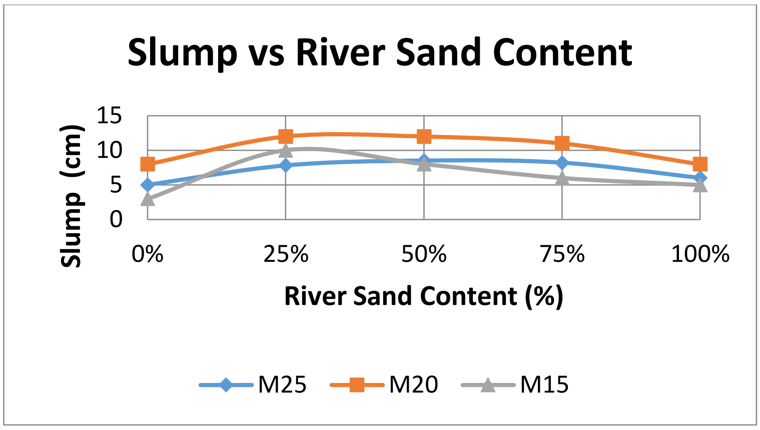

Figure 5: Variation of Slump with River Sand Substitution

4. Findings and Discussion

Specific gravities, fineness moduli, and water absorption of the aggregates were within the required range of 2.3 to 2.9, 2.3 to 3.1 and 0.5 to 4.0, respectively, according to ASTM C33. The ACV values of the coarse aggregates were found to be below 30% with acceptable elongation and flakiness requirements. The percentages of the organic contents were found to be below the maximum organic content requirement of 3% for fine aggregates. Similar limits may also be found in other comparable standards such as EN and ISO. Therefore, it could be concluded that the materials used for the research met the requirements for their use.

From the results of the compressive strength tests it was noticed that the samples that had 50% river sand and quarry dust content had the highest strength at 28days, with gain in strength of 7.2 to 10.8%. Similar results were obtained in terms of split cylinder test results. This is because at this river sand / quarry dust combination led to a well graded material or better packing in the concrete matrix.

In terms of workability, it may be observed that beyond 50% substitution of river sand, the workability (slump) decreased.

5. Conclusions and Recommendations

5.1 Conclusions

Extensive research on partial substitution of river sand with quarry dust has been conducted, especially in India, aimed at establishing gain in concrete compressive flexural, split tensile strengths with increased quarry dust content. Increased strengths have been established up to a maximum 50% substitution of river sand. Substitutions of the order of 35% gave the best results. Beyond 50%, reductions in strength and workability have been recorded. It has been demonstrated that the use of quarry dust brings about desirable effects, in terms economic and environmental issues.

In Zambia, limited studies have been conducted establish some of the properties of quarry dust and partial replacement for river sand in concrete production. A 50% substitution produced the best compressive strength gains, of 7.2 to 10.8% for concrete grades 15 to 25 MPa for quarry dust in Lusaka. Beyond 50% substitution, a reduction in workability was observed.

5.2 Main Recommendation on Partial substitution in Zambia

Based on the above study, a partial substitution of 35 to 50% of river sand may be used, to ensure gain in strength and reasonable workability.

5.3 Recommendation for future research

The previous studies were conducted in Lusaka and clearly there is need to extend the beyond Lusaka. The specific recommendations are:

- Research on partial substitutions should be extended to other regions of the country
- Professional Bodies should spearhead the preparation of standards and guidelines on the use Quarry dust in Zambia and in the sub-region.

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DII-2017-049

Waste Control and Management System in Polokwane Capricorn Municipality District of South Africa

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Abstract

The management of waste generated from the construction activities is a critical issue requiring serious and adequate attention. Construction waste constitutes nuisance to the construction environment and could lead to negative public impression of the construction industry as well as poor project performance, if not properly managed. Thus, this paper investigates the measures that can be taken for effective management of construction waste in the Polokwane municipality of South Africa. Data were collected using a questionnaire design. The targeted respondents were the contractors who are involve in various types of construction activities in Polokwane. Based on factors identified from the review of literature, the respondents were asked to rate the methods and measures that can be adopted for the effective control of construction waste in Polokwane. A total number of 44 questionnaires were obtained and were analysed using statistical package for the social sciences (SPSS). Mean value was used to determine the level of significant of each identified factor.The study revealed fifteen measures that could be put into consideration for effective waste management system in Polokwane. These measures include, on site management systems, implementation of environment management system, implementation of a waste reduction framework plan, standardization of design to improve buildability, reduction in quantity off-cuts, waste auditing to monitor and record environmental performance on-site, provision of an on-site sorting facilities, controlling land fill area, legislation control, stock control measures, quantities flexibilities measures, education and awareness measures, just-in-time delivery measures, penalty for poor site waste management and employment of specialist waste managers. The adoption of these measures would go a long way in enhancing efficient construction project performance in Polokwane District of South Africa.

Keywords: construction waste, waste control, waste management, Polokwane, South Africa

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1. Introduction

Waste generated during different stages of construction activities is one of the serious problems in construction industry at large (Nagapan et al., 2011). The construction waste constitutes nuisance to the construction environment and also lead to negative public impression of the construction industry (Adewuyi and Odesola, 2015). Moreover, poor planning and inadequate control of these construction waste lead to poor project outcome and poor project performance in the construction industry (Jayamathan and Rameezdeen, 2014). Thus, there has been serious concern about the volume of waste generated in the construction industry (McDonald and Smithers, 1998). One of the major problem of construction waste is the poor manner at which the waste generated from the construction activities are being handled. For instance, the report of Gauteng Department of Agriculture Conservation and Environment (GDACE, 2009) reveals that the majority of construction waste in Gauteng province of South Africa is being disposed of either illegally or to landfill. This action has a serious potential environmental impact on the country and all relevant stakeholders. Some notable consequences of illegal dumping and disposal to landfill include environmental degradation, poor public image of construction industry, increase demand for landfill, pollution, resources and material loss among others (GDACE, 2009). While it is true that, it is impossible to completely avoid construction waste, proper control and effective management of these waste are very necessary (Teo and Loosemore, 2001). It is on this background that this study investigates the measures that can be put in place for the effective waste management practice in Polokwane district of South Africa.

