

PROCEEDINGS OF THE 3RD
INTERNATIONAL CONFERENCE ON
INFRASTRUCTURE DEVELOPMENT AND
INVESTMENT STRATEGIES FOR AFRICA

DII - 2016
31 August – 2 September, 2016
Livingstone, Zambia



**ACHIEVING SOLUTIONS FOR RENEWABLE
ENERGY AND SUSTAINABLE DEVELOPMENT**

Editors: Dr EM Mwanaumo, Dr I Musonda & Dr F Muleya
Co-editors: Prof M Muya, Dr JN Agumba & Mrs CS Okoro



UNIVERSITY
OF
JOHANNESBURG

DII – 2016

3rd International Conference on Development and Investment in InfrastructureStrategies for Africa

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**ACHIEVING SOLUTIONS FOR RENEWABLE ENERGY AND SUSTAINABLE
DEVELOPMENT**

Editors

Erastus Mwanaumo
Innocent Musonda
Franco Muleya

Co-Editors

MundiaMuya
Justus Agumba
Chioma Okoro

2016

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Correspondence:

All correspondence pertaining to the International Conference on Development and Investment in Infrastructure (DII) Strategies for Africa, should be sent to info@diiconference.org or to:

Dr Erastus Mwanaumo
DII-2016 Chair: Technical Programme
School of Engineering
University of Zambia
Box 32379
Lusaka, Zambia
Erastus.mwanaumo@unza.zm

Dr Innocent Musonda
DII-2016 Chair: Scientific Programme
Department of Construction Management & Quantity Surveying
University of Johannesburg, Johannesburg
P. O. Box 17011
Doornfontein
2028, South Africa
imusonda@uj.ac.za

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ENDORSEMENTS



FOREWORD

On behalf of the Organizing Committee, it is my pleasure to welcome you to Livingstone, Zambia, the host city of the 2016 International Conference on Development and Investment in Infrastructure (DII). The DII-2016 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 renewable energy, general infrastructure development and investment in Africa, the 2016 conference, themed “*“ACHIEVING SOLUTIONS FOR RENEWABLE ENERGY AND SUSTAINABLE DEVELOPMENT”*”, 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
- 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 organizing 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
Chair: Technical Programme
DII-2016

ACKNOWLEDGEMENT

The organizing committee of the DII-2016 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, the Network of Energy Excellence for Development (NEED), the Universal Mining and Chemical Industries Limited, the South African Council for the Project and Construction Management Professions and other South African, African and International universities and Institutions for supporting the conference through their valued contributions.

The contributions and unique support of the International Advisory and Scientific Committees, who worked tirelessly to prepare refereed and edited papers, which produced this published proceedings of the highest standard including satisfying the criteria for subsidy by the South African Department of Higher Education and Training (DHET), is truly treasured. The contributions of Prof MundiaMuya, Dr Trynos Gumbo, Dr Justus Agumba, Dr Ackim Zulu, Prof DidibhukuThwala, Dr Innocent Musonda, Prof Clinton Aigbavboa, Dr Erastus Mwanaumo, Dr Franco Muleya, Mrs Chioma Okoro, Mr Tresor Mbayahe, Mr Johan de Koker, Ms Chama Mwansa, Dr Brian Mutale and Mr William Nkomo are recognized. The support of Mr Ansary Nazeem and Prof Steve Ekolu is also laudable.

DISCLAIMER

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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

Organizing Committee

Zambia

Dr Erastus Mwanaumo (Chair: Technical Programme)
Prof MundiaMuya
Dr Franco Muleya
Dr Ackim Zulu
Ms Chama Mwansa
Mr Brian Mutale
Prof Clive Chirwa

South Africa

Dr Innocent Musonda (Chair: Scientific Programme)
Prof Clinton Aigbayboa
Dr Trynos Gumbo
Dr Justus Agumba
Prof Didibhuku Thwala
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 E Mwanaumo, University of Zambia
Dr I Musonda, University of Johannesburg, RSA
Dr F Muleya, Copperbelt University, Zambia
Prof M Muya, University of Zambia
Dr J Agumba, University of Johannesburg, RSA

Technical Review Committee

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

Dr A Zulu, University of Zambia, Zambia

Dr C Trinkl, TechnischeHochschule Ingolstadt (THI), Institute of new Energy Systems (InES)

Dr D Mzyece, University of Wolverhampton, UK

Dr E Munshifwa, CopperbeltUniversity, Zambia

Dr L Chipungu, University of Kwazulu-Natal, RSA

Dr M Sumbwanyambe, University of South Africa, RSA

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Dr S John, University of Science &Technology, Namibia

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Prof FA Emuze, Central University of Technology, RSA

Prof G Ofori, National University of Singapore, Singapore

Prof J Katende, University of Science and Technology, Botswana

Prof J Khatib, University of Wolverhampton, UK

Prof JJ Smallwood, Nelson Mandela University, RSA

Prof KK Shakantu, University of Free State, RSA

Prof Mbaiwa, Okavango Research Institute/Botswana

Prof PD Rwelelamilia, University of South Africa, RSA

Prof W Zörner, TechnischeHochschule Ingolstadt (THI), Institute of new Energy Systems (InES)

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 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.

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 67 submissions, 45 papers were finally accepted and included in the DII-2016 conference proceedings.

At no stage was any member of the Scientific Review Panel or the Organizing 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



Tresor Mbayahe

DII-2016 Secretariat (PRP)



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 recognized 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;
- Maximize its intellectual capital;
- Ensure institutional efficiency and effectiveness;
- Cultivate a culture of transformation;
- Offer the preferred student experience;
- Secure and grow competitive resourcing; and
- Focus on the Gauteng city regions.



The Copperbelt University

History

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

The School of Built Environment

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

After successful completion of their degree programmes, our students join both public and private sector reputable organizations within and outside the country where they work as Architects, Design Consultants, Construction Managers, Valuers, Planners, Project Managers, Quantity Surveyors, Investment Bankers and many more. Other than the masters programme, which takes up to two years to complete, all our

undergraduate programmes should take five years to complete. Our students come from within and outside Zambia. In terms of staffing, it is the policy of the University that it recruits highly qualified personnel. For this reason, the university has put in place a policy where the minimum qualification of a lecturer is not only a masters' degree but also that the masters' degree must be in the same discipline as the lecturer's first degree. In addition to this profile, the SBE has a very ambitious programme where it intends to expand the school by introducing more programmes like the MSc. Degree in Land Management. This will help in meeting the ever increasing demand for qualified professionals within and outside the SADC region. More information on CBU in general and SBE in particular, can be found on our website at www.cbu.edu.zm.



THE 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 21,700. The School of Engineering located at the main campus of the University of Zambia in Lusaka is one of the nine 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 450 undergraduate and 90 postgraduate students across all the departments. There are currently 40 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 specialized 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 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 these programmes are being offered in the Departments of Civil & Environmental

Engineering and Mechanical Engineering. The School also undertakes interdisciplinary research in conjunction with other institutions.

MSc programmes

The following is the list of programmes offered at MSc level:

- Master of Engineering Research Programme;
- Master of Engineering in Agricultural Engineering;
- Master of Engineering in Environmental Engineering;
- Master of Engineering in Structural Engineering;
- Master of Engineering in Electrical Power Systems;
- Master of Engineering in Production Engineering and Management;
- Master of Engineering in Thermo-fluids Engineering;
- Master of Engineering in Renewable Energy Engineering;
- Master of Engineering in Project Management;
- Master of Engineering in Construction Management;
- Master of Engineering in Engineering Management;
- Master of Engineering in Geo-Informatics and Geodesy;
- Master of Engineering in Telecommunications Systems;
- Master of Engineering in Information and Communication Technology;
- Master of Engineering in Information and Communication Technology Security;
- Master of Engineering in Information and Communication Technology Policy and Management;
- Master of Engineering in Computer Communications; and
- Master of Engineering in Wireless Communications.

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.

CONFERENCE PROGRAMME

WEDNESDAY, AUGUST 31, 2016			
14:30-16:50	Workshop: Postgraduate research		
17:00-19:00	Conference Registration Networking opportunity & welcome cocktail		
THURSDAY, SEPTEMBER 1, 2016			
07:30-08:30	Registration		
	Welcome ceremony & Keynotes Chair: Dr E. Mwanaumo – Assistant Dean Post Graduate , School of Engineering – UNZA		
08:30-08:50	Welcome addresses- Dr Innocent Musonda & Dr Erastus Mwanaumo		
08:50-09:30	High shares of renewable energy and renewable fuels for mobility in the energy system – concepts and critics taking the example of the German “Energiewende” (energy turnaround) - Dr Ludger Eltrop, IER, Universität Stuttgart		
09:30-10:10	Alternative methods of creation of an optimal electricity supply-demand structure to serve Zambia - Dr Simon Tembo, University of Zambia		
10:10-10:50	Why are renewables so successful in Germany? - Prof. Dr.-Ing. Wilfried Zörner, Technische Hochschule Ingolstadt, Institute of new Energy Systems		
10:50-11:10	Tea break/Networking		
	Technical Sessions		
	Breakaway Session 1: Theme: Renewable Energy Infrastructure Development Session chair: Dr C. Kaliba	Breakaway Session 2: Theme: Integrative Infrastructure Planning and Management Session chair: Dr B. Mwiya	Breakaway Session 3: Theme: ICT and Skills Transfer in Infrastructure Development Session chair: Dr E. Munshifwa
11:10-11:30	Evaluation of the Chitungwiza, Firle and Crow borough municipal sewage plants' potential to produce biogas from municipal sewage sludge for electricity generation: Case Study Zimbabwe - Manyuchi, M. et al	Critical success factors for managing infrastructure projects in Africa: A critical review and lesson learned – Chileshe, N. et al.	Knowledge exchange in construction practice: Exploring the impact of embedded BIM process standards – Maradza, E.
11:30-11:50	Innovative municipal solid waste management in the city of Johannesburg: Towards sustainable green landfill gas to electricity infrastructure – Gumbo, T. et al.	Establishing the relationship of cost changes to construction work groups and the estimated construction cost to improve overall project control – Oliphas, D. et al.	Challenges faced by construction companies in retention of workers in South Africa: A literature review - Nkomo M. W. et al
11:50-12:10	Turning to smart grid in Zambia - Namukolo, S. et al.	Optimisation of tyre traction force in wheeled construction related vehicles traversing in off-road deformable terrain – Muleya, F. et al.	Equipping 21st century construction graduates: a review of key skills in fostering infrastructural development – Aliu, J. et al.
12:10-12:30	Evaluation of infrastructure development of roadway new technologies for renewable energy generation: Lessons learnt – Olaadele, A. S.	Modeling uncertainty and risk of cost and time in infrastructure projects: Theoretical perspectives – Moghayedi, A. et al.	Sustenance of construction skills – A case for Zambia – Nondo, C. M.
12:30-12:50	Strategic Direction to Sustainable Electricity Generation in Zambia - A Critical Comparison of Electricity Generation Options – Tembo, S. et al.	An appraisal of critical risk factors in construction projects in South Africa: Perspective of contractors – Renault, B. Y. et al.	The Utility of the ‘Step-In’ Clause in the South African Prison Public Private Partnerships – Khatleli N.
12:50-13:50	Lunch Break		
	RENEWABLE ENERGY TECHNOLOGIES SUMMIT – NEED PROJECT Chair: Mr D. M. Ngendo / Dr Ackim Zulu		
14:00-14:10	Introduction - Dr Ackim Zulu (UNZA) & Prof Wilfried Zörner (THI)		
14:10-14:30	Keynote: Status of energy supply in Zambia: Perspectives / way forward, integration of renewables, legislative framework and regulations to increase renewable energy in the national energy mix - Eng. Geoffrey Musonda - CEO Rural Electrification Authority (REA)		

14:30-15:10	Research Requirements in Renewable Energy Technologies for Southern Africa - Dr Ackim Zulu (UNZA)
15:10-15:50	Dual Studies – An Alternative Pedagogy for RETs in Southern Africa - Mr Andrew Zulu (NUST)
15:50-16:30	Development and Harmonization of Renewable Energy Technology (RET) standards through the Southern African Development Community Cooperation in Standardization (SADCSTAN) platform - Prof James Katende (BIUST)
16:30-17:00	Tea Break
17:00-17:40	Perceptions of tourism operators towards the use of RETs in the Okavango Delta, Botswana m- Prof Joseph E. Mbaiwa, ORI
17:40-18:20	Sustainable Development of Renewable Energy Mini-grids: A case of Gobabis in Namibia - Dr Paul Chisale, NUST
18:20-18:30	Closing remarks Dr Ackim Zulu (UNZA & Prof WilfriedZörner (THI)
19:00-22:30	Gala Dinner