2. Construction Waste and its Impacts on the Environment

The construction industry plays an important role in the growth of any national economy and contributes meaningfully to the development of relevant stakeholders. Notwithstanding its importance, the industry has particularly been noted for its contribution to environmental degradation not only in South Africa but also in most other countries across the globe (Ali et al, 2014). The impact of the construction industry in terms of the resources it consumes and the waste it generates has been widely acknowledged (Tam, 2007, GDACE, 2009). Literature reveals that 50% of municipal solid waste in developing countries comes from construction (Lu and Yuan, 2011). In fact, more than 50% of waste entering land fill in the United Kingdom (UK) originates from construction (Ferguson et al., 1995). Similarly, research reports from Australia reveals that 44% of the total waste being deposited in landfilled annually is coming from the construction industry (McDonald, 1996; Craven et al., 1994) In South Africa, although there is limited published information on the composition and volume of construction waste generated at different provincial level, the observations have shown that construction and demolition sites generate substantial commingled wastes (Purnell, 2009, GDACE, 2009). For instance, the reports of the Department of Agriculture Conservation and Environment on the waste generated in the Gauteng Province of South Africa shows that 20% of waste generated within the province arise from building demolition and construction waste. The report further indicates *inter alia* that approximately one quarter (25%) of waste entering landfills are building and demolition waste. Unfortunately, based on an analysis of waste generation in nine South African provinces, there is an indication that waste generation continued to increase in all provinces over the last decade (SAEO) (South Africa Environment Outlook, 2012). The increase volume of construction waste generation has attracted considerable attention in the recent times (Lauritzen, 1998; Ali et al, 2014). The major concern lies on the fact that most of the waste generated from construction ends up in landfills or at times illegally dumped (GDACE, Gauteng Department of Agriculture Conservation and Environment, 2009). Thus the increase in the amount of waste generated and the lack of appropriate waste control and management system has become an issue of major concern in all countries including South Africa and Polokwane Municipality (Ikau et.al., 2016; Jawad and Omar, 2016, SAEO, 2012). The official country problem statement according to the National Waste Management Strategy (NWMS) (Department of Environmental Affairs 2012) has highlighted 10 major challenges faced by South Africa in the waste management field. According to this reports, the major challenges include, the increase in the population has resulted in increased volumes of waste generated, the increased complexity waste stream due to industrialization, Inadequate waste services lead to unpleasant unhealthy environment; policy and regulatory environment that does not actively promote the waste management hierarchy, growing pressure on outdated waste management infrastructure, with declining levels of capital investment and maintenance among others. The increase in construction activities usually leads to increase in the waste generated from construction. Thus, it is expected that all effort should be put in place for effective management of the waste produced. Several consequences accompany ineffective waste management system notably are the fact that it leads to environmental degradation, encourages further dumping which aesthetically degrade the landscape, increase pollution, reduction in the amount of natural resources and increase burden on scarce land resources GDEAC, 2009). Having realised that construction waste constitutes nuisance to the construction environment and could lead to negative public impression of the construction industry as well as poor project performance, the need for comprehensive strategies to reduce waste through more efficient planning and good management system becomes very necessary.

3. Strategies for Controlling Construction Waste

Strategies for controlling construction wastes have been the subject of several research projects. As identified from previous studies, most of the problems concerning waste on building are related to flaw in management system (Formoso et al., 1999). Thus there has been several calls for effective waste management. Waste management encompasses collection, transporting, storage, treatment, recovery and disposal of waste (Hwang, 2011). It involves waste minimisation and effective waste control strategies. According to Ferguson et al. (1995) there are three waste minimisation strategies that can be used on construction projects. These are, reduce, reuse and recycle. El-Haggar (2007) developed waste management hierarchy framework and noted that waste management plan involves five steps which are reduce, reuse, recycle, recover and disposal. The benefit associated with the adoption of this framework include cost saving, reduction in the demand for landfill, construction industry image improvement, productivity and quality improvement, and better resource management (Hwang, 2011). Poon et al., (2004) emphasised the need to adopt certain measures in order to reduce waste. He further noted the need to implement measures at the planning and construction stages in order to avoid and minimise waste generation. Such planning includes preparation of a detailed waste management plan as well as implementing waste control measures at the construction stage. According to him, this measures should include a good housekeeping and on-site sorting of inert from non-inert materials, which enable reuse and recycling. In addition to his findings, many other researchers have highlighted other measures needed to be in place for the effective waste management on construction sites. Some of these measures includes: legislative control, controlling public filling facilities, controlling landfill areas, providing on-site sorting facilities, implementation of an environmental management system, implementation of a waste reduction framework plan, standardization of design to improve ability and reduce the quality of off-cuts, stock control measures to avoid the over ordering of materials and just in time delivery strategy (McDonald and Smithers, 1998; Poon et al., 2001; Shen et al., 2002; WDO, 2006).

4. Research Methodology

This study employed a quantitative research approach. Data were collected using a questionnaire design. The questionnaire formulation begins with a review of related literature to identify possible measures that can be adopted for the effective control of construction waste. From the literature review, sixteen potential measures were identified and were presented in a questionnaire form for survey. The questionnaire design consists of two main sections. The first was the introductory section which was design to collect the background information of the respondents. The second section is the principal section which requested the respondents to appraise the significance level of each of the identified factors as possible measures that can be adopted for the effective management of construction waste. The respondents were to judge the significance on a predefined 5 point Likert scale (1=Strongly Disagree, 2=Disagree. 3=Neutral, 4=Agree and 5= Strongly Agree). Based on the ranking given to each of the factors by the respondents, MIS score was obtained for each of the identified factors and were ranked from highest to lowest. An hypothesised mean of 3.5 was used as relevant level determinant as used in some earlier studies (Ahadzie *et al.,* 2008). Thus, a factor is considered relevant if it has a mean item score of 3.5 or more.

Since the focus of this research is on management of waste generated from construction activities in the Polokwane municipality of SA, the sample for the study were randomly drawn from the construction professionals who are involve in various types of construction activities and their firms are duly registered in the Polokwane Capricorn Municipality District. The target respondents were contractors, builders, engineers, project managers and site agents who operates at the senior level in all categories of construction firms visited. These respondents were asked to rate the methods and measures that can be adopted for the effective control of construction waste in Polokwane. The research survey attracted 44 responses and they were analysed using SPSS. The analysis shows that respondents are involved at both private and public construction sectors of the industry. Further, the analysis shows that 29.5% of the respondents were site agents/foreman, 31.9.4% were project managers, 22.7% were engineers, and 15.9% were Construction Managers. The years of experience of the participants varies, 79.5% had experience that ranged from 1-5 years, 18.2% had experience in the range 6-10 years and 2.3% had experience that ranged between 11-15 years. The analysis further revealed that 52.3% had worked in 4-10 projects, 36.4% had worked in 11-15 projects, 6.8% had worked in 16-25 projects, 2.3% had worked in 1-3 projects and 2.3% had worked in more than 25 projects. This demographic information implies that the respondents have involved in a number of projects within the province and are suitable for this type of project which make the data reliable.

5. Results and Discussion

As aforementioned, the mean item score (MIS) was utilised in the analysis of respondents' perceptions of the relevance of each factor identified as measure that can be taking for effective waste control and management system. The MIS takes into account each factor's frequencies as being the perceived potential measure that can be employed for effective waste control in Polokwane. For the purpose of clarity and better presentation of the agreement reached by the respondents, the mean item score and ranking of each factor were tabulated. A summary of the analysis results is shown in Table 1. In addition, the mean item score for each factor, including the associated standard deviation, is also reported In Table 1. Consequently, based on the five-point Likert scale, a factor was deemed very significant if it has a mean item score of 3.5 and above. In the situation where two or more factors have the same mean item score, the factor with the lowest standard deviation was allotted the highest importance ranking.

From Table 1, it was revealed that on site management systems ranked first with a MIS of 4.59, implementation of an environment management system ranked second with a MIS of 4.55, implementation of a waste reduction framework plan ranked third with a MIS of 4.45 while standardization of design to improve build ability and reduce the quantity off-cuts, waste auditing to monitor and record environmental performance, provision of an on-site sorting facilities, controlling land fill area, design management to prevent over specification of material, legislation control, stock control measures, supply quantities flexibilities measures, use of contractual clauses to penalised waste poor management performance, dedicated specialist sub-contract package for on-site waste management, education and awareness measures, just-in-time delivery measures were ranked fourth, fifth, sixth, seventh eight, ninth, tenth, eleventh, twelfth, thirteenth, fourteenth, fifteenth, sixteen and seventh respectively. It is very important to note that the results of this study offer an interesting observation in that all the factors with exception of the last factor named 'Just in time delivery strategy' have a MIS that is higher than hypothesised mean of 3.5.

Table 5: Measures for controlling construction waste

MEASURES FOR CONTROLLING CONSTRUCTION WASTE	MIS	SD	RANK
On site management system	4.59	0.658	1
Implementation of an environment management system	4.55	0.791	2
Implementation of a waste reduction framework plan	4.45	0.730	3
Standardization of design to improve build ability and reduce the quantity of off-cuts	4.41	0.984	4
Waste auditing to monitor and record environmental performance on –site	4.36	0.892	5
Controlling landfill areas	4.34	0.963	6
Providing on-site sorting facilities	4.34	1.010	7
Design management to prevent the over specification of materials	4.30	0.904	8
Legislative control	4.23	0.937	9
Stock control measures to avoid the over ordering of materials	4.20	0.954	10
Supplier flexibility in providing smaller quantities of materials	4.05	0.872	11
Contractual clauses to penalize poor waste performance	3.98	0.876	12
Dedicated specialist sub-contract package for on-site waste management	3.75	0.967	13
Educate clients about the measures to reduce waste levels	3.68	1.196	14
Controlling public facilities	3.50	0.952	15
Just in-time delivery strategy	3.23	1.292	16

Consequently, a cursory evaluation of the order at which these factors are ranked may suggest priorities and level of relevance attributed to each of the factors by the professionals' as waste control measure. However, it is important to note that the fifteen factors are having very high MIS and the MIS are close to each other. This is an indication that there is possibly no discernable difference in the level of relevance attached to the identified potential measures. This implies that though the potential measure factors can be prioritized, all the fifteen factors are potential measures that can be adopted for effective control of waste on construction projects. A careful observation of the first three factors identified as the potential measure for waste control by the professionals shows that they can be grouped under source reduction measure. Source reduction has been advised and in most countries taken as highest priority (Ali *et al*., 2014). In the hierarchy of waste management, reduction of waste is to be considered first due to the fact that it provides economic benefits by reducing the costs associated with transportation and disposal (Tam, 2008; Wang et al, 2010). Thus, the management system of source reduction, reuse, recycling, and landfilling are very important (Wang et al, 2010).The waste management hierarchy put emphasis on reduction, reuse, recycle and disposal. It is therefore very important to educate all relevant construction stakeholders so that they can have adequate knowledge that can promote effective waste management within the construction industry.

6. Conclusion

The measure that can be adopted for an effective waste management system was examined in this study based on the potential waste control measured that were identified from the literature. The study revealed fifteen measures that could be put into consideration for effective waste management system. These measures include on site management systems, implementation of environment management system, implementation of a waste reduction framework plan and education of various construction participants on the importance of adequate waste control and management system. Thus, the study adds to the body of knowledge by providing information on measures that can be adopted for effective construction waste management in Polokwane district in South Africa. The adoption of these measures would go a long way in enhancing efficient construction project performance in Polokwane district of South Africa. It is very important to note that this paper is limited to Polokwane district professionals, and as such affects its generalization. This limitation suggests wider study of this investigation within South Africa.

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DII-2017-047

A desk study of road infrastructure performance measurement criteria

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Abstract

Transport infrastructure meets the demands for people and cargo delivery by providing access to working, shopping and travelling and improving the quality of life of citizens. Road infrastructure needs to be sustained for eons after its development. However, there is no consensus on the criteria upon which the operational performance of road infrastructure projects is assessed. This paper aims to identify all potential criteria for assessing road projects in operation. A desk study was conducted using relevant journal and conference papers obtained from databases including ASCE Library, Science Direct and Ebscohost. The review was conducted based on international and South African context. Thematic analysis was used to identify emerging themes from extant literature. The themes were tabulated and ranked based on their frequency of occurrence to determine the most important criteria for measuring the performance of road projects in operation. Findings indicated that institutional productivity and effectiveness, operational efficiency, health and safety, mobility, environmental element, public acceptability, asset value, legal and technical factors can be used to assess the performance of road projects. The study provides vital information which would be beneficial to project managers, and indeed investors, in assessing and projecting sustainable performance of road projects in operation.

Keywords: performance, performance measurement, roads, transportation

1. Introduction

Transportation infrastructure meets the demands for people and cargo delivery by providing access to working, shopping and travelling and improving the quality of life of citizens. Countries require well-developed transport infrastructure to compete internationally and to provide a high level of accessibility in terms of traffic and goods flows (Schuckmann *et al.*, 2012). Road transport infrastructure, in particular, facilitates mobility of people and specialized products and services which are essential for development and growth, meets the demands for access to working, shopping and travelling, enhances the value of land within the locality in which they are provided and improves the quality of life of citizens (Brown-Luthango, 2011). Road networks make the location of households and their business and social activities more attractive and lucrative, increase demand for properties and encourage changes in land use (Bon, 2015). In addition, employment opportunities are created for unskilled workers during construction and taxi ferrying of passengers to neighbouring areas (Renner and Gardner,

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2010; Bon, 2015). Suffice to say, road transport infrastructure contributes to economic growth and social welfare (Doll *et al.*, 2009).