FRIDAY, SEPTEMBER 2, 2016

	Keynotes Chair: Dr. J. Agumba		
08:30-09:00	Production of Rebars - Requirements, processes and benefits – <i>Dr Julius Kaoma, Universal Mining and Chemical Industries, Zambia</i>		
09:00-09:40	Project Finance for the Construction Sector in Africa: Challenges and Prospects- <i>Dr LubindaHaabazoka, Copperbelt University, Zambia</i>		
09:40-10:20	The importance of water resource management and environmental protection in the development of economic infrastructure – <i>Eng. Christopher Chisense, Zambezi River Authority, Zimbabwe & Zambia</i>		
10:20-10:40	Tea break		
	Technical sessions		
	Breakaway Session 4:	Breakaway Session 5:	Breakaway Session 6:
	Theme: Infrastructure Leadership and Governance Session chair: Dr. N. Chileshe	Theme: Sustainability Session chair: Dr T Gumbo	Theme: Health and Safety in Infrastructure Development Session chair: Dr V. Samwinga
10:40-11:00	An evaluation of political risks affecting international construction projects in Namibia – Muchenga, I. et al.	Failure of small and medium contracting firms in Gauteng province, South Africa – Oke, A. et al.	An evaluation of the attitude and behaviour of casual workers towards health and safety on construction sites on Zambian construction industry – Mutwale, J et al.
11:00-11:20	Compliance by Public Sector CDPs to the CIDB Guidelines for Contractor Development - Adediran, A. et al.	Adoption of best value selection criteria in the Zambian road sector – Mwiya, B. et al.	Identifying health risks related to construction of water supply infrastructure: Case of Lusaka water, supply, sanitation and drainage project - Mwanaumo, E. et al.
11:20-11:40	Key factors for the development of sustainable stakeholder management framework for construction projects in Ghana – Eyiah-Botwe, E. et al.	Exploring factors that influence firm's growth among small and medium-sized construction firms in Ghana – Arthur-Aidoo, B. M. et al.	The influence of workers 'attributes on organisational safety performance – Lusenga, E. et al.
11:40-12:00	Exploring Gilbert's behavioural engineering model in enhancing risk allocation in the construction industry – Tembo, C. K. et al.	Sustainable water provision for the urban poor: Rights-based or commodity-based Approach? – Kaunda, B. S. et al.	The impact of environmental thermal changes on construction health and safety (H&S) in Zimbabwe – Chigara, B. et al.
12:00-12:20	Performance of construction projects in South Africa: Perception of consultants and contractors - Aigbavboa, C. et al.	Evaluating the use of PPPs in delivering sustainable building projects in Zimbabwe – Mawondo-Dhliwayo, R. A. et al.	Utilisation of materials safety data sheet on Zambian construction worksites- Mwanaumo, E. et al.
12:20-12:40	Investigating factors leading to project abandonment in the ZCI: A case of the public sector - Chiponde, D. B. et al.	Impact of involvement of foreign companies on Zimbabwe's public sector projects – Mukawa, M. et al.	Conceptualized integrated health and safety compliance model for contractors in Ghana- Mustapha, Z. et al.
12:40-13:40	Lunch Break		
	Keynotes Chair: Dr. F. Muleya		

13:40 -14:10	TBA - Eng. Wallace Mumba. National Road Fund Agency, Zambia	
14:10-14:40	Practical ways of promoting joint ventures of foreign and local contractors within the SADC region – Eng. Charles Mushota, National Council for Construction, Zambia	
	Breakaway Session 7: Theme: Social Infrastructure and Sustainability Session chair: Prof C. Aigbavboa	Breakaway Session 8: Theme: Integrated Infrastructure Investment, Procurement and Finance Session chair: Dr M Manyuchi
14:40-15:00	An evaluation of the development of renewable energy sources in South Africa – Daw, D.	Assessment of credit accessibility to construction SMEs in the South African construction industry using binary logistic regression- Balogun, L. et al.
15:00-15:20	Developing alternative roof tiles from plastic waste and copper tailings - Siluonde, H. et al.	Sovereign bonds and infrastructure development in Africa: the case of Zambian road infrastructure - Munshifwa, E.
15:20-15:40	Utilisation of materials safety data sheet on Zambian construction sites – Mwanaumo, E. et al.	Comparison of the clients, consultant and contractors perspectives of pre-tender unit cost factors in Zambia – Chipulu C. et al.
15:40-16:00	The effect of Johannesburg inner-city regeneration of the resident communities - Khatleli N. et al.	Critical considerations in transport performance forecasting: A literature review – Okoro, C. S. et al.
16:00-16:20	Dispute Causation in Integrated Procurement System in Gauteng, South Africa – Mewomo, M. et al.	Development of a conceptual main contractor-subcontractor partnering model - Mudzvokorwa, T. et al.
16:20-16:50	Conference End and Closing: Q&A with Keynote Speakers; Closing Remarks - Prof Wellington Thwala- (UJ)	
16:50	Sunset Cruise on the Mighty Zambezi River – (Optional event)	

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 has recently been 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). Themed, "*ACHIEVING SOLUTIONS FOR RENEWABLE ENERGY AND SUSTAINABLE DEVELOPMENT*", the 2016 conference will focus on renewable energy, general infrastructure development and investment in Africa, addressing a broad range of topics around infrastructure investment, development and sustainability. 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. Confirmed keynote speakers include:

Prof. Dr.-Ing. Wilfried ZÖRNER

Prof. Dr.-Ing. Wilfried Zörner is Professor for Product Development and Design (since 1998), currently heads the Institute of new Energy Systems (InES), and is member of the research council at Technische Hochschule Ingolstadt, Germany. He lectures at the same institution presenting Renewable Energies, Solar Energy Engineering, Product Design, Design Elements, Pneumatics and Cost Management. He was previously Head of Research at the Research Institute for Renewable Energies, Neuburg, Germany. He has conducted various renewable energy research projects including '*Optimisation of biogas production with regard to plant design and electricity grid interaction*', '*System analysis and development of optimal system design of thermosyphon solar water heaters*', '*Application of solar-thermal systems for process heat in industrial use*' and '*Feasibility analyses on alternative design solutions and polymeric materials for solar-thermal collectors considering production process automation*'. Prof Zörner holds a PhD (Dr.-Ing.) in Solar Energy Systems and Dipl.-Ing. in Mechanical Engineering, both from Technical University of Munich, Germany. He is a member of Task 49 (Solar Heat Integration in Industrial Processes) and Task 39 (Polymeric Materials for Solar Thermal Applications) within the Solar Heating and Cooling Programme of the *International Energy Agency*, member of the advisory committee of the German Solar Thermal Technology Platform (DSTTP), member of the scientific committee of Euro sun 2010 conference (Graz, Austria) and consults with the industry in the field of sustainable energy.



In his speech, Prof Zörner wants to answer the question '*Why are renewables so successful in Germany?*' In doing so, he will show the status of renewables in Germany and then concentrate on electricity generation aspects. He will explain what happened in Germany to boost renewable electricity generation and put a focus on energy legislation. Prof Zörner hopes to provide advice (at high level) on the approach developing nations could adopt.

Eng. Geoffrey MUSONDA

Eng. Geoffrey Musonda has extensive practical experience in project management of power development and policy formulation. Eng. Musonda has worked with the private sector and in international organisations such as the United Nations Industrial Development Organization (UNIDO). He is currently the Chief Executive Officer (CEO) for the Rural Electrification Authority (REA) and is a former Assistant Director at the Ministry of Mines, Energy and Water Development (Department of Energy). Eng. Musonda holds a Master's Degree in Maintenance Engineering from Augsburg University of Applied Sciences, Germany and a Bachelor's Degree in Mechanical Engineering from the University of Zambia.



Eng. Musonda will speak on the "*Status of energy supply in Zambia, perspectives/way forward, integration of renewables, legislative framework and regulations to increase renewable energy in the national energy mix*".

Eng. Christopher CHISENSE



Eng. Christopher Chisense holds a Master degree in Environmental Engineering from University of Nottingham, in United Kingdom, and Bachelors of Engineering in Mining Engineering from University of Zambia. He is a registered Engineer with EngRB, Professional Member of Engineering Institute of Zambia and a Professional Impact Assessment Member. He is currently a Director -Water Resources & Environmental Management, at the Zambezi River Authority. Eng. Chisense will address delegates on "*The importance of water resource management and environmental protection in the development of economic infrastructure*". Development of small and large dams is key for sustainable water resources management for economic and social development in a world where population increase and the development agenda are leading to increased demand for water and energy and treating available limited water resources and environmental protection as well. Countries are increasingly planning to use water infrastructure to systematically and sustainably harness the available water resources to meet the demands of society without causing the limited resource neither to run out nor to cause threats to existing ecosystems and the environment. The International Commission on Large Dams (ICOLD) during its 24th Congress in Kyoto, Japan on 5th June 2012 made a

World Declaration on Water Storage which stated that “Humanity is facing a more severe water situation than it has ever faced in the past” and calls for “Joint efforts to develop water storage infrastructure in a sustainable way.” If society is to harness water resources sustainably and with environmental protection in mind, this declaration points to key strategy that is implementable for sustainable water resources management especially in the wake of climate change.

Dr. Ludger ELTROP



Dr Ludger Eltrop is the Head of Department in System Analysis and Renewable Energies at the Institute for Energy Economics and Rational use of Energy - University of Stuttgart, Germany. He lectures in renewable energy technologies, bioenergy and RE systems. Dr Eltrop has conducted research on acid rain impact on sugar maple, renewable energy and integration into energy systems, research and development projects in biomass and solar energy and systems integration of renewable energy technologies international in Asia, Africa and South America. He has been Research Assistant in Fungal Microbiology and Research Assistant in Plant Physiology at University of Toronto. Dr Ludger Eltrop holds a PhD in agricultural and environmental sciences, from Universität Hohenheim, German, a post-diploma research on nutrient cycles in mycorrhizal fungi and a Diploma in Biology, allgemein, Rheinische Friedrich-Wilhelms-Universität Bonn.

Dr Ludger Eltrop will cover “*Mobility and use of alternative fuels and biogenic gases from biowaste and landfill*” and will report from some *experiences in Germany on penetration and high shares of renewable energy in the energy system, solar and wind energy*. Dr Eltrop’s presentation will *address the systems integration aspect*“.

Dr. Lubinda HAABAZOKA



Dr. Lubinda Haabazoka is a Senior Lecturer in Economics, Banking and Finance in the School of Business. He is currently Head of the Accounting and Finance Department. He holds a Doctor of Philosophy degree in economics with a focus on Banking, Master of Science degree in Finance and Credit with a specialization in Banking from Rostov State Economics University (Russia). Dr Haabazoka has worked at the Copperbelt University since 2010 and also serves as northern region Economics Association Zambia Chairperson. As Senior Lecturer at the Copperbelt University, Dr. Haabazoka has conducted several research projects, among which are a study on Capital Market developments in Zambia, the National Economic Advisory Council commissioned study on youth employment creation in Zambia (with other researchers) and the National Economic Advisory Council study on Railway Industry Developments in Zambia. In the last four years, he has conducted research on employment creation, Effects of Fuel Price Subsidy Removal in Zambia, Role of Banking Sector in Economic Development and Diversifying the Copperbelt’s economy. Dr Haabazoka is also author of four

academic books and more than twelve academic research papers. He has presented a number of academic papers at international conferences in Europe, Asia and Africa.

Dr Haabazoka will endeavour to answer the questions: *Is Zambia and Africa ready for one sided DFI? Or should Zambia and Africa push for a more balanced /equitable sharing of investment? Does Africa have choice in the matter?*

Dr. Simon TEMBO

Dr. Simon Tembo has over 20 years of experience in the ICT/Telecommunications sector with expertise on equipment Conformance and Interoperability (C&I) as a practitioner, academic and researcher. His expertise in strategic planning and operation for the ICT/Telecom operators; developing policy and regulation; and network planning and development has enabled him to develop curriculum for the Master and Bachelor of Engineering degree programmes in ICT/Telecom at the University of Zambia. He has also developed a diploma programme curriculum in Legal and Industrial Metrology. Dr. Tembo has published widely in both Journal and conference publications on human capacity development. He is a former CEO / Managing Director of Zambia Telecommunications Company Limited (ZAMTEL), Assistant Dean Postgraduate in the School of Engineering at the University of Zambia, and he is currently serving as the Head of Department for Electrical and Electronic Engineering Department in the School of Engineering at the University of Zambia. Dr.Tembo is a member of the Energy Regulation Board Grid Code Technical Committee, where he serves as a Vice Chairman. He holds a Dr. Eng. Degree in Electrical, Electronic and Computer Systems Engineering from Akita University in Japan, a Master of Engineering Degree in Information and Network Science from University of Electro-Communications in Japan, a Bachelor of Engineering Degree in Electrical and Electronics Engineering from the University of Zambia and a Registered Practicing Engineer with Engineers Registration Board of Zambia.



Dr Simon Tembo will address the delegates on *New Strategic Direction to Generate Electricity in Zambia – the Smart Grid Power Generation in the 21st Century*. The 2015/2016 drought which the country experienced has revealed the risks, uncertainties and consequences involved in dependence on the hydropower generation. This has led to electricity load shedding throughout the country thereby affecting every sector of the country's social-economy. The impact of load shedding has been increasingly severe and diverse on all spheres of the country's economy. There is an urgent need for Zambia to switch over from conventional hydropower generation to create a diverse electricity generation (called source mix) by promoting the use of other energy technologies that are sustainable and can meet the present and projected country's electricity demand. His presentation will share the experience and methods other countries have adopted to create an optimal electricity supply-demand structure to serve the nation.

Eng Charles MUSHOTA



Eng. Charles Mushota is the Executive Director of Zambia's National Council for Construction. He is a Civil Engineer by profession and holds a Master of Science in Infrastructure Planning, a Bachelors of Engineering in Civil Engineering and a Post-Graduate certificate in International Construction Management. He has served the built environment in many capacities including being the Director and Chief Officer at the Road Development Agency, Deputy Director (Standards) at the Zambia National Tender Board and an Executive Director at Estal Pride Limited.

Other previous engagements include being contracted by the Uganda National Road Authority (UNRA) to carry out an evaluation of priority road tenders in 2011, a Lecturer at University of Zambia, a Consultant to the Technical Education, Vocational and Entrepreneurship Training Authority (TEVETA) and also an imprest Accounting Officer for the European Development Fund. Eng. Mushota serves on many committees such as the Zambia Certified Accountant's Tender Committee, Food Reserve Agency Tender Committee and National Water and Sanitation Council Tender Committee. He is a deputy task manager for the Public Expenditure Management and Financial Accountability Programme (PEMFA) at the Ministry of Finance and National Planning, a Commissioner at the Energy Regulation Board Commission of Inquiry and a member of the National Pensions Scheme Authority.