However, despite their contribution to the development of economies, road transport projects may become very complex, although they usually start with a single primary function (the interconnection of several urban nodes on a line of infrastructure) (Salet *et al.*, 2013). Along the line, they have to deal with the varying emerging purposes and interests in ever-changing and unpredictable context of possibilities and constraints (Salet *et al.*, ibid.). This unpredictability affects performance of road projects both in the short and long term and therefore they have to be managed to ensure that they continue to fulfill the objectives for which they were initially planned and constructed and do not disrupt the lifestyle, health, wellbeing and quality of life of the citizenry for which they are planned (Kaare and Koppel, 2012; World Bank, 2013). Hence, research on the indicators to measure performance of road transport projects is important. Performance measurement of road projects, which relates to how well a system is fulfilling or meeting its set of predicted goals and objectives, is essential for effective planning and management (Dhingra, 2011). It includes various parameters that track a system's ability to achieve intended objectives.

Copious studies have been conducted on the indicators of road transport performance. However, these studies were not really comprehensive, focusing on one or two factors, and/or excluding important aspects that affect the quality of life of the citizenry directly or indirectly. For instance, Dhingra (2011) focused on public transport service systems; Litman's studies (2011; 2017) dwelt on mobility and accessibility; Faturechi and Miller-Hooks (2015) reviewed performance measures related to physical performance (robustness, resilience, and so on) and travels only, and ability to withstand or absorb pressure or demand (travellers'behaviour) in the event of uncertainties such as natural disasters, bombings and/or terrorist attacks; and more recently, Yatskiv and Budilovich (2017) evaluated the transport system in Riga with a focus on sustainability. Another study (Haas *et al.*, 2009), although comprehensive, satisfaction of users among social values, as well as preservation of green spaces and wildlife welfare. In addition, Ramani *et al.* (2009) and Kaare and Koppel (2012) identified performance measures in terms of sustainability including financial, environmental and social indicators.

The present study identifies all possible indicators (measurable and immeasurable) that reflect road infrastructure performance, especially those which can be relatable to the users, and their wellbeing and satisfaction. The objective of this study is therefore to identify all possible criteria on which road infrastructure performance can be assessed and the level of attention given to the wellbeing and satisfaction of the citizenry (users). The findings from the study will be useful to planners, investors and policy makers in assessing prosperity of investments in terms of holistic achievements of social, financial and economic objectives. Performance measurement allows transit planners and operators to determine if resources are used efficiently and equitably, as well as to identify potential problems, and verify whether a particular improvement strategy achieves its predicted targets with regard to satisfaction and quality of life of the public (users). Hence, it paves way for course correction which translates into a constant effort at improving services to match standards, whilst considering its impact on the community. The succeeding sections describe the methodology employed in conducting the study, the findings and conclusion drawn from the study.

2. Methodology

The current study is part of a preliminary investigation in a wider study investigating prefeasibility factors that should be considered to predict performance of road projects. A review of literature was conducted from databases including Science Direct, Google, Google Scholar, Taylor and Francis and

ASCE Library. Materials for review were sought using relevant keywords including performance, roads and transport, and combined with words and phrases such as measurement, indicators, success and so on. Materials were chosen if they met the following criteria: possession of the relevant keywords, and currency (published in the last twelve years, from 2006 to date). Each piece of literature was reviewed and synthesized to determine the focus, context and key findings. Findings were synthesized using thematic analysis, to identify emerging road transport performance factors discussed in the literature, and to create new findings (Thomas and Harden, 2008). The indicators appearing mostly were also shown, to reflect the degree of consensus or agreement among the authors in the sampled literature.

3. Road Transport Infrastructure Performance Measurement

Road infrastructure performance measures or indicators are transport statistics which are used to evaluate progress toward established goals and objectives (Dhingra, 2011). According to Kaare and Koppel (2012) and Schiff *et al.* (2013), performance indicators depend on the objectives for which the investment was made. If a given road project performs as intended in terms of originally set objectives, then success is said to have been achieved performance of road projects in operation can be deemed successful if it achieves and continues to achieve the objectives for which it was initially implemented (Kaare and Koppel, 2012). This view was also supported in a report on a road transport project in Brazil (World Bank, 2013). The report indicated that the project was expected to contribute to economic development through reduction of road transport costs, increasing competitiveness in domestic and external markets, improving social benefits by facilitating access to social services, reducing travel times, sustainability of transport investment programs by supporting the federal transport agency in improving effectiveness of environmental and social impact mitigation policies. It was therefore evaluated based on the level of satisfaction by which those parameters were perceived.

Similarly, Estonia's road transport development whose objectives were to reduce transport costs, improve road safety and road administration and improve competitiveness in trade, was evaluated based on those measures. Other factors include cash flows, customer feedback and growth potential. These output measures can help to establish and quantitatively measure effectiveness of the project, transaction and transportation costs, which could partly be influenced by the degree of efficiency of roads (quality and speed), predictability, safety, security, comfort and reliability of travel, travel times, and so on. Nonetheless, performance measures used should be suitable and appropriate for planning and evaluation purposes (Dhingra, 2011). The factors which have been identified to measure performance of road projects are discussed in the next section.

3.1 Measures of road project performance

Extant literature indicated a plethora of road projects performance indicators. These are discussed hereunder, according to their frequency of occurrence in the sampled literature, to show the consensus and discourse on the themes in literature.

3.1.1 Productivity and effectiveness of the transport system

The level of efficiency and/or productivity and effectiveness of the transport system can reflect its performance. According to Haas *et al.* (2009), productivity and effectiveness of the transport system reflect costs and benefits ratio, maintenance costs and learning possibilities. Operational efficiency relates to the volume of service outputs and/or margins that are realised from the quality of resource inputs (capital, labour, fuel) (Matsuo, 2015). Indicators here include load factor, cost-per-vehicle-kilometer, response to accidents and injuries, rate of detection of accidents, response time to incidents and complaints, and traffic delay due to maintenance works (Haas *et al.*, 2009; Ramani *et al.*, 2009; Dhingra, 2011).

Other studies suggested that productivity and effectiveness of the funding institution also reflects the performance of the road transport system since it affects the flow and adequacy of finance for the transport activities to remain in a state as to continuously command the set fares or tolls. The measures of institutional effectiveness include internal rate of return, net present value, incitement of commerce to communities, assurance of liquidity cushion, cost recovery(revenues/expand ratio, revenue/maintenance expenditure ration), economic or expenditure productivity (total, expansion and betterment, presentation, operations and administrative expenditures), economic returns (cost effectiveness, benefits, network depreciation – current value of roads and replacement cost), shortfalls or lags (quantity and value of backlogs); and service demand (Briefing Memorandum, 2007; Bryce, 2008; Haas et al, 2009; Kaare and Koppel, 2012; Bivens, 2014; Liepziger and Lefevre, 2015; Liu *et al.*, 2015; Liyanage and Villalba-Romero, 2015; Rudžianskaitė-Kvaraciejienė *et al.*, 2015).