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31 August -2 September 2016, Livingstone, Zambia

**International Conference on Infrastructure Development
and Investment Strategies for Africa**

31st August – 2 September, 2016

Dear Author

PEER REVIEW PROCESS: INTERNATIONAL CONFERENCE ON DEVELOPMENT AND INVESTMENT IN INFRASTRUCTURE – (DII 2016): LIVINGSTONE, ZAMBIA 2016

I confirm that a three-stage double blind peer review process was undertaken in this conference to ensure a high quality of conference proceedings. At least two acknowledged experts in a subject area were asked to review a one paper. In this context, submitted abstracts were twice blind reviewed. Authors, whose abstracts were accepted were provided with anonymous reviewers' comments and requested to submit their full papers provided they addressed all the comments and concerns raised by the reviewers. The scientific committee ensured that all the comments from the reviewers had been attended to. In addition, evidence was required relative to the action taken by authors regarding the comments received. The full papers were reviewed in terms of their:

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

Authors whose papers were accepted after this second review were provided with additional anonymous reviewers' comments and requested to submit their revised full papers. These final papers were only included in the conference programme and the conference proceedings after evidence was provided that all comments were appropriately responded to. At no stage was any member of the Scientific Committee or the editors of the proceedings involved in the review process related to their own authored or coauthored papers. The role of the editor was to ensure that the final papers incorporated the reviewers' comments and arrange the papers into the final sequence as captured on the USB memory stick and Table of Contents. Of the 67 submissions received, only 45 papers were finally accepted for presentation at the conference and included in these proceedings. In order to be eligible for inclusion in the proceedings, these papers were required to receive a unanimous endorsement from all the reviewers who had been assigned the paper to review that indeed the paper was suitable for inclusion in the proceedings and publication.

Regards

Tresor Mbayahe

DII-2016 Secretariat (PRP)

Email: info@diiconference.org

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KEYNOTE ADDRESSES

DII-2016-K-001

High Shares of Renewable Energy and Renewable Fuels for Mobility in the Energy System – Concepts and Critics taking the example of the German “Energiewende” (Energy Turnaround)

Dr. Ludger Eltrop

Abstract

The energy world has changed drastically, at the latest after the Fukushima nuclear accident in March 2011. Many countries of the world have focused their energy policy towards renewable energy and exploiting their own regional energy resources. The challenges for an energy system with high shares of renewables are nevertheless high. To meet the variable energy demand, the fluctuating solar and wind energy needs to be compensated by other flexible energies, particularly biomass and geothermal. Other technologies and e.g. storage add on to what is known as flexibility options and a merit order of flexibility. The potentials of renewable energy are high, but technologies need to be organized in a smart way. Recent developments show a trend towards “sector coupling” - the interconnection and merging of electricity generation, thermal energy and mobility. High amounts of renewable electricity can be converted to gaseous fuels (e.g. hydrogen, methane) or heat at times when electricity demand is low. These technologies, widely known as Power-to-X (P2X), play an important role in balancing an energy system with high shares of renewable energy. The mobility sector plays a particular role in P2X concepts. Excess renewable electricity can be converted to gaseous fuels (hydrogen, methane) or used directly in electric vehicles. Renewable fuels are widely used in various parts of the world and are now successively growing together with the (renewable) energy sector. In the presentation, the use of renewable fuels and the interconnection with the power sector are described and demonstrated, taking the example of Germany and other European countries, where high shares of renewables are an explicit objective of energy policy.

Keywords: renewables, flexible energies, sector coupling

DII-2016-K-002

New Strategic Direction to Generate Electricity in Zambia: The Smart Grid Power Generation in the 21st Century

Dr. Simon Tembo

Abstract

The 2015/2016 drought which the country experienced has revealed the risks, uncertainties and consequences involved in dependence on the hydropower generation. This has led to electricity load shedding throughout the country thereby affecting every sector of the country's social-economy. The impact of load shedding has been increasingly severe and diverse on all spheres of the country's economy. There is an urgent need for Zambia to switch over from conventional hydropower generation to create a diverse electricity generation (called source mix) by promoting the use of other energy technologies that are sustainable and can meet the present and projected country's electricity demand.

This presentation shares the experiences and methods other countries have adopted to create an optimal electricity supply-demand structure to serve the energy needs of the nation.

Keywords: electricity generation, smart grid, Zambia

DII-2016-K-003

Why are Renewables so Successful in Germany?

Prof. Wilfried Zörner

Abstract

This presentation enlightens on why renewables are successful in Germany. The status of renewables in Germany is shown, with a focus on electricity generation aspects. The factors and occurrences which contributed to boosting renewable electricity generation, with a focus on energy legislation are also addressed. In addition, the presentation provides advice (at high level) on the approach which developing nations could adopt.

Keywords: energy, renewables, success factors, sustainability

DII-2016-K-004

Project Finance for the Construction Sector in Africa: Challenges and Prospects

Dr. Lubinda Haabazoka

Abstract

The construction sector remains one of the most important economic sectors of any country's economy. A well-developed construction sector is a prerequisite to enhanced infrastructure development which is cardinal to a country's economic development. One of the factors that enhance construction sector growth is finance. Unfortunately, Africa still is unable to attract large investments into its construction sector as compared to other continents because investors view the continent mostly as a source of cheap mineral resources.

The main aim of this paper is to outline the role of project finance in enhancing construction sector growth in Africa. The paper also aims to outline the size of Africa's construction industry, major sources of project funding and also study the challenges and prospects for the sector.

The paper contains 6 sections: Section one is the introduction; Section two gives an overview of Africa's construction sector; Section three outlines the main sources of construction sector project funding in Africa; Section four presents an overview of Zambia's construction sector and its funding structure; Sections five discusses the challenges facing project finance in Africa's construction sector; and section six offers prospects for construction sector growth in Africa.

In general, the presentation attempts to answer the following: *Is Zambia and Africa ready for one sided DFI? Or should Zambia and Africa push for a more balanced /equitable sharing of investment? Does Africa have choice in the matter?*

Keywords: Africa, construction sector, project finance, public private partnerships

DII-2016-K-005

Production of “UMZ” High Quality Steel Rebars: Requirements, Processes and Benefits

Dr Julius Kaoma

Abstract

Universal Mining & Chemical Industries Ltd - Kafue Steel Plant manufactures high quality rebars under the “UMZ” trade name. This brief presentation will enlighten on the manufacturing of these high quality rebars. The following are highlighted:

- i) the consumers’ requirements with respect to the properties of rebars;
- ii) different processes for the production of rebars under which the process of “UMZ” high quality rebars will be described; and
- iii) the benefits that accrue when the UMZ rebars vis -a-vis their properties when used.

Keywords: high quality production, steel rebars

DII-2016-K-006

The Importance of Water Resource Management and Environmental Protection in the Development of Economic Infrastructure

Eng. Christopher Chisense

Abstract

Development of small and large dams is key for sustainable water resources management for economic and social development in a world where population increase and the development agenda are leading to increased demand for water and energy and treating available limited water resources and environmental protection as well. Countries are increasingly planning to use water infrastructure to systematically and sustainably harness the available water resources to meet the demands of society without causing the limited resource neither to run out nor to cause threats to existing ecosystems and the environment. The International Commission on Large Dams (ICOLD) during its 24th Congress in Kyoto, Japan on 5th June 2012 made a World Declaration on Water Storage which stated that “Humanity is facing a more severe water situation than it has ever faced in the past” and calls for “Joint efforts to develop water storage infrastructure in a sustainable way.” If society is to harness water resources sustainably and with environmental protection in mind, this declaration points to key strategy that is implementable for sustainable water resources management especially in the wake of climate change.

Keywords: economic development, environmental protection, water resource management

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RENEWABLE ENERGY TECHNOLOGIES SUMMIT (RETS) ABSTRACTS

DII-2016-RETS-001

Research Requirements in Renewable Energy Technologies for Southern Africa

Ackim Zulu¹, Mwansa Kaoma², Mundia Muya³, Shadreck Mpanga⁴, Donat

Ngendo⁵

Abstract

This paper presents the outcome of an assessment of the research needs in Renewable Energy Technologies (RETs) as applied to the Southern Africa region. The Southern African region is endowed with extensive renewable energy (RE) resources but is somewhat retarded in the development and assimilation of RETs which could increase the human development index of the countries in the region and help preserve the environment by avoidance of technologies that exploit polluting resources. This work has the premise that RETs in the region need to be developed and starts with identification of the immediate research needs. The approach to identifying the research needs was based on discussions held with targeted stakeholders, through innovative arrangements of focus groups, with the results of the discussions assessed for common elements. The investigation revealed four main areas that had common ground and had popular appeal, namely solar energy, bioenergy, control aspects and cross-cutting issues. It is believed that the results of this work can form a basis for creating well-directed development plans that systematically move the region in a common development direction.

Keywords: academic research, development, environment, renewable energy technologies, strategic planning

¹Senior Lecturer; Department of Electrical and Electronic Engineering; University of Zambia; Box 32379, Lusaka, Zambia; ackim.zulu@unza.zm.

²Lecturer; Department of Agricultural Engineering; University of Zambia; Box 32379, Lusaka, Zambia; mwansa.kaoma@unza.zm.

³Associate Professor and Dean; School of Engineering; University of Zambia; Box 32379, Lusaka, Zambia; mmuya@unza.zm

⁴Lecturer; Department of Electrical and Electronic Engineering; University of Zambia; Box 32379, Lusaka, Zambia; shadreck.mpanga@unza.zm.

⁵Lecturer; Department of Electrical and Electronic Engineering; University of Zambia; Box 32379, Lusaka, Zambia; dmngendo@unza.zm.

DII-2016-RETS-002

Dual Studies - An Alternative Pedagogy for Renewable Energy Training in Southern Africa

Andrew Zulu¹, Samuel John², Paul Chisale³

Abstract

Striking the right balance between theoretical and practical studies in academia is generally not an easy thing especially when implementing a new programme. With the continuous decline in production and supply uncertainty of fossil fuels, renewable energy curricula and technologies are taking centre stage. This elicits for the development of an alternative pedagogical approach, of dual educational programs, that combines both theoretical and practical training for technicians and engineers. The dual studies approach has worked well in many European countries and is proposed as the right mix for Southern Africa, in general, and for renewable energy technologies (RETs) in particular. RET training needs surveys were conducted and a curriculum framework and structure for dual studies for the vocational and professionals has been developed for the region. A strategy has also been developed to promote science and renewable energies among young people. It was observed that the dual study approach was warmly welcomed by the respondents, but industry participation holds the key to its success. Because of the need to bridge the identified skills gap, industry was also ready to join hands with academic institutions in the region for training in RETs.

Keywords: capacity building, dual studies, NEED, pedagogical, renewable energy technologies

¹Lecturer; Department of Mechanical & Marine Engineering; Namibia University of Science & Technology; P/Bag 13388, Windhoek, Namibia; azulu@nust.na

²A/Professor & Dean; Faculty of Engineering; Namibia University of Science & Technology; P/Bag 13388, Windhoek, Namibia; sjohn@nust.na

³A/Professor; Department of Mechanical & Marine Engineering; Namibia University of Science & Technology; P/Bag 13388, Windhoek, Namibia; pchsale@nust.na

DII-2016-RETS-003

Development and Harmonization of Renewable Energy Technology (RET) Standards in the SADC Sub-Region

Leungo Kelebopile¹, James Katende¹, Tunde Oladiran¹, Tedman Onyango¹,
Wilfried Zörner², Sabine Kapfhamer², Samuel John³, Paul Chisale³, Andrew
Zulu³, Mundia Muya⁴, Ackim Zulu⁴, Donat Ngendo⁴, Joseph Mbaiwa⁵, Moseki
Motsholapheko⁵

Abstract

The Southern African region is endowed with abundant renewable energy resources. However, the lack of access to sufficient and sustainable energy supply still affects most of the region. A number of factors hindering a widespread uptake of renewable energy technology have been identified in technical literature. These include a lack of: skilled human resources, clear policies and strategies to promote Renewable Energy Technologies (RETs), financial mechanisms, and relevant RET standards in the region. The paper will focus on the latter and considers the Southern African Development Community Cooperation in Standardization's (SADCSTAN) pathway for development and harmonization of RET standards in the Southern African region. A multiple case study methodology was adopted to compare the SADCSTAN model to the European model which is more established and successful at harmonization of standards. Similarities were observed between the two models; however, the number of standards that have been harmonized at regional level through SADCSTAN is low and non-existent in some fields such as RETs. The overall objective of the study is to identify and mitigate factors that might be attributed to the delay in development and adoption of harmonized RET standards in the Southern African region.

Keywords: harmonization, NEED, renewable energy technology, SADC, standards development

¹College of Engineering and Technology; Botswana International University of Science and Technology, Botswana;
kelebopile@biust.ac.bw)

²Institute of New Energy Systems, Technische Hochschule Ingolstadt, Ingolstadt, Germany

³School of Engineering, Namibia University of Science and Technology, Namibia

⁴School of Engineering; University of Zambia, Zambia

⁵Okavango Research Institute, Botswana

DII-RETS-2016-004

Perceptions of Tourism Operators towards Renewable Energy Use in Accommodation Facilities in the Okavango Delta

Joseph E. Mbaiwa^{*1}, Moseki R. Motsholapheko¹, Donald L. Kgathi¹

Abstract

This paper analyses perceptions of tourism operators on the use of renewable energy in lodges and camps in the Okavango Delta, Botswana. The paper is informed by the concept of sustainable tourism. Both primary and secondary data sources were used in study. Secondary sources include: management plans, policy documents, published and unpublished articles on energy and tourism development in the Okavango Delta. Primary data collection focused on the administration of a structured and unstructured questionnaire to tourism operators. In addition, informal interviews were conducted with key stakeholders of the energy and tourism industries. Results indicate that fossil fuels are largely used in lodges and camps in the Okavango Delta when compared to renewable energy sources like solar power. Much of the fossil fuels used in the Okavango come from petroleum products. Lodges and camps in the Okavango Delta rely on individual diesel generators to meet their energy demands. Fuel wood is also used for bonfires and heating the water. However, some of the lodges have started using solar energy to complement that which is generated from petroleum products. The majority of the tourism operators especially those who have registered for Eco-certification have positive perceptions towards the use of renewable energy particularly solar energy. There is need, therefore, for policy developments that address the lack of renewable energy distribution in the Okavango Delta. Policy development should encourage renewable energy particularly solar energy which is environmental friendly when compared to fossil fuels to achieve sustainable tourism in the Okavango Delta.

Keywords: renewable energy, solar energy, Okavango Delta, fossil fuels

¹Okavango Research Institute, University of Botswana

Private Bag 285, Maun, Botswana

*Corresponding author: Phone: +267 6861833, e-mail: JMBaiwa@ori.ub.bw

DII-RETS-2016-005

Sustainable Renewable Energy Mini-grids for Energy Access: Economic and Social Benefits of Mini-grid Systems

Paul Chisale¹, Samuel John², Andrew Zulu³

Abstract

Sub-Saharan African region has one of the highest solar irradiation levels; approximately 6kWh/m². Yet, most of the people who live in rural areas, approx. 64%, are energy-poor. Mini-grid systems provide alternative means to access clean energy, especially for rural communities, since they can operate in stand-alone and central grid modes. Despite the numerous advantages of solar photovoltaic (mini grids) systems, there are also several challenges that inhibit successful deployment of renewable energy mini-grids in order to ensure their long-term sustainability. These challenges range from economic, financial, technical, policy and legal impediments. The social and economic benefits that come along with renewable energy mini-grids deployments at local and national level are key ingredients of the country Human Development Index (HDI) and these are discussed in the session.

Keywords: HDI, laws, mini-grids, policy, sustainability, sustainability

¹Associate Professor, Namibia University of Science and Technology, Faculty of Engineering, Department of Mechanical and Marine Engineering, PB 13388, Windhoek, Namibia, pchisale@nust.na,

²Associate Professor, Namibia University of Science and Technology, Faculty of Engineering, Department of Mechanical and Marine Engineering, PB 13388, Windhoek, Namibia, sjohn@nust.na

³Lecturer, Namibia University of Science and Technology, Faculty of Engineering, Department of Mechanical and Marine Engineering, PB 13388, Windhoek, Namibia, azulu@nust.na

3

RENEWABLE ENERGY INFRASTRUCTURE DEVELOPMENT

DII-2016-021

Sewage Plants' Potential to Produce Biogas for Electricity Generation: Case Study of the Three Zimbabwe Municipalities

Mercy Manyuchi^{1*2}, Shepherd Tichapondwa³, Joseph Govha¹, Daniel Ikhuhu-Omoregbe², Oluwaseun Oyekola²

Abstract

Treatment of municipal sewage sludge is a problem in Zimbabwe. However, if the appropriate waste-to-energy technologies are applied, sewage plants can generate their own electricity thus minimizing municipalities' reliance on the already strained national grid. An experimental study was therefore conducted on the Chitungwiza, Firle and Crowborough sewage plants, assessing the potential to harness biogas for electricity generation. These plants have sewage treatment capacities of 19.6 ML/day, 140 ML/day and 54 ML/day, respectively. Plant tours and inspections of the plants were conducted and an understanding of the plant designs as well as the current process flow was attained. Particular emphasis was placed on establishing the availability and state of infrastructure available for the production, handling and storage of biogas. All three plants have bio-digesters on site. However, the Chitungwiza digesters are open at the top thus releasing gas to the atmosphere. Firle and Crowborough plants are equipped with the basic infrastructure for biogas generation and storage; however, major refurbishments are required. Samples of sewage sludge were collected from the plants and placed under conditions that mimic a typical digester, the resultant biogas was analysed. The biogas was predominantly composed of methane (53-65%), CO₂ (22-27%), trace gases such as H₂S, N₂ and H₂ accounted for the balance. Experimental results revealed that the use of 50 g/m³ Acti-zyme as a bio-catalyst increases the quantity of methane produced to 72-78%. Based on the experimental results and the design capacities of the plants, the estimated power generation potential was 0.57-1.20 MW, 4.2-8.1 MW and 1.53-4.56 MW for the Chitungwiza, Firle and Crowborough, respectively. These

¹Department of Chemical and Process Systems Engineering, Harare Institute of Technology, Harare, Zimbabwe

²Department of Chemical Engineering, Cape Peninsula University of Technology, Bellville, Cape Town, South Africa

³Institute of Applied Materials, Department of Chemical Engineering, University of Pretoria, Hatfield, Pretoria

*Corresponding author:mmmanyuchi@hit.ac.zw

capacities vary depending on whether it is the wet or dry season. An economic assessment indicated the viability of harnessing biogas from the three plants especially after incorporating Acti-zyme as the digestion catalyst to actively increase the electricity generated.

Keywords: Acti-zyme, biogas, digestion, electricity generation, municipal sewage sludge

1. Introduction

The energy demand in Sub-Saharan Africa (SSA) continues to grow on a yearly basis. This is mainly driven by increasing population as well as increased industrial, mining, agricultural activities. The rise of these activities results in higher levels of pollution and waste generation; municipal waste water treatment plants are particularly affected. Government and private sectors are constantly on the lookout for technologies that will allow for more efficient and cost-effective waste treatment. One such technology is the ability to successfully treat municipal sewage sludge through digestion in biogas plants. When fully optimized, biogas plants with anaerobic digesters not only provide pollution reduction, but also allow for sustainable energy, compost and nutrient recovery. Thus, wastewater treatment with the aid of biogas plants converts a waste disposal problem into a profit making venture.

Municipal sewage sludge biogas collection and utilization for power generation is also a proven technology to deal with municipal sewage sludge in a sustainable manner. Municipal sewage sludge biogas plants can thus be seriously considered for implementation at the Chitungwiza, Firle and Crowborough municipal sewage plants in Harare, Zimbabwe. This consideration stems from a win-win situation that realizes several environmental benefits and the provision of a renewable source of energy for potential usage at the plant. Methane (CH_4), which is the main component of biogas, is a greenhouse gas (GHG) that has to be mitigated in line with the COP 21 and according to the Kyoto protocol. The Chitungwiza, Firle and Crowborough municipal sewage plants are currently releasing methane into the atmosphere but have the potential of harnessing the biogas for usage in the plant resulting in sustainable development.

The amount of municipal sewage inflow feeding into the Chitungwiza, Firle and Crowborough municipal sewage plants is a rapidly increasing beyond the installed capacity of the plants due to increased population growth, development of new residential areas coupled with higher standards of living, which result in a substantial increase in the amount of daily household and commercial waste. Environmental and health concerns, coupled with the ever-increasing cost of new municipal sewage plants, have forced the authorities to look for alternative methods to deal with the problem of municipal sewage sludge disposal looking into more sustainable and profitable ways of dealing with solid waste such as composting and municipal sewage sludge conversion to biogas. The harnessing of the biogas in

the municipal sewage plants will change the situation by eliminating many negative environmental impacts and also provide a renewable source of energy that can be used to provide power in the plants and this formed the basis of this study.

1.1 Problem Statement

Currently, the sewage plants are not harnessing biogas from sewage sludge which can be converted to electricity yet they are using electricity from the national grid which is currently facing a large energy deficit.

1.2 Project objectives

The main objectives of the project were:

- i. Evaluating the existing infrastructure for suitability of biogas production. i.e. currently existing bio-digesters or ponds
- ii. Conduct a techno-economic assessment for applying the Acti-zyme technology in optimizing sewage sludge conversion to electricity

2. Background

2.1 Biogas production process

Biogas is a gas produced from the anaerobic digestion of any biomass in the absence of oxygen to produce a mixture of gases comprising of methane, carbon dioxide, hydrogen sulphide and other trace gases depending on the type of the organic material. Biogas can be produced under mesophilic (20-40 °C) and thermophilic (>50 °C) conditions and if harnessed, it can be used for cooking, heating and electricity generation purposes (Arthur and Brew-Hammond, 2010). The natural anaerobic degradation of municipal sewage sludge in a digester follows similar pathway as the one that takes place in any anaerobic digester with net production of biogas (mainly methane). Figure 1 depicts the biological transformations that the municipal sewage sludge undergoes under anaerobic conditions such as hydrolysis, fermentation, acetogenesis and methanogenesis respectively. These steps occur simultaneously within in a digester and the microorganisms involved with each phase are metabolically dependent upon each other for survival.

2.2 Description of the biogas production processes

2.2.1 Hydrolysis

The hydrolysis phase consists of breaking down complex particulate matter into lower molecular weight compounds using hydrolytic enzymes such as proteases, cellulases, and lipases. The large compounds, for example proteins, carbohydrates, and lipids, are hydrolysed into smaller units such as amino acids, sugars and fatty acids. These small units will be taken in by microbial cells.

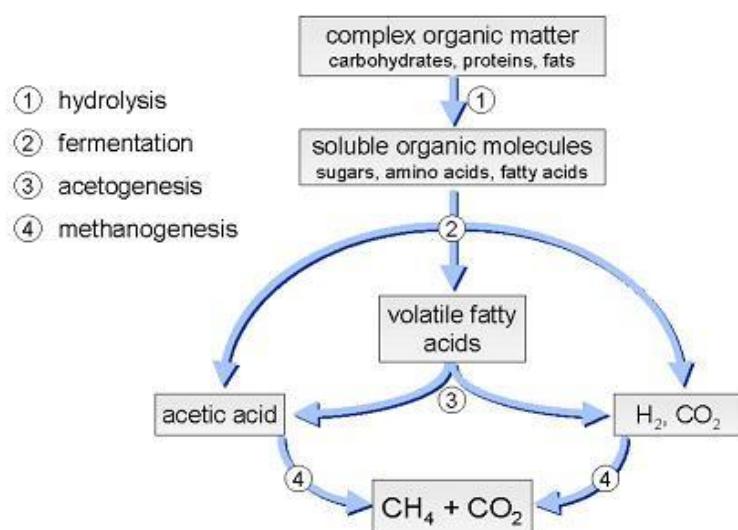


Figure 1: Basic anaerobic biochemical steps that transform organic municipal sewage sludge in municipal sewage plants to methane

2.2.2 Acidogenesis

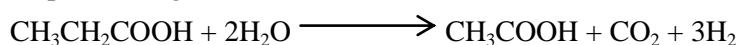
Acidogenesis is known as the beginning of fermentation. It continues breaking down the small units from the hydrolysis phase into more simple ones. The facultative and obligate bacteria used in this phase break down amino acids and sugars that resulted from hydrolysis into acetic acid and volatile fatty acids such as propionic and butyric acid. These bacteria also break down fatty acids existing in the digester into hydrogen, carbon dioxide and more volatile fatty acids. The simple molecules including acetic acid, hydrogen and carbon dioxide can be taken by the bacteria in the last phase – methanogenesis. The volatile fatty acids are more complex and need to undergo another phase called acetogenesis. The role of facultative bacteria is essential for the whole digestion process. They can metabolize through the oxidative pathway, and thus remove any dissolved oxygen within the mixture. Oxygen is toxic to some microorganisms, especially the methanogenic bacteria.

2.2.3 Acetogenesis

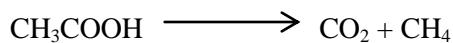
During acetogenesis, volatile fatty acids which are formed during the acidogenesis phase react with water in the presence of acetogenic bacteria. The products of these reactions are acetate, hydrogen and carbon dioxide. These products are also formed during the acidogenesis phase, but the complete acid break down is only achieved during acetogenesis. The reactions below show how propionic acid and butyric acid react with water as examples of volatile fatty acids getting broken down to form methane (Beam, 2011).

Breakdown of propionic acid:

Step 1: Acetogenesis

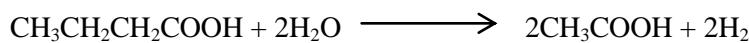


Step 2: Methanogenesis

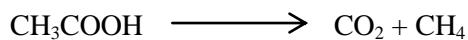


Breakdown of butyric acid:

Step 1: Acetogenesis



Step 2: Methanogenesis

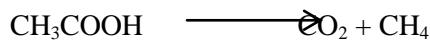


The first step occurs during acetogenesis while the second step is seen in methanogenesis. These two steps occur simultaneously. The products of acetogenesis are converted to biogas at the same rate at which they are produced.

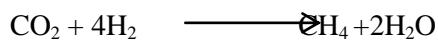
2.2.4 Methanogenesis

Methanogenesis is the last stage of digestion. Methanogenic microorganisms break down the end products of acetogenesis which are acetate, carbon dioxide and hydrogen to form biogas, predominantly made up of methane and carbon dioxide. About 70% of methanogens use acetoclastic pathway to form methane; while the other 30% use carbon dioxide reduction.

Splitting of Acetic Acid:



Reduction of carbon dioxide:



Acetotrophic methanogens break down acetate into methane and carbon dioxide. Hydrogenotrophic methanogens further the formation of methane by utilizing hydrogen to convert carbon dioxide to methane. Figure 2 shows a summary of biogas production to electricity generation.

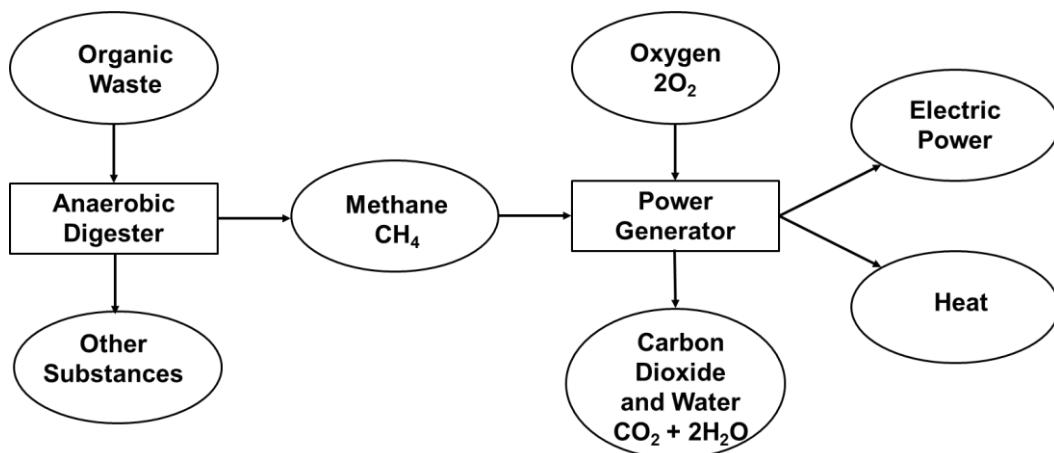


Figure 2: Biogas production stages for electricity generation

2.3 Use of acti-zyme in enhancing biogas production

Acti-zyme is an immotile biocatalyst which contains several enzymes that can be used in sewage treatment such as catalase, protease and amylase. However, Acti-zyme does not produce urease which promotes ammonia production which has a potential to cause eutrophication. From its biochemical tests, Acti-zyme does not promote hydrogen sulphide production meaning that the biogas produced will be of good quality and will not need to go through further treatment processes. Lastly Acti-zyme does not contain *Enterobacteriaceae* especially *E. Coli* and *Salmonella* which are pathogenic and are found in sewage. Therefore, Acti-zyme usage is not associated with health hazards and can efficiently promote and enhance biogas production in anaerobic sewage treatment.