3.1.2 Environmental elements

Environmental elements include environmental protection and quality factors such as air and noise pollution (atmospheric levels of carbon monoxide, nitrous oxides and particulates), proportion of green area preserved, welfare of wildlife, and percentage of investment in environmental protection (Ramani *et al.*, 2009; Haas *et al.*, 2009; Kaare and Koppel, 2012; Liu *et al.*, 2015; Liepziger and Lefevre, 2015; Rudžianskaitė-Kvaraciejienė *et al.*, 2015; National Geographic, 2016). Road transport activities produce pollutants, which can cause unfavourable and undesirable changes in the environment by altering a species' growth rate, interfering with food chains, and disrupting health, comfort, amenities and human property values (Razak et al., 2013). In the opinion of the National Academies of Sciences (NAS), 2005), ecological concerns should be balanced with goals of transportation mobility, capacity and social needs in determining whether and how to undertake projects. Street ambience and aesthetics (trees, public art, scenic views, *etcetera*), parking and pedestrian countdown signals enhance the attractiveness of the environment as well as lifestyle and should be considered in road transport (VanZerr and Seskin, 2011; Schmale et al., 2015).

3.1.3 Acceptability

The level of acceptability or opposition to the subject project reflects performance. According to Carter (2015) and Mišic and Radujković (2015), public acceptability should be a vital consideration in road transport performance measurement since it affects the demand for services provided by the network, which in turn invariably affects the cash flow accruing to an investor. For instance, in Mišic and Radujković (2015), it was reported that public opposition to the development of the Lignes a` Grande Vitesse Me´diterrane´e in Paris resulted in the passing of a statute to ensure that there is public debate about future infrastructure developments at the time of decision to build and understanding and subsequent acceptability by the public. Other studies suggested that willingness to pay, number of complaints, acceptable tariff levels, and perceived level of satisfaction from services (security and delays) reflects acceptability (Briefing Memorandum, 2007; Canterelli *et al.*, 2010; Liu *et al.*, 2015; Liepziger and Lefevre, 2015; Osei-Kyei and Chan, 2016).

3.1.4 Social benefits

Social benefits relate to the experience of users, which are important for developing public transport systems that respond to demands and so are able to attract even choice riders. This needs serious attention in most developing cities today, but are sometimes ignored in transport planning (Dhingra, 2011; Randolph, 2016). Measures of social benefits consist of rider comfort/convenience (ride quality, road smoothness and quality), travel speed and reliability, affordability, integration and satisfaction, cost reduction of accidents, number of displaced families/individuals, travel time reduction, vehicle operating costs reductions, increase of welfare of communities, and unit saving in fuel (Briefing memorandum, 2007; Bryce, 2008; Haas *et al.,* 2009; Dhingra, 2011; Liepziger and Lefevre, 2015; Liu *et al.*, 2015; Rudžianskaitė-Kvaraciejienė*et al.*, 2015; Mišic and Radujković, 2015).

3.1.5 Mobility and accessibility

According to Litman (2017), mobility refers to the physical movement, measured by trips, distance and speed. Accessibility is the ease with /which people reach desired destinations and/or participate in activities from specific locations to a destination using a mode of transport at a specific time (Taylor, 2008). Increased mobility increases accessibility, which refers to people's overall ability to reach services and activities and therefore the time and money that people and businesses must devote to transportation. Factors that affect accessibility includes motor vehicle travel conditions (car travel speeds, affordability and safety), quality of other modes (walking, cycling, public transit, delivery service speeds, convenience, comfort, affordability and safety), transport network connectivity (quality of connections between modes such as the ease of walking or cycling to public transport stations), and land use proximity (development density and mix and thus, distance s between activities). These measures include congestion, average travel speed, detours, closures and road restrictions and access to jobs and labour (Taylor, 2008; Ramani *et al.*, 2009; Haas *et al.*, 2009; Kaare and Koppel, 2012; Liepziger and Lefevre, 2015).

3.1.6 Asset value

Asset value has to do with preserving and maintaining the quality of existing assets to continuously be consistent with set toll fees, and thus leveraging the maximum possible funding (Ramani *et al.*, 2009). Due to declining fuel tax revenue on existing highway infrastructure and possibility of new highway projects, the quality of highways must be maintained. Measures here include rate of depreciation, reduced replacement cost, reduced impact of expansion, leveraging non-traditional funding sources (Haas *et al.*, 2009; Ramani *et al.*, 2009; Kaare and Koppel, 2012). Asset value also has to do with the technical aspects of roads including design risks and functionality, designed life span of road (in years), adoption of sustainable material and renewable resource, and improved road network density (Liu *et al.*, 2015; Liyanage and Villalba-Romero, 2015).

3.1.7 Health and safety

Vehicle safety, pedestrians' and cyclists' protection as well as serious road injuries reduction are priority interests and major concerns with most agencies and countries (Transportation Association of Canada (TAC), 2006: European Transport Safety Council (ETSC), 2016). Safety can be compromised by use of mobile phones while driving, drivers' fatigue, etc. (ETSC, 2015). The performance measures include accidents rates per million vehicle kilometers (number of accidents), rates of crash risk and stress (TAC, 2006; Haas *et al.*, 2009; Kaare and Koppel, 2012; Liepziger and Lefevre, 2015).

4. Implications and Conclusion

The afore-discussed factors were identified from the sampled literature, as being reflective of road transport performance. They are summarised in Table 1 based on their frequency of occurrence among the sampled literature. The way in which transportation is evaluated can affect planning decisions. Institutional productivity and effectiveness, followed by environmental elements, acceptability, social benefits, and mobility and accessibility, seemed to be the most frequent indicators emerging among the sampled literature. This implies that in addition to the economic returns attracted by road transport infrastructure investments, environmental and social benefits/values are also attached and should be given consideration in transport planning. If social benefits such as travel time reduction, comfort and convenience (ride quality) and reduction in congestion are the bases of evaluation, then roadways' quality should be improved. Likewise, if acceptability is the basis, then engagement with the public/users of the system should be a priority since this will in turn increase service demand and willingness to pay which will invariably contribute to the rate of cost recovery and return on investment.