Sewage sludge, like any other wastewater sludge, can be used for biogas production using Acti-zyme as bio-catalyst anaerobically (Duncan, 1970; Cailet *et al.*, 1986; Manyuchi, 2015). A typical biogas generation trend from the sewage sludge is shown in Figure 3 whereby the maximum amount of biogas is produced during the exponential phase whereby the bacteria is at its optimum. A summary of cases where biogas was used using Acti-zyme was used as the digestion catalyst during biogas production is shown in Table 1.

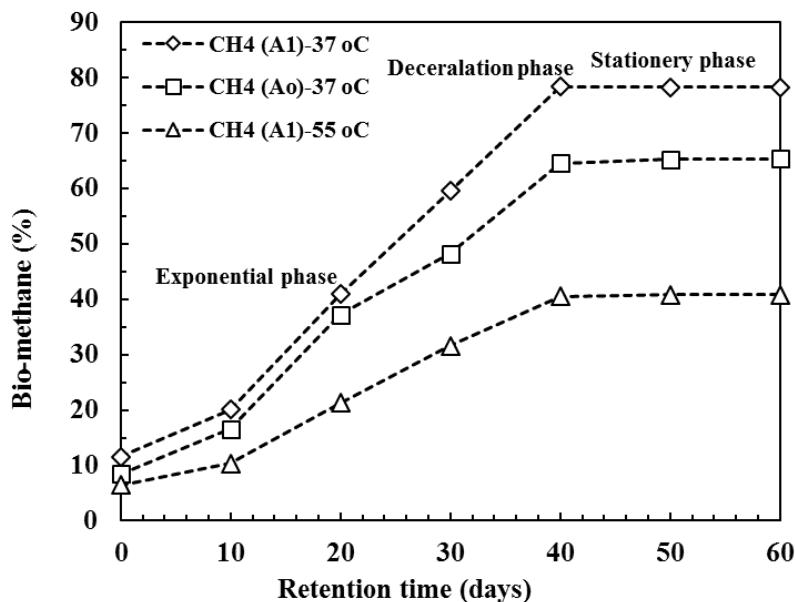


Figure 3: Typical biogas production trend (Manyuchi, 2016)

Table 1: Summary of biogas generated in Acti-zyme catalysed systems

Type of wastewater	Acti-zyme loading	Retention time (days)	Organic loading rate	T (°C)	pH	Biogas production rate	Bio-methane content	Ref
Wool scouring wastewater	1% (w/v)	207-211	0.75-0.99 kg/kg VSS	35 °C	7.1-7.4	2.9-3.3 m ³ /(m ³ .day).	68% higher compared to an A _o system	Cai et al., 1986
Hog waste	0.00625 %	50	0.5-1.5 L/day	35 °C	7.1-7.2	60% CH ₄ , 38% CO ₂ , 1% N ₂ , 1% water and H ₂ S traces	Duncan, 1970	
Sewage sludge	50 g/m ³	40	7.5 g/L.day	37 °C	400 mL/day	400 mL/day	72-78% CH ₄ , 16-20% CO ₂ , and traces (H ₂ S, N ₂ , H ₂)	Manyuchi, 2016

3. Process Description of Chitungwiza, Firle and Crowborough Municipal Sewage Plants

3.1 Detailed process description for the municipal sewage plants

The Chitungwiza, Firle and Crow borough municipal sewage plants all have two different types of plants at their water works, namely the conventional municipal sewage treatment plant and the biological nutrient removal (BNR) plant. Figure 4 shows the general flow diagram of both plants.

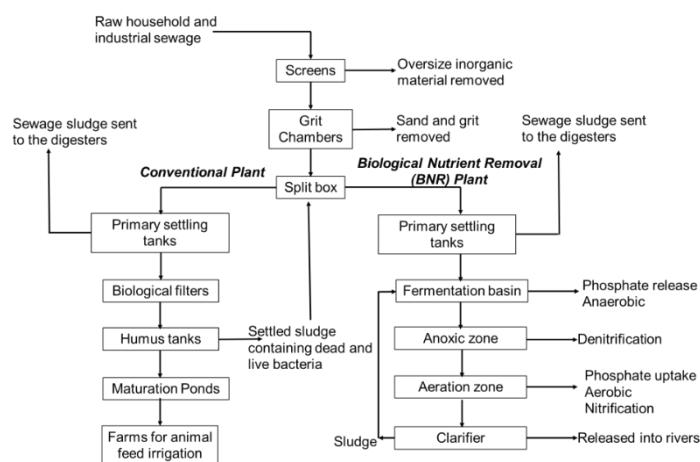


Figure 4: Municipal sewage treatment plants processes

3.2 Bio digester section description

Municipal sewage sludge from the primary settling tanks is sent to the digester section where it is treated in the manner shown in Figure 5. Once the sludge has been distributed into the different digesters which typically have a volume of $1\ 400\ m^3$ are of concrete construction. Anaerobic digestion of sludge takes place in the digesters, with microorganisms acting on the digestible matter and converting it to biogas. There are several conditions and variables that must be applied to obtain proper breakdown of the organic compounds. The operating parameters of the digester must be controlled so as to enhance the microbial activity and thus increase the amount of biogas produced. These parameters include: total solid content, temperature, retention time, pH and mixing.

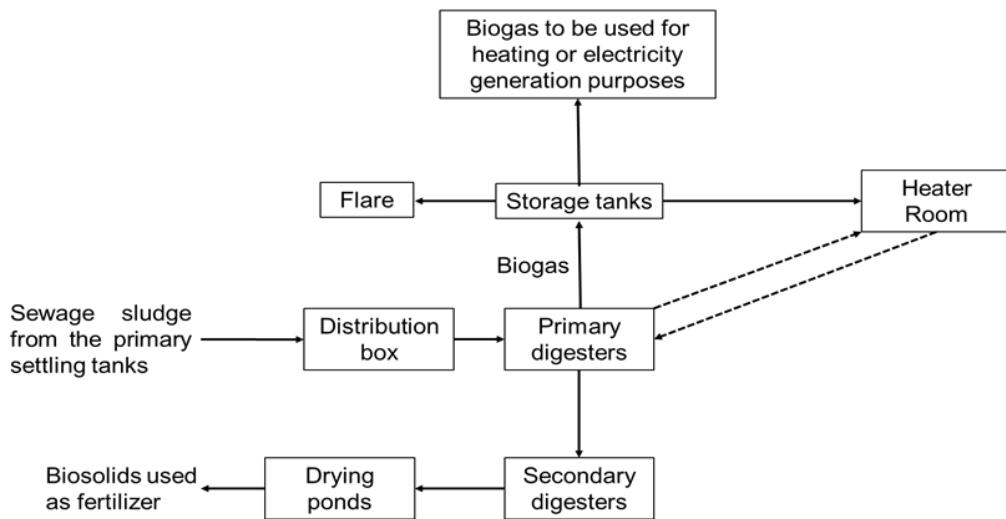


Figure 5: Schematic presentation of the biogas plants at the three plants

4. Main Features of Chitungwiza, Firle and Crowborough Municipal Sewage Plants Biogas Plants

4.1 Chitungwiza plant

Chitungwiza has two plants with a design capacity of 19.6 megaliters per day (ML/day) however currently it has an operating capacity of 23.5 ML/day in the dry season and 33.0 ML/day in the wet season. The biological nutrient removal (BNR) plant has two open primary digesters; however, this plant is currently not operational. The conventional plant where municipal sewage is currently being treated has no infrastructure to harness biogas although municipal sewage sludge is produced.

4.2 Firle plant

Firle has a design capacity of 140 ML/day; it is fitted with 19 primary digesters which have a residence time of 21 days and 3 secondary digesters however currently the plant is operating at 170-175 ML/day during the dry season and 220-230 ML/day during the wet season. Operation is under mesophilic conditions. The plant is also fitted with a heater room which consists of boilers which are heated by the biogas produced in the digesters. The heated water is then fed into heat exchangers that maintain the digester temperature at its optimum of 37 °C. This temperature is one of the parameters necessary for optimizing biogas generation together with good mixing and adequate residence time. The plant is also equipped with 2 biogas holding tanks which store and pressurize the gas. Currently no biogas is being harnessed despite the infrastructure being available, but Firle has a capacity to produce 97 000m³ in 3

hours of biogas if the plant is operating normally 4 megawatts per day and can save up to \$280 000.00 annually if the biogas is harnessed.

4.3 Crowborough plant

Crowborough has a design capacity of 54 ML/day but currently it is operating at 67.5 ML/day in the dry season and 125 ML/day in the wet season. The sludge treatment section consists of 7 x 1400 m³ primary digester with a residence time of 21 days under mesophilic conditions and 1 secondary digester. It also has a heat exchanger room and 1 biogas holding tank. No biogas is being harnessed at the moment.

Features inherent to the Chitungwiza, Firle and Crowborough municipal sewage plants energy system have determined the important requirements for comprehensive energy planning, these features include: (i) Chitungwiza, Firle and Crowborough municipal sewage plants has limited energy resources (ii) The infrastructure for harnessing biogas is available (iii) The current treatment being employed does not cater for biogas collection.

The summary of the design, dry and wet season capacities of the plants is given in **Table 2** based on the information found in the plant documents. The current operational capacities are way higher than the set design due to the increased population in Harare.

Table 2: Municipal sewage capacities for the three plants

Plant	Design capacity	Dry season capacity	Wet season capacity
Chitungwiza	19.6	22-25	28-38
Firle	144	170-175	220-230
Crowborough	54	65-70	120-130

5. Experimental Results

5.1 Municipal sewage sludge characterization

The raw municipal sewage sludge for all the three plants was characterized for its physicochemical parameters to determine the quality of the municipal sewage sludge and the results are shown in Table 3. The total solids (TS) which comprises of about 10% of the sewage is critical in determining the amount of biogas produced.

Table 3: Average raw municipal sewage sludge characteristics

Parameter	Value
pH	6.3-8.3
COD	750±12.5 mg/L
TS	1143±14.35 mg/L
VS	2.5±0.05%
Moisture content	60±20%/ /
TKN	245±5.1 mg/L
TP	52.5±2.7 mg/L
BOD ₅	557±2.5 mg/L

5.2 Biogas quality produced

The composition of the gas produced with and without Acti-zyme inoculation is shown in Table 4. Both sets of results show that methane (CH₄) is the predominant gas formed. Addition of the Acti-zyme biocatalyst significantly increased the amount of CH₄ formed by between 20 and 36%. The substantial amount of CO₂ and trace gases formed has a negative impact on the calorific value of the biogas this may therefore necessitate a scrubbing stage before the gas is used. The experimental results were used for quantifying and estimation of the amount of biogas produced from the three municipal sewage plants at industrial scale.

Table 4: Biogas composition from anaerobic digestion of municipal sewage sludge for systems with and without Acti-zyme

Gas	% (without Acti-zyme)	% (Acti-zyme)
CH ₄	53-65	72-78
CO ₂	22-27	16-20
Traces (H ₂ S, N ₂ , H ₂)	8-12	5-9

6. Municipal Sewage Sludge Biogas Production in the Municipal Sewage Plants

The possible amount of biogas to be generated from the 3 plants is indicated in Table 5 for all the various seasons of municipal sewage at the three plants. The electricity production potential was estimated according to Arthur and Brew-Hammond (2010) conversions and methodology (Table 6). The values presented hold within a deviation of ±20% of the current values in the sewage plants.

Table 5: Energy balance for electricity generated, usage and potential surplus at the three plants

Plant		Flowrate (ML/day)	Electricity produced without Acti-zyme (KWh per annum)	Electricity produced with Acti-zyme (KWh per annum)	Electricity required in plant (KWh per annum)	Surplus to the grid (without Acti-zyme)	Surplus to the grid (with Acti-zyme)
Chitungwiza	Design	19.6	5010203.74	6262754.68	4905600	104603.74	135715.68
	Dry season	23.5	6007132.04	7508915.05	4905600	1101532.04	2603315.05
	Wet season	33.0	6748437.70	8435547.12	4905600	1842837.70	3529947.12
Firle	Design	144.0	36809660.16	46012075.20	36441600	368060.16	9570475.20
	Dry season	172.5	44094905.40	55118631.75	36441600	7653305.40	18677031.75
	Wet season	225.0	46012075.20	57515094.00	36441600	9570475.20	21073494.00
Crowborough	Design	54.0	13803622.56	17254528.20	13665600	138022.50	3588928.20
	Dry season	67.5	17250528.20	21568160.25	13665600	3588928.20	7902560.25
	Wet season	125.0	25562264.00	31952830.00	13665600	11896664.00	18287230.00

Table 6: Potential electricity generation from bio-methane (Arthur and Brew-Hammond, 2010)

Parameter	Values
Bio-methane heating value	37.78 MJ/m ³
Bio-methane content	65 %
Biogas engine efficiency	29 %
Conversion factor	1KWh = 3.6 MJ

Assumptions: (i) The flowrate during the design and dry season have the same solids content which is about 10% of the sewage of which 0.5% of it is convertible to sewage sludge. The high flowrate is due to increased populations as well as legal and illegal settlements. (ii) During the wet season, there is an increase in flowrate due to surface runoff which mainly composes of soil and is removed during grit removal during sewage treatment. The remaining sewage has about 10% solids however about 0.4% is convertible to sewage sludge due to the dilution by surface runoff.

7. Economic Assessment for Harnessing Biogas

7.1 Energy balance for electricity produced in the three plants

A detailed energy balance was conducted so as to determine the amount of electricity that can be generated from the Chitungwiza, Firle and Crowborough plants. From the assessment indicated in Table 5, it is possible to generate bio methane than can sufficiently power the sewage plants especially systems which are inoculated with Acti-zyme. Excess electricity can also be generated and this can be sold to ZESA so that the energy deficit in the country is minimised.

7.2 Economic balance for biogas production at the Chitungwiza, Firle and Crowborough

Production of electricity from bio methane is a feasible process especially when Acti-zyme is incorporated as the digestion catalyst. For all the three plants an average of 20% increase was obtained for Acti-zyme incorporated digestion in terms of the electricity generated (Table 7). This shows the economic viability of generating biogas for reuse in municipal sewage plants resulting in sustainable development. The following was considered in conducting the economic balance:

- 60% on average is generated in sewage plants without biocatalysis
- 75% on average is generated in sewage plants with the aid of Acti-zyme as biocatalyst
- The internal rate of return was calculated over a 15 year sewage biogas harnessing period
- The economic assessment was based on refurbishment of the digestion section only

8. Conclusions and Recommendations

8.1 Conclusions

The Chitungwiza, Firle and Crowborough plants have potential to harness biogas for production of electricity for usage in the sewage plants, excess electricity can be sold to the national grid and alleviate part of the energy deficit. There is however need for refurbishment on infrastructure as well as optimizing the operation of the plants.

Table7: Summary of economic potential for producing biogas from the three plants

Plant		Flowrate (ML/day)	Sewage sludge quantity (t/day)	Biomethane produced without Acti-zyme (t/day)	Biomethane produced with Acti-zyme (t/day)	Electricity produced without electricity (MW)	Electricity produced with Acti-zyme (MW)	Capital investment without Acti-zyme (US\$)	Capital investment with Acti-zyme (US\$)	Payback period without Acti-zyme	Payback period with Acti-zyme	Net present value without Acti-zyme (\$)	Net present value with Acti-zyme (\$)	Internal rate of return without Acti-zyme (%)	Internal rate of return with Acti-zyme (%)
Chitungwiza	Design	19.6	101.92	2.65	3.31	0.57	0.71	3355882.13	3641852.67	10.30	8.19	1587009.34	2166049.64	5	9
	Dry season	23.5	122.20	3.18	3.97	0.69	0.86	3583491.33	3926364.17	8.51	6.97	2050304.30	2074561.80	8	12
	Wet season	33.0	137.28	3.59	4.46	0.77	0.96	3752739.20	4137924.00	7.63	6.35	2394805.68	3174737.52	10	13
Firle	Design	144.0	748.0	19.47	24.34	4.20	5.25	23468032.00	25869040.00	7.56	6.51	15113253.84	19338210.02	10.0	13.0
	Dry	172.0	897.0	23.32	29.15	5.03	6.29	25131330.00	27948162.50	6.62	5.78	1849870.85	23565798.91	13	15
	Wet	225.0	936.00	24.34	30.42	5.25	6.57	25569040.00	28495300.00	6.42	5.62	19389822.70	24678322.30	13	16
Crowborough	Design	54.0	280.80	7.30	9.13	1.53	1.97	7781 512.00	8 569 390.00	6.97	5.97	5438 015.59	7033033.72	12	15
	Dry	67.5	351.00	9.13	11.41	1.97	2.46	8569 390.00	9 554 237.50	5.93	5.15	7 041 728.91	9 035 872.82	15	18
	Wet	125.0	520.00	13.52	16.90	2.92	3.65	10466133.33	11925166.67	4.67	4.19	10902520.25	13856807.51	20	23

8.2 Recommendations

As for the sewage biogas energy harnessing, the following are recommended: (i) Cooperation/collaboration links should be established between ZERA, research institutes, the relevant ministries and Chitungwiza, Firle and Crowborough municipal sewage plant's for harnessing the biogas for reuse and transfer to national grid; (ii) In the new municipal sewage plants, new proven technologies should be investigated and possibly adopted such as the Acti-zyme technology for optimal biogas production. This specific technology has been implemented in other developing countries like Canada, Australia and America; and (iii) A detailed feasibility must be done for refurbishment of the 3 plants for biogas production and a comprehensive energy audit.

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Leveraging the Urban Dividends of Renewable Landfill Gas to Energy Infrastructure in EThekwini and Johannesburg Cities

Trynos Gumbo¹, Bonolo Letlape²

Abstract

World cities, particularly those within developed and transitional economies have been adopting and implementing better ways of managing municipal solid waste with the aid of advanced technologies. More special, innovative technological infrastructures have been adopted to collect, transport, dispose and treat waste not only improve the cleanliness of cities but also to leverage socio-economic and environmental benefits through the generation of renewable energy sources from landfills. In developing economies very few but albeit interesting and successful cases have been noted where landfill gas has been captured, flared as well as converted into renewable energy sources. This is particularly so in EThekwini and Johannesburg metropolitan cities in South Africa. Using the case study research design as well as both qualitative and quantitative research approaches, this work aimed to investigate the extent to which innovative technological adoption in the management of municipal solid waste has leveraged the urban dividends within the two metropolitan cities. Specifically, interviews, observations, photographic surveys and questionnaires were used to gather data from key informants, residents and four landfill sites; two from each metropolitan city. The study findings provided novel insights on the social, economic, environmental and physical benefits of the innovative technological infrastructures to the two metropolitan cities. The paper highlights the challenges that are being faced by the institutions responsible for the implementation of the innovations, particularly technological, skills and financial shortages necessary for the adoption and implementation of the innovations. Pursuant to that, the paper concludes by acknowledging the importance of investments in innovative technological infrastructures in the management of municipal solid waste, particularly in leveraging the urban dividends in cities of the developing world. The paper recommends the scaling up of innovative infrastructural technologies in renewable energy projects in South Africa and the replication of lessons from these best practices to other African cities.

Keywords: EThekwini, Innovative infrastructure technologies, Johannesburg, renewable energy, urban dividend

1. Introduction

Traditional energy sources that include coal, oil and natural gas among others; face an uncertain future due to a myriad of factors that range from depletion, price volatilities to environmental concerns (Hall *et*

¹Senior Lecturer, Department of Town and Regional Planning; University of Johannesburg; P O BOX 2298, Florida 1710;

²Btech Student; Department of Town and Regional Planning; University of Johannesburg; P O BOX 2298, Florida 1710;
bonololetlape@gmail.com

al., 2014). On the other hand positive developments associated with globalisation, industrialisation and improved standards of living have led to the emergence of new challenges such as increased solid waste generation that is costly to manage (Muzenda *et al.*, 2011). In the quest to devise solutions to these related global challenges, world cities, particularly those within developed and transitional economies have been adopting and implementing better ways of managing municipal solid waste with the aid of advanced technologies. More special, innovative technological infrastructures have been adopted to collect, transport, dispose and treat waste not only improve the cleanliness of cities but also to leverage socio-economic and environmental benefits through the generation of renewable energy sources from landfills (Ruiz *et al.*, 2013). In developing economies very few but albeit interesting and successful cases have been noted where landfill gas has been captured, flared as well as converted into renewable energy sources. In the African continent, among the renewable energy infrastructures worth noting is the landfill-gas to electricity infrastructural technologies that have been embraced since the advent of the new millennium. Innovative infrastructural technological investments in landfill gas to energy have been initiated to play an important role in MSW management (Nie, 2008).

The shift from a heavy reliance on fossil fuels as major sources of fuel has become imperative as it helps to mitigate the negative environmental impact that emanates from urban waste and also supports the production of more secured, clean energy sources that are critical for economic growth and sustainable development. This is particularly so in EThekwini and Johannesburg metropolitan cities in South Africa; that have joined a band wagon in the adoption and use of technologies that promote the production of renewable energy sources from municipal solid waste. Paradoxically, there is dearth of explicit studies that inform the impact of these innovations, hence a serious lack of scholarly literature on the impact of infrastructural technological investments on the urban settings and the dividends that accrue thereafter. This work therefore aims to investigate the extent to which the adoption and implementation of such innovative infrastructural technologies in the management of municipal solid waste have leveraged the urban dividends within the two South African metropolitan cities. The article in particular examines the social, economic and environmental benefits of converting municipal solid waste to energy sources that include gas and electricity at Marrianhill, Bisasar road landfill sites in EThekwini metropolitan municipality as well as Marie Louise and Robinson Deep landfill sites in Johannesburg metropolitan municipalities. The article therefore highlights the contribution of the innovative infrastructural technological investments towards the realisation of sustainable, secure and safe cities particularly in the African continent.

The paper starts by highlighting the key and relevant conceptual issues that illuminate the importance of managing municipal solid waste and the pertinence of the adoption of innovative infrastructural technological investments particularly in cities of the developing world. It goes on to present the research methodological approaches that were adopted and used to conduct the study on four landfill sites within the two cities. The research results are then presented and discussed in detail highlighting the various urban dividends that accrue to South African cities as direct and indirect results of the adoption and use of innovative renewable energy infrastructural technological investments. The paper ends by discussing the novel insights that are contributed within the discussions and ways of replicating the best practices that have been developed and implemented in South Africa to other parts of developing economies, particularly cities within the African continent. It also concludes by suggesting ways of improving management systems and processes to leverage the urban dividends accruing from the investments in innovative renewable energy technologies and approaches to making the technologies affordable and their implementation feasible in cities of the developing world.

2. Conceptual and Theoretical Synopsis

The triple processes and fairly recent developments that include globalisation, industrialisation and urbanisation have resulted in a paradox, where progressively there have been improved standards of living in most cities and retrogressively high volumes of municipal solid waste are being generated and productive activities demand high energy volumes to support the improving lifestyles (de Ligneris, 2013). This has resulted in opportunities as well as economic growth and development existing side by side to emerging new challenges in the ever-growing urban centres indiscriminately and improperly disposed wastes that decompose and release poisonous gases such as methane that are known to contribute to global warming and climate change (Basura *et al.*, 2012). This phenomenon is common in developing countries, particularly within the African continent, where the few ever growing cities continue to experience high urbanisation rates and the rapid and high concentrations of the urban people give rise not only to high demands for energy sources but also the generation of huge volumes of municipal solid waste (Simelane and Mohee, 2012). It has been noted that most African countries are facing fuel and energy deficits that give rise to costly energy imports (Frost and Sullivan, 2009) and in response to the clarion calls for the need for increased and huge financial investments as well as massive mobilisations of human and technological resources for the purposes of generating value and realising beneficiation from municipal solid waste, municipalities have begun to develop innovative ways of managing municipal solid waste where landfill gas is captured and thereafter flared, packaged or converted into electricity. The landfill gas to electricity conversion projects are believed to be one of the solutions to high import bills in the African continent. Besides, innovative infrastructural technological investments in the African cities for the purposes of converting waste into energy have great potential to achieve the goals of waste management, sustainable urban development and environmental management (Brunner & Rechberger, 2014).

2.1 Sources of municipal solid waste

Municipal solid waste is categorised depending on source of generation and as such the different types of such waste include household waste, industrial waste, commercial waste, construction and demolition waste, agricultural waste and municipal services waste (Gumbo 2016). Waste such as paper, plastics, metals, wood, ashes, glass, leather, yard wastes, e-waste (computers, phones and televisions), cardboards, food waste and household hazard waste belong to the household class, whilst waste from construction sites, power and chemical plants, fabrication, light and heavy manufacturing are referred to as industrial waste (Hoornweg & Bhada-Tata, 2013). According to Tchobanoglou *et al.*, (1993) commercial waste is generated by stores, hotels, office buildings, food markets and restaurants whilst construction and demolition waste is generated by demolition of building, renovation sites, road repair and new construction sites. It includes wood, dirt, bricks, tiles, concrete, and steel waste materials. Crops, diaries, farms, feed lots, vineyards and orchards, spoiled food wastes, hazardous waste such as pesticides and agricultural wastes such as rice husks, cotton stalks, coconut shells and coffee waste make up agricultural waste (Rand, Haukohl & Marxen, 2000). According to Rant *et al.*, (2000) municipal services waste is generated by street cleaning, parks, beaches, landscaping, water and waste water treatment plants, tree trimming, general wastes from parks, beaches and other recreational areas, sludge and street sweepings. More than 1.3 billion tonnes of municipal solid waste are generated a year worldwide and the Asian, European and Middle East countries have the fastest growing amounts of municipal solid waste (Hoornweg & Bhada-Tata, 2013). In most African countries the lack financial and technological

resources, municipal solid waste is improperly managed, rarely collected, indiscriminately dumped and decomposing on open spaces and dumping sites leading to emissions of greenhouse gases into the atmosphere thus affecting the earth's climate (Basura *et al.*, 2002; Simelane & Mohee, 2012). In South Africa for example, over 42 million m³ of solid waste are generated every year (SA Govt, 1999), consequently, the country has noted the impact of waste as a big challenge particularly to the environment and the state of cities (Simelane & Mohee, 2012).