Table 1a: Summary of identified road project performance indicators

Indicator	**Measures**	**Source**	**Year**
Institutional (funding structure) and operational productivity and efficiency	- Internal rate of return	- Briefing Memorandum	2007
	- Net present value	- Bryce	2008
	- Incitement of commerce to communities	- Haas *et al.*	2009
	- Assurance of liquidity cushion	- Ramani *et al.*	2009
	- Cost recovery	- Kaare and Koppel	2012
	- Economic productivity	- Bivens	2014
	- Service demand	- Liepziger and Lefevre	2015
	- Response to accidents and injuries	- Liu *et al.*	2015
	- Rate of detection of accidents	- Liyanage and Villalba-Romero	2015
	- Response time to incidents and complaints	- Matsuo	2015
	- Traffic delay due to maintenance works	- Rudžianskaitė-Kvaraciejienė *et al.*	2015
Environmental elements	- Air and noise pollution	- NAS	2005
	- Proportion of green area preserved	- Ramani *et al.*	2009
	- Percentage of investment in environmental protection	- Haas *et al.*	2009
		- VanZerr and Seskin	2011
	- Street ambience and aesthetics	- Kaare and Koppel	2012
		- Liu *et al.*	2015
		- Liepziger and Lefevre	2015
		- Rudžianskaitė-Kvaraciejienė *et al.*	2015
		- Schmale *et al.*	2015
		- National Geographic	2016
Acceptability	- Acceptable tariff levels	- Briefing Memorandum	2007
	- Willingness to pay	- Canterelli *et al.*	2010
	- Number of complaints	- Liu *et al.*	2015
	- Level of opposition	- Mišic and Radujković	2015
	- Perceived satisfaction from services (security and delays)	- Carter	2015
		- Liepziger and Lefevre	2015
		- Osei-Kyei and Chan	2016
Social benefits	- Cost reduction of accidents	- Briefing memorandum	2007
	- Number of displaced families/individuals	- Bryce	2008
	- Travel time reduction	- Haas *et al.*	2009
	- Vehicle operating costs reductions	- Liepziger and Lefevre	2015
	- Increase of welfare of communities	- Liu *et al.*	2015
	- Unit saving in fuel	- Rudžianskaitė-Kvaraciejienė *et al.*	2015
	- Comfort/convenience (ride quality, road smoothness, quality)	- Mišic and Radujković	2015
	- Congestion		
Mobility and accessibility	- Congestion	- Taylor	2008
	- Average travel speed	- Ramani *et al.*	2009
	- Detours	- Haas *et al.*	2009
	- Closures and road restrictions	- Kaare and Koppel	2012
	- Access to jobs and labour	- Liepziger and Lefevre	2015
		- Litman	2017
		- Yatskiv and Budilovich	2017

Table 1b: Summary of identified road project performance indicators (continued)

Indicator	Measures	Source	Year
Quality /Asset value/ Technical/engineering aspects	- Ride quality (convenience) - Rate of depreciation/maintenance frequency/replacement cost - Maintaining quality consistent with the set toll fees - Reduced impact of expansion - Design risks and functionality - Designed life span of road (in years) - Adoption of sustainable material and renewable resource - Improved road network density	- Haas *et al.* - Ramani *et al.* - Kaare and Koppel - Liu *et al.* - Liyanage and Villalba-Romero	2009 2009 2012 2015 2015
Health and safety	- Perception of safety - Number of accidents - Rates of crash risk - Stress	- TAC - Haas *et al.* - Kaare and Koppel - Liepziger and Lefevre	2006 2009 2012 2015

Furthermore, mobility and accessibility is considered to be important in evaluating performance of transport system. On these bases, transit service and alternative modes of transport (cycling and walking) should be improved to avoid congestion, improve travel speed and provide alternative routes and modes of access to opportunities (work, school, etc.). Health, safety and security seemed to be the least considered factors among the sampled study. This is concerning since the health and wellbeing of the users should be of paramount concern given that they are the one who inhabit and use the transport networks and structures and are expected to be for the services accruing from the existence of the network. As such, their health and safety should be given considerable attention. Another possible explanation for the health and safety outcome could be that the elements are intertwined and related to other factors. For instance, improving the quality of the transit service will improve their response to accidents and complaints (operational efficiency) and increase acceptability as well. This suggests that the factors could be interrelated and further studies could explore this relationship.

The objective of the study, which was to identify road performance measurement indicators, has been achieved. Through a review of selected literature, institutional productivity and efficiency, acceptability, social benefits, environmental elements, mobility and accessibility emerged as the most considered indicators. With these findings, the current paper adds to the body of knowledge on road performance measurement indicators and in addition, presents evidence of the most considered indicators in performance measurement to ensure that road projects continue to perform as they were intended.

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DII-2017-064

A Comparative Study between 'Traditional and Green' Lease Provisions in Tenanted Office Buildings: The Case of Lusaka

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Abstract

Globally, the real estate sector is a contributor of greenhouse gas (GHG) emissions, a great consumer of energy, water, raw materials and generator of waste. A large number of tenanted commercial buildings are non-green which means they are not environmentally efficient. On the other hand, the use of traditional lease agreements compound the problem by acting as a barrier in achieving sustainability goals and a hindrance in reducing expenditure on water, energy and waste. Traditional lease agreements also increase maintenance expenditure. The research design was a case study approach and Lusaka Central Business District (CBD) was used to collect primary data being the commercial hub of tenanted office commercial buildings. This study carried out a comparative analysis between traditional leases being used in tenanted office buildings and the proposed green lease provisions in eight proposed thematic areas. The study also investigated the types of buildings whether green, non-green, certified, lease and data sharing management between the property owners and occupiers. The study highlights the benefits of the green leases and also brings out the principle of sustainability with its global benchmarks, the drivers of sustainability and also develops a theoretical framework which shows that increasing sustainability of buildings brings about an increase in building worth. The Zambian context shows that most of the interventions in having an environmentally friendly real estate sector are still at infancy stage although the legal mandate has been given to Zambia Environmental Management Agency (ZEMA) and Zambia Green Building Association (ZGBA) to manage the environment sustainably and hence these should be the major drivers of this process. The key findings of the research show that all the buildings sampled in the study area were not green, not certified and used traditional lease agreements. The current status quo poses environmental challenges as buildings tend to consume a lot of water, energy, generate waste, contributes to pollution, incurs high maintenance costs and act as a barrier in increasing productivity of the occupants. The study therefore recommends the use of green lease provisions that have the potential to improve profitability and productivity.

Keywords: commercial building, green buildings, lease, sustainability, tenanted office

1. Introduction

According to the Construction, Building and Real Estate Research Conference of the Royal Institution of Chartered Surveyors (RICS COBRA) (2015) 'Green Leasing' has become a familiar terminology in recent years. This is so simply because 'Green Leasing' encapsulates the idea of a new form of leasing that will help solve many environmental challenges that the world is facing today. In some way, this

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convenient and catchy phrase has however, generated both fears and hopes. On one hand, the fears are that 'Green Leasing' is a radically different and therefore, risky form of leasing. While on the other, hopes and expectations are that it will actually positively transform the environmental performance of tenanted buildings. The significance of green leases has been supported by many scholars in different literature and amongst the most recent is Janda et al. (2016) who argued that 'Green leasing' seeks to enable landlords and tenants to meet environmental targets by changing their organisational practices. Green leases incorporate 'green' clauses within the lease and are designed to account for energy efficiency and other sustainability goals.