2.2 Collection, transportation and disposal of municipal solid waste

Local government organisations have single-handedly managed municipal solid waste for a very long time without receiving any meaningful support from other stakeholders (Gumbo, 2013). The municipalities play critical roles of collection, transportation, disposal and treatment of municipal solid waste mainly because such services are considered the prerogative and responsibility of municipal authorities. However, other stakeholders that include national governments, private sector and civil society organisations have of late joined the bandwagon in managing municipal solid waste in support of municipalities. According to Muzenda *et al.*, (2012), the management of municipal solid waste involves several processes and stages such as the eco-design of production plants to assist in the reduction of waste at the source; reusing of waste; recycling and recovery of waste and composting, incineration and landfilling of collected waste from different sources. Waste collection processes differ depending on the state of the waste, that is whether it is sorted and separated or not. Recyclable waste can easily be collected and transported to recycling plants and companies for example paper from waste paper, steel from ferrous metal scraps whilst commingled waste from skips, curbs, drop-off centres and bunks before separating and sorting it into different material streams ((Tchnobannoglous & Kreith, 1993; Sabbas *et al.*, 2001). Unrecyclable municipal solid waste, particularly organic waste composed of food left overs is disposed at landfill sites and it is this part of the waste that decomposes and emits greenhouse gases such as methane and carbon dioxide in the process causing global warming and climate change (Jaramillo and Mathews, 2005). Consequently, landfill gas capture projects become necessary so as to reduce emissions and generate energy (Qin *et al.*, 2001; Bove and Lunghi, 2006; Demirbas, 2009).

2.3 Treatment of municipal solid waste

There are several methods of treating municipal solid waste such as incineration, gasification, landfilling, generation of biogas and utilization in a combined heat and power plant, generation of biogas and conversion into fuel and they involve technologies such as thermal treatment, chemical treatment and mechanical or biological treatment (Sabbas *et al.*, 2001). Incineration involves the burning of municipal solid waste (Gumbo, 2014) and the greenhouse gasses emitted during the incineration process from the waste is recycled in the process aiding in the reduction of greenhouse gases, hence the technology is more viable than the burning of fossil fuels such as coal which release carbon dioxide into the atmosphere (Hamer, 2003). Gasification involves the heating of solid waste at a temperature of above 1000°C in a gasifier, in an atmosphere starved of oxygen in order to have an incomplete combustion of the waste, thus resulting in the production of syngas that is made up mostly of carbon monoxide, hydrogen and methane that are used as a fuel (Pilusa & Muzenda, 2014). Municipal solid waste may also be treated through composting particularly the organic part of the waste to produce manure that is used in farming activities. Landfilling is also common in most developing countries and gas capture from landfills is also practised and the gas is used to generate electricity.

2.3.1 Landfill gas to electricity

Gases at landfill sites have traditionally been captured and flared solely to reduce the levels of poisonous gases such as methane, odours and to improve air quality of the surrounding communities (Ruiz *et al.*, 2013). It has however been recently realised that the flaring of landfill gas and its conversion into electricity has not only environmental benefits but also economic and social benefits, hence the past recent decades have witnessed innovative infrastructural technological investments that assist in the generation of electricity from landfill gas (Hall and Scrase, 1998). Landfill gas to electricity plants consist of extraction and utilisation systems. Extraction systems consist of vertical and horizontal perforated pipes and the gas is sucked out of the landfill through pumps or compressors directing the gas into production systems. The captured gas is in most cases purified, upgraded to almost methane and then used as fuel in gas engines running electric generators and can also be used in gas boilers to produce hot water for heating or in natural gas networks (Daskalopoulos *et al.*, 1997).

Landfill gas to electricity is a necessity. It enhances the quality of life, ensures a decrease in illegal dumping sites, reduces the reliance on fossil fuel combustion and a low carbon economy also leads to waste minimization and promotes the development of pollution prevention technologies the and the effective use of energy, materials and resources (Brunner & Rechberger, 2014). When designing and establishing landfill gas to electricity projects several factors are considered and these include the years of operation of landfill sites under consideration, the volumes of waste disposed, the configurations of the landfill site as they determine how wells and both vertical and horizontal pipes that capture and transport the gas to the engines need to be installed and overall assist in determining the likely amount of gas to be captured from the site (Jaramillo and Mathews, 2005; Escobar *et al.*, 2009). It is very important to make the right choices of appropriate engines that convert the gas to heat and electrical energy as they have different costs and efficiencies and in most cases the reciprocating internal combustion engines the so called IC engines that burn the gas by combining it with oxygen in the process running the engines connected to crankshafts that triggers the turning of generators that in turn produces electricity (Ravindranath and Balachandra, 2009).

3. Research Methodology

There have been clarion calls to academics for concerted engagement in informative and impactful topical research on environmental sensitive and friendly, more secure, clean energy sources that are critical for economic growth and sustainable development of cities (Pilusa & Muzenda, 2014). This study is a swift response and an attempt to highlight the benefits of renewable energy sources generated from municipal solid waste, one of the renewable resources that include wind, solar, marine and many others. The work adopted a case study phenomenological research design to investigate the extent to which innovative technological infrastructural adoption and implementation in the management of municipal solid waste has leveraged the urban dividends within the two metropolitan cities, EThekwin and Johannesburg. A case study research design is essential in focusing the study in terms of selecting the target population, data collection, data analysis, data interpretation and presentation (Barbie and Mouton, 2001).

The work applied both qualitative and quantitative research approaches to reveal the direct and indirect social, economic and environmental as well as physical benefits of generating landfill gas and electricity. Specifically a coterie of research tools that include interviews, observations, photographic surveys and

questionnaires (Leedy and Ormrod, 2010) were used to gather data from key informants, residents and from four landfill sites; Marrianhill, Bisasar road (EThekwini), Marie Louise and Robinson Deep (Johannesburg). Textual and statistical data was collected from officials working for the relevant national government departments, the two metropolitan municipalities, private sector organisations, non-governmental organisations and also community based organisations that are actively involved with the infrastructural technological innovations and their implementations in landfill gas to electricity generation projects. Pictorial data and images were captured with the aid of observations and photographic surveys of the four landfill sites. Both quantitative and qualitative data gathered from the field were analysed using appropriate tools and techniques such as excel and statistical package for social sciences (SPSS) for statistical data and through the application of content analysis for textual data. Data was presented in the form key themes that highlight the economic, social, environmental, physical and institutional urban dividends accruing from innovations in municipal solid waste management, particularly the capturing of gas from landfills and its flaring and conversions into renewable energy sources. Graphs, pictures and tables were also used to present the results of the study.

4. Leveraging the Urban Dividends of Renewable Landfill Gas to Energy Infrastructures - Cases of EThekwini and Johannesburg Cities

The South African government, at all spheres that are national, provincial and local; has been investing in innovative infrastructural technologies and advancements to deal with the challenges of municipal solid waste that has for a long time been polluting land, water and air. One of the innovations that have been adopted and implemented in the country is the capturing of gas from landfill sites for the purposes of removing it from the atmosphere and converting it into renewable energy sources. The innovations have been adopted to support global of reducing the heavy reliance on fossil fuels that pollute that are harmful to the environment (Nie, 2008; Kohler, 2015). Energy that is generated from methane gas that is captured from landfill sites is used for cooking, heating and other several uses thus helping to support not only energy security but also economic growth and development (Ouedraogo, 2005; Pilusa & Muzenda, 2014). This section presents novel insights on the urban dividends that are accruing from innovative infrastructural investments in municipal solid waste management; first in EThekwini metropolitan municipality and second and last in the Johannesburg metropolitan municipality. The results of the investments that include social, economic and environmental benefits are discussed in detail and illustrations in the form of tables, figures and photographs are provided the findings of the study.

4.1 Leveraging Urban Dividends through landfill gas to electricity projects in EThekwini

Innovative infrastructural technological investments in municipal solid waste in the case of South African metropolitan cities commenced in 2006 with Marrianhill project and later Bisasar road project that are both situated within the EThekwini metropolitan municipality. Table 1 more details about the two landfill sites. The landfill gas to electricity projects are the first in the African continent that seek to stabilise greenhouse gas concentrations in the atmosphere of which South Africa is a signatory to the agreements and efforts by the United Nations Framework Convention on Climate Change (UNFCCC).

Table 1: Characteristics of Landfill Sites in EThekweni

Characteristics Landfill site	Year site opened	Year of energy project commissioning	Size of site	Deposit rate/day
Marrianhill	1997	2006	18.5 Ha	700 Ha
Bisasar Road	1980	2008	44 Ha	3000 Ha

Source: Field Work Results 2013

The EThekweni landfill gas to electricity projects are installed with advanced infrastructure gas for the extraction, transportation, flaring and conversion of gas into electricity. Figure 1 illustrates the gas wells, vertical and horizontal gas pipes flare systems, gas engines and electricity generators that are installed at the projects. The costs of setting up of the infrastructure run into hundreds of millions of dollars, whilst annual running costs of such small to medium projects also run into tens of thousands (Gumbo, 2014).

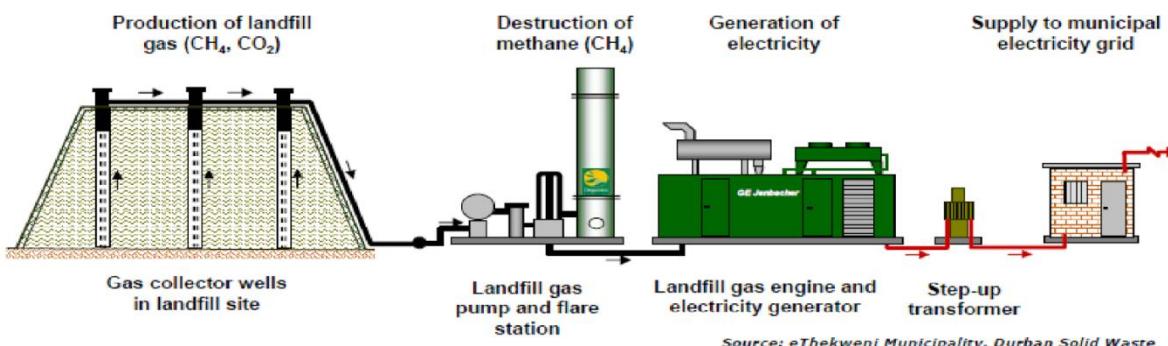


Figure 1: The sequence of landfill gas to electricity conversion in Durban (Source: EThekweni Municipality, 2013)

The illustration shows gas collector wells that are drilled in the landfill to suck the gas. It is then transported to all the pipes and then to the gas pump and flare station. When it reaches the engines, turbines and generator, the gas is converted into electrical energy. A step up transformer is used to assist in feeding the electricity of the same voltage into the municipality's grid.

There are several economic dividends that have accrued due to the implementation of the projects. The landfill gas to electricity projects in EThekweni generates a total of 7.5 MW of electricity. Figure 2, illustrates that the Bisasar road is the largest project as it produces about 87% of the total electricity whilst Marrianhill project that produces the remainder, which is 13%.

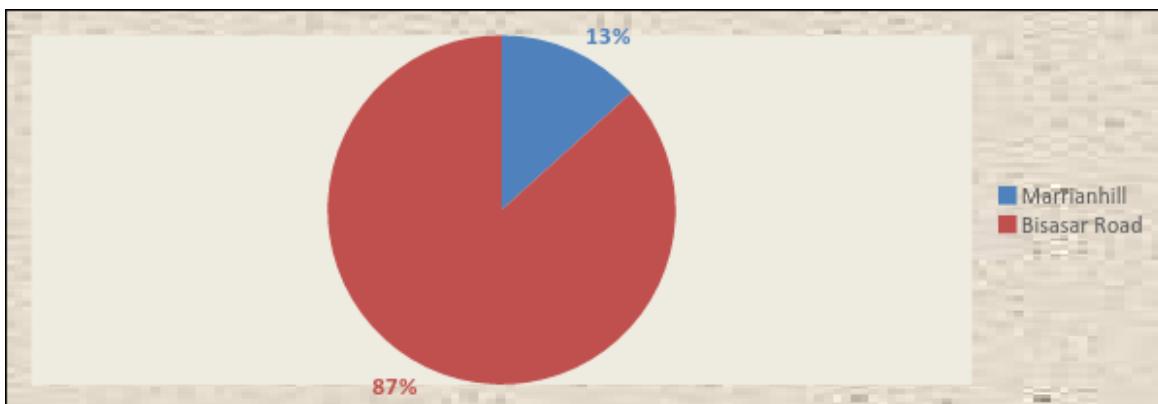


Figure 2: Electricity generated at the two landfill sites

The generated electricity is supplied to at least 3 750 houses within the municipality and a single MW is enough to cover at least 500 houses, thus generating income for the city. The landfill gas to electricity projects have already generated more than R48 million, mainly through the selling of certified carbon credits and it is estimated to generate a total of R400 million during its electricity generating life. The projects have managed to operate financially and technically due to government incentives and also support from international organisations and private sector companies that have been making huge investments thus making them feasible and sustainable.

The projects have resulted in several social urban dividends. First, the standard of living of the low income urban residents living around the Bisasar road landfill site for example has been changed as they are now benefiting immensely from the project, directly and indirectly. According to Figure 3, the project has led to employment creation for waste recyclers, unskilled labourers, semi-skilled and skilled personnel within the project.

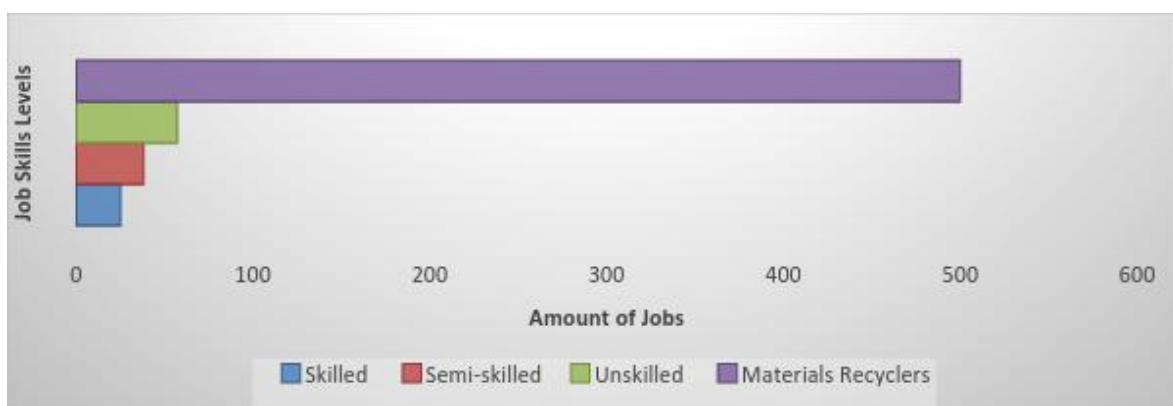


Figure 3: Employment created by the projects

The projects have also resulted in improved health standards of the residents due to the capturing of the gas and the spraying and fumigations around and within the landfill sites. Educationally, the projects have supported several students with bursaries. Figure 4, depicts recycling activities that are taking place at the landfill sites. The project has created employment for some local urban poor residents as reclaimers are able to sell collected waste to the informal recycling market.