The real estate sector is responsible for more than 20% of the world's carbon emissions and other environmental impacts (World Economic Forum, 2016). Such environmental impacts have to do with waste production and management, pollution, water and the consumption of other natural resources (World Economic Forum, 2016). Improving the energy efficiency of buildings and of the appliances installed therein could offset about 85% of the projected incremental demand for energy in 2030. Assessing the environmental performance of real estate investments is important because investing in more environmentally-friendly buildings may well be a path towards increased shareholder value to a large extent. The investments needed to improve energy efficiency in buildings have positive net present values (Creyts et al., 2007) and literature documents higher asset values for commercial buildings certified as green or energy efficient (Kok and Quigley, 2010).

Boyd and Kimmet (2009) indicate that there are four expected results from greater environmental efficiency and that three of the four impacts should have a positive effect on the capital value of the building. However, the degree and timing of the impact is complicated and will differ according to the type of environmental improvement. It is too simplistic to conclude that the change will always, or even frequently, have a positive impact on the capital value. What is important is that environmental factors have the potential to provide a better return from a building asset.

2. Conceptualisation of 'Traditional and Green Lease' Provisions

Traditional lease agreements vary in many aspects and in different property markets. In some cases, these leases are prepared by different professionals such as lawyers, property managers, and property owners amongst others. Traditional lease agreements tend not to incorporate specific clauses that could achieve environmental sustainability of the rented space. Research carried out by Janda et al in 2016 shows that improving environmental performance of non-domestic buildings is a complex and 'wicked' problem (one which is difficult or impossible to solve because of incomplete, contradictory and changing requirements that are often difficult to recognise) problem due to conflicting interests and incentives. This is particularly challenging in tenanted spaces, where landlord and tenant interactions are regulated through leases that traditionally ignore environmental considerations.

Literature shows the benefits of green leases as opposed to traditional leases and notable among the researchers is theJones Lang LaSalle (JLL), 2015), which views green leases as an enabler in providing a mechanism to allow buildings that weren't originally designed to achieve 'sustainability' to achieve high environmental performance and other benefits of a green lease as outlined in the following table.

Table 1: Benefits of green leases

Greater transparency	Sharing data and regular reporting improves transparency to enable tenants and landlords to measure success against agreed sustainability goals.
Improved environmental performance	Securing critical commitments by the landlord and the tenant. A sound sustainability strategy will improve efficiency and performance. JLL clients have identified between 3 - 10% energy reductions from easy to implement sustainability measures built into leases.
Greater engagement	Brings about improved working relationship between landlords and tenants as green leases focus on collaboration and mutual benefit.
Improved productivity and comfort	Green leases bring about green buildings and increasingly green leases aim to address sustainability concerns beyond energy, water and waste. Example; improved "Indoor air quality (IAQ) can result in productivity gains by occupants between 8-11%" and "Thermal comfort can have single figure impacts on productivity as well as material energy savings"

Source: JLL, 2015

Further benefits include amongst others improved Civic Relations where you lease: Many cities are strong advocates of green leasing such as New York where the Mayor assembled a Green lease Taskforce and San Francisco Business council for climate change developed a green tenant toolkit for local occupiers and landlords (Meagan, 2013). Green leases are a contribution towards the city's efforts to make cities more sustainable by 2030 which is in line with the 2030 Sustainable Development Goals (SDGs). According to Council of Australian Government (2012) green leases bring benefits to both the tenant and the landlord. Menard and Elliot (2008) pointed out that there may be several barriers which hamper the initiatives of a landlord who wishes to make his building more energy, water and resource efficient such as:

i. A green lease does not adapt well to a "net" lease environment where there is little incentive for the landlord to conserve.
ii. When negotiating a lease the emphasis is still put on "base-rent", which means that reductions (or potential reductions) in additional rent are not considered important in the decision to enter into a lease of a specific site.
iii. There are usually long pay-back periods for some type of improvements.
iv. There is generally little, if any, leadership, compulsion or incentive from governments.

Property firms and industry associations are also researching the impact of sustainability on property with 'green' being seen as 'good for business.' (Corps, 2005) According to Armitage (2009) the Canadian study showed a clear link 'between the market value of real estate and its environmental friendliness.' It found that greener buildings can:

i. Earn higher rents and prices,
ii. Attract tenants and buyers more quickly,
iii. Cut operating costs,
iv. Benefit occupiers and
v. Improve productivity

In identifying the impact of sustainability on rents and values the results of studies by Miller et al. (2008), Fuerst and Mcallister (2008) and Pivo and Fischer (2009) identified a positive relationship by varying percentages. Green leases are an enabler in providing a mechanism to allow buildings that weren't designed with sustainability in mind to achieve high environmental performance (JLL, 2015). Sayce et al. (2009) states that 'the benefit of green leases, which have so far largely been associated with office buildings, are considered to be numerous and include improved public relations, revenue savings and the ability to recruit and retain staff'.

There is a clear green premium for office buildings adopting the sorts of energy efficiency and other measures associated with green leases. There is also a proven statistical correlation of green properties with improved rents, reduced vacancies, reduced outgoings and reduced incentives (Council of Australian Government, 2012). Literature points to more benefits than barriers in the use of green leases as opposed to traditional leases. The theoretical framework in Figure 1 is supported by the theory that any building which is environmentally friendly brings about positive economic and social effects.

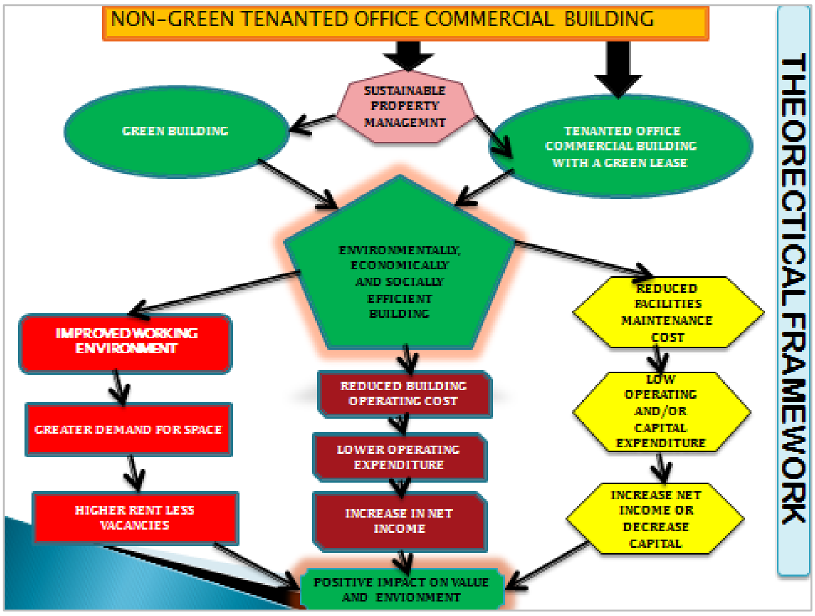

Figure 1: The theorectical framework (Source: Authors, 2017)

Most developed countries have institutionalised green leases through development and implementation of toolkits for green leases. The green lease toolkits are meant to enable owners and occupiers of commercial buildings to work together to reduce negative environmental impacts of their buildings. These countries include UK, USA, France, Canada, Australia, New Zealand and South Africa amongst others. One synonymous thing about countries with toolkits is that they also have well established Green Building Councils (GBCs). France further developed in 2013 Green legislation also known as “annexe environmentale” to support the implementation of green leases. The purpose of this legislation helps to balance owner and tenants environmental obligations with transparency between both parties (Besnier, 2014).

3. Research Methodology

It is the aforementioned discourse that prompted an inquiry into a comparative study between the use of green leases with its social and economic benefits as opposed to using traditional leases in tenanted office commercial buildings. The methodology provided a systematic framework for the investigation into the utilisation of green leases with its provisions in the tenanted commercial office buildings. This paper’s methodology adopted a two-tiered approach of reviewing secondary peer-reviewed literature and undertaking in-depth interviews and a distribution of questionnaires to key informants in the real estate sector. Literature reviewed included reports published by different local and international agencies as well as journal articles and books. Questionnaires targeted property owners, facilities managers/ property managers and tenants of both private and parastatal companies with valid lease agreements. For the parastatal companies, questionnaires were distributed to Property managers of National Housing Authority (NHA), Zambia State Insurance Corporation (ZSIC), Real Estate Investment of Zambia (REIZ), and National Pension Scheme Authority (NAPSA). On the other hand, property managers apart from the landlords and tenants from the private companies such as Keystone Property Consultants, Spiral Property Consultants, Madison Assets were also targeted. With respect to in-depth interviews conducted, institutions were purposively sampled due to their knowledge and experience in green buildings and these were; Zambia Green Buildings Association (ZGBA), Zambia Environmental Management Agency (ZEMA), Lusaka City Council and National Council for Construction (NCC). Out of a total population of 424 commercial office spaces in Lusaka's CBD only 278 were sampled. The study adopted a case study approach of Lusaka's Central Business District (CBD) due to the fact that it has the largest number of commercial properties in Zambia (Knight Frank, 2016).

4. Results and Discussion

The study found that all the tenanted office commercial buildings sampled in the study area were non-green buildings as they were not certified either by LEED or Energy star as green buildings and this may be due to the fact that all the offices were still using traditional lease agreements and not green lease agreements. These traditional lease agreements did not also incorporate data sharing policies which a green lease incorporates to enable tenants and landlords to measure success against agreed sustainability goals and thereby increase transparency. Although not legally binding as a provision in the lease agreement, the study found that attempts are being made by most office occupiers to incorporate aspects of sustainability such as; the use of energy saving bulbs and using alternative sources of energy such as solar to achieve energy efficiency. This was seen as a step forward to the achievement of environmental sustainability although artificial heating and ventilation using air conditioning was still practiced and this is a major consumption of energy in most office commercial properties. Green leases are an enabler in providing a mechanism to allow buildings that weren't designed with sustainability in mind to achieve high environmental performance. With regards to the efficient use of water through rain water harvesting and recycling there were no efforts to recycle grey water and most plumbing fixtures used were ordinary fixtures with a few traces of high efficiency plumbing fixtures. Most of the commercial buildings did not have office waste separation policies which a green lease incorporates but instead had contracts with Lusaka City Council -Waste Management Unit (LCC-WMU). Car-pooling policies were not present in any commercial properties in the study area.

According to ZGBA, ZEMA, NHA, ZSIC, REIZ and NAPSA green lease agreements in non - green tenanted commercial buildings were not being used in Lusaka apart from Foxsdale office park in Lusaka's Foxdale area but was not part of the study area. Another point worth noting is that the study found that there was no proper coordination among professional bodies such as NCC, ZEMA and ZGBA in the area of promoting green office buildings in Zambia although institutions such as ILO have attempted to initiate a programme known as 'Green jobs' which is currently constructing residential houses that incorporate environmental sustainability in North Western Province of Zambia. Zambia Green Building Association (ZGBA) which is supposed to play a significant role in promoting green buildings was a fairly new association and was still in the process of trying to recruit members. The institution had very little information concerning the number of green office buildings nor green initiatives in the country. The study found that most of the property managers are implementing certain green practices in the management of these facilities without the knowledge of green leases and no legislation to guide them. Health and safety committees were not a common feature in most commercial properties, as the majority did not have these committees in place although fire management plans and facilities were in the majority of commercial buildings probably due to the fact that it is a legal requirement in Zambia to satisfy fire safety before a trading licence is granted. The majority of the commercial buildings in the study area had in place building maintenance plans but did not have the following which a green lease incorporates such as; a building maintenance committee incorporating both landlord and tenants, building user guides and no formal mechanisms for gathering tenant feedback. In appreciating the importance of mitigating impacts of commercial buildings on the environment by including sustainability concepts in commercial buildings the world environment day was commemorated at Foxdale office park on 03rd June 2017 by the stakeholders. This was to showcase the initiatives and sensitise the public on the benefits of using green policies in commercial buildings.

5. Conclusion

It was evident from the findings above that all the tenanted office commercial buildings in the case study area were non - green buildings, did not use green leases but had traditional lease agreements. This indicates that Zambia is still in its infancy stage in the promotion of green buildings. This information was also confirmed by ZGBA, ZEMA and Property Managers of these commercial buildings. The only exception was Foxsdale office park which was not in the Central Business District and hence not in the study area.

The above background shows that the non - green tenanted office commercial buildings are contributing negatively to the environment in terms of energy consumption, water consumption, waste management, pollution, high maintenance costs, attracting blue chip tenants and increasing productivity of occupants, retention and recruitment of employees It has been proved and shown in the literature of this study that the above scenario can be improved through green leases for non-green tenanted office commercial buildings. Literature shows that there is a link between improved sustainability of the buildings with enhanced financial and social performance, through lower operational costs, higher rents, better occupancy rates, improved productivity of occupants and higher sale prices than non - green tenanted office commercial buildings with traditional lease agreements. Green leases ultimately also enhance the corporate image, improves recruitment and retention of employees and ultimately achieves environmental sustainability which is in line with the Sustainable Development Goals (SDGs) 2030 which is an international agenda.

6. Recommendations

The study recommends the use of green leases as opposed to using the traditional leases in tenanted office buildings as this will help achieve environmental sustainability of buildings and improve the productivity of occupants. It proposes thematic areas to be used in green lease provisions. The study further recommends a sensitisation programme nationwide by institutions such as ZEMA and ZGBA on the importance and benefits of using green leases in non - green tenanted office commercial buildings. ZGBA also needs to enhance the accreditation of existing buildings through a green lease toolkit. Ultimately Green leases should then be able to boost the corporate brand of institutions when institutions aim to address climate change and sustainability.

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