Figure 4: Recycling activities at the two landfill sites

The recycling projects at the sites have resulted in the creation of jobs for the ordinary people within the municipality. Environmentally, the projects have yielded several benefits. Figure 5 illustrates essential environmental dividends accruing from the projects. The quality of air has improved; there is now clean water that is purified from leachate, clean land which has led to an environmentally safe, socially inclusive and economically productive municipality.

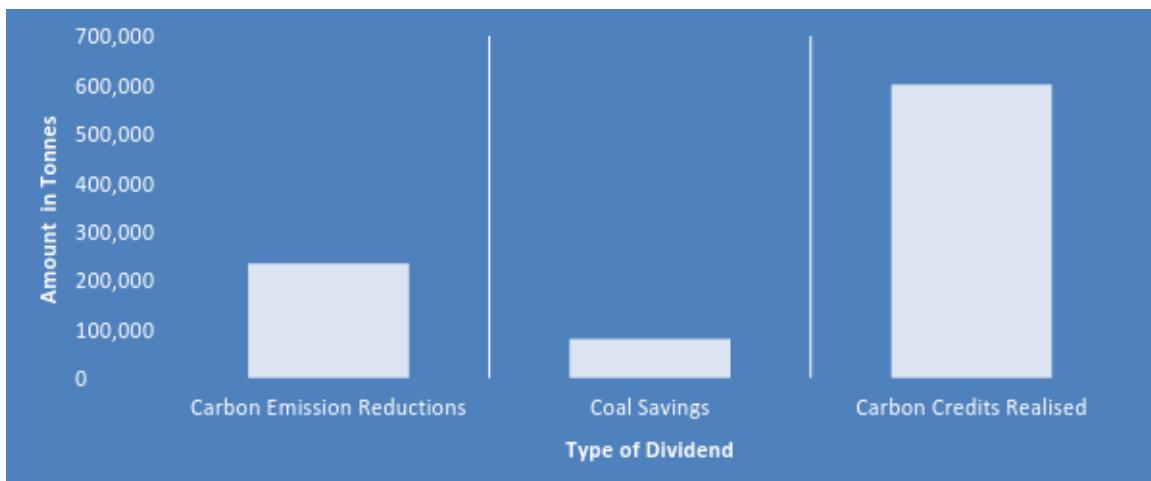


Figure 5: Environmental dividends accruing from the projects

The projects yielded higher environmental benefits compared to the financial costs and revenues, this has been proven in previous projects where costs of setting and establishing the technology and running the project is always higher than economic benefits , however this is always offset by massive reductions in gas emissions(Demirbas 2009; Lia and Tiberius, 2010). The projects have also reduced the burning of coal by thousands of tonnes every year and decrease the amount of methane and carbon dioxide in the atmosphere that are the main contributors of climate change. Leachate treatments at the landfill sites and also conservancy and plant rescue units (PRUNIT) have helped to reduce contamination of land and underground water as water purification that is recycled is used to irrigate plants at the sites. Physically, there have been massive developments of infrastructure within the cities emanating from huge investments within the landfill gas to electricity projects. Such investments in physically infrastructure lend the cities beautiful and sound development outlook. Institutionally, several organizations that are

efficient and innovative in their approaches have been set up to run the projects in their different capacities hence giving rise to reliable and effective institutions within the cities. The developments of strong partnerships among public, private and non-governmental organisations have also created strong capacities within the cities, as tackling the serious energy shortages becomes manageable.

4.2 Leveraging Urban Dividends through landfill gas to electricity projects in Johannesburg

The two landfill sites, Marie Louis and Robinson Deep receive hundreds of municipal solid waste such as domestic waste, green waste and recyclable waste is disposed of at the landfill site. Figure 6 shows that 64 116 321 381 132 kg and 65 906 308 431 663 kg municipal solid waste was disposed at Marie Louis; whilst 94 686 556 080 535 kg and 62 315 465 530 237 kg of waste was disposed between 2013 and 2014.

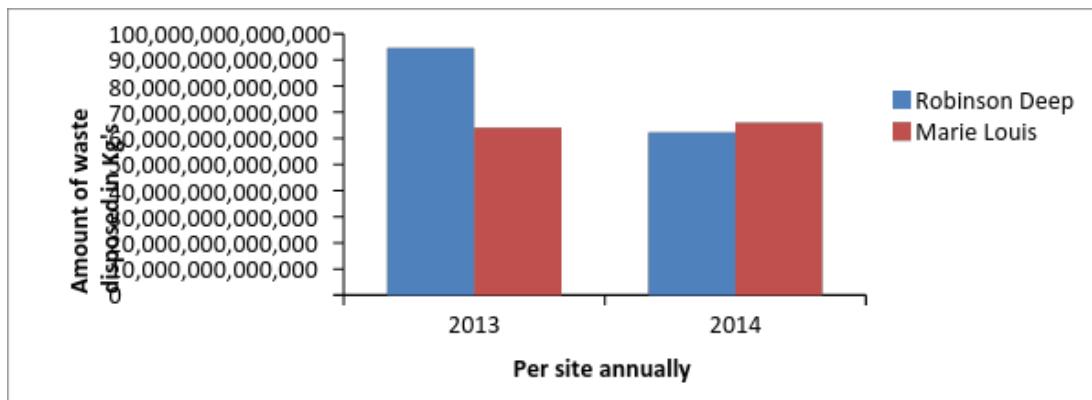


Figure 6: Amount of waste disposed at Marie Louis and Robinson Deep landfill sites in 2013 and in 2014

The landfill sites are served by a number of depots that include Zondi, Avalon and Roodepoort for Marie Louis whilst Robinson Deep landfill site is served by Southdale, Selby, Norwood, Waterval, Randburg and Melboro depots where 18 tonne compactor vehicles collect compact waste from households and transport it to the landfill sites. Figure 7, illustrates recycling activities taking place at the two landfill sites, where informal reclaimers select valuables for sale.



Figure 7: Reclaimers collecting waste from the tip

There are currently, 160 men and 140 women involved in informal waste recovery at Marie Louis landfill site, who separate it into different categories. The residual waste is spread around the active cells and sprayed with water, then covered with 5cm height of soil and later compacted using compactor trucks. Compacting helps to reduce the volume of waste, reduce odours and keep pest out. Covered waste is watered using watering tanks to reduce dust being blown to the nearby residents. Both Marie Louis and Robinson Deep landfill sites have energy plants where gas is sucked from the landfill. Currently, the energy plant on the Marie Louis landfill site is only flaring the gas from the landfill. There are plans to convert the landfill gas into electrical energy in the near future. The Robinson Deep landfill site is a candidate for landfill gas recovery, as the landfill gas recovery project was started in 2004. It is expected that the flared gas will be converted into electricity.

There are several benefits of innovations in municipal solid waste management. These include the potential renewable energy that is going to be generated in the near future, employment creation for skilled, semi-skilled and unskilled personnel. Poverty is reduced through the selling of waste by reclaimers to the informal recycling market.

Figure 8 illustrates the benefits of compacting of solid waste which has gone a long way in increasing the lifespan of the landfill site; whilst water spraying of waste has helped to reduce the spread of dust to the surrounding communities and the flaring of gases assists in reducing the amount of gases such methane and carbon dioxide that can be released into the atmosphere.

Ultimately, these innovations will lead to clean air, clean water and clean land; which are environmentally safe, socially inclusive and economically productive cities (Lia & Tiberiu, 2010) which are basically an enhanced quality of life. When renewable source provides energy to the grid, the demand for electricity is reduced from traditional sources (fossil fuels) such as coal, which release large quantities of carbon dioxide into the atmosphere. Gas generation at a landfill unlike wind and solar power rarely comes to a stop (Brown, 2013).



Figure 8: Water spraying and soil compaction

5. Conclusions

The article unpacked the overarching essential and imperative impact of renewable energy technologies in shaping the wellbeing of the ordinary residents in South African urban communities. The work highlighted the innovative renewable energy technologies where landfill gas is converted to electricity technologies in generating employment and improving livelihoods, fighting poverty, reducing inequalities in South African cities beyond their primary objectives of reducing global warming and mitigating climate change and pollution. Innovations in infrastructural technological investments in municipal waste management have resulted in massive transformations of communities within the two metropolitan cities and these mostly are environmental, economic, social physical and institutional advancements being enjoyed by residents. The paper pushes the frontiers of knowledge generation to greater lengths, as it focuses not only on the impact of the eccentric technologies to environmental conservation and preservation but also on socio-economic transformation of communities.

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DII-2016-030

Turning to Smart Grid in Zambia

Sebastian Namukolo¹, Ackim Zulu², Changala Nswana³, Nangalelwa Sitwala⁴

Abstract

This paper reviews the current state of electricity generation, transmission and supply in Zambia with a view of smart grid implementation as a strategy in addressing the current energy deficit. The energy deficit has been occasioned by increased consumer activities (industrial, commercial and household) and compounded by the effects of recent adverse weather patterns. A review and appraisal of the infrastructure for power generation, transmission, distribution, on one hand, and that for utilisation, monitoring and control on the other hand, for Zambia is presented here, with allusion to the emergence of smart grid (SG) technology. The inference appears to be that SG sets a more effective stage for production and utilisation of power in Zambia at this stage. SG technology would not only enhance grid visibility for improved management and control of the available power in the current state but also facilitate effective management of distributed resources in the manner that encourages investment in the new forms of power generation facilities.

Keywords: control, distribution, energy, generation, smart grid

1. Introduction

The current installed power generation capacity in Zambia stands at 2323 MW, and is mainly from hydro sources. About 1000 MW is being generated, contrasted with a peak national demand of nearly 2000 MW. Over the past five years, there has been a reduction in the power output from the hydro sources due to low water levels in the holding reservoirs as a result of reduced annual rainfall in the period.

To resolve the deficit in power, a complex system that involves manual load shedding has been implemented by the national and public utility, Zesco Ltd (Zesco, 2015). As preference for supplying power in this scheme is given to the mining industry, it being the main economic driver of the country, the situation has severely affected other economic and social activities to a point of general slowdown.

Zambia has substantial generation potential from others sources such as solar, wind, biomass and coal (ECA-SA, 2006). These distributed resources (DER), are widely dispersed and are away from the existing power utility infrastructure, requiring to be integrated into the main utility grid. Additionally, the natural variability of resources such as solar and wind, give a challenge for close monitoring and control, the problem which is in need of novel solutions and close attention. The formulated solutions must lead to implementation of projects to safely convey the generated renewable energy to the grid when needed. The hallmark of a modern power flow chain is that it is effective, reliable, secure and green. Alternative

¹Lecturer; Department of Electrical and Electronic Engineering, University of Zambia, Box 32379 Lusaka; namukolo1@yahoo.com

²Senior Lecturer; Department of Electrical and Electronic Engineering, University of Zambia, Box 32379 Lusaka; ackim.zulu@unza.zm

³Senior Manager; National Control Centre,Zesco Ltd, Box 33304, Lusaka; cnswana@zesco.co.zm

⁴Senior Manager; Fibercom, Zesco Ltd, Box 33304, Lusaka; nsitwala@zesco.co.zm.

power sources that augment the hydro sources therefore need to be investigated. Application of smart grid (SG) technology can safely integrate the distributed resources in the grid and is capable of enhancing grid visibility for improved management and control. A more flexible, elastic and efficient distribution system for power to the extent that it avoids the traditional huge investment in new generating infrastructure is within sight.

2. Power Generation Landscape for Zambia

The total power potential for Zambia with a landmass of 752,000 km² stands at about 38GW, constituted by types as shown in Table 1 (Singh, 2013), all of which are of the renewable type. In the production and use of energy, this potential can make Zambia not only compliant with the COP21 Agreement (UNFCCC, 2015), but also a source of energy for its neighbours.

Table 1: Distribution of potential of energy resources in Zambia

Resource	Potential Capacity (MW)
Photovoltaic Solar	15,000
Wind	10,000
Biomass	2,000
Geothermal	500
Hydro	6,000
Total	38,000

Even with the current installed capacity in Zambia shown Table 2, the existing demand of about 2000 MW can be met, but this is not so due to the adverse effects posed by poor rainfall in the last five years which has constricted the hydropower generation. For instance, the national power utility Zesco has catalogued the generation constraint up to August 2016 as follows.

- *Kariba North Bank*: with a total capacity of 1080MW was only generating 600MW and would go to 750MW for only six hours; out of the four machines installed only three were operational, the fourth coming in only during peak demand;
- *Kafue Gorge*: only 5 machines were in operation out of the six installed;
- *Itezhi-Tezhi*: water level in the reservoir was at 1028m, down from the maximum of 1035m, giving a shortfall of 7m.

Even with this indicated capacity, Zesco still has other notable power generation projects under development at the following locations:

- Batoka hydro, 100MW;
- Lusiwasi in Serenje, 100MW;
- Kafue lower, 750 MW;
- Kalungushi 349MW.

The planned power projects by Zesco are being augmented by other new players, of note being

- Copperbelt Energy Corporation (CEC) at Kabompo hydro, 40 MW;

- Maamba coal fired power station, 150 to rise to 600 MW;
- Ndola Energy Company, using heavy fuel oil from Indeni refinery, 50 MW.

As the indicated future projects cannot help alleviate the current situation where there is deficit of 1000 MW, the situation is getting immediate redress from expensive imports of power from Turkey through ships docked at ports in Mozambique contributing a capacity of 100 MW, and additional import of 300MW power from Eskom of South Africa when that country is at off-peak.

Table 2: Distribution of potential energy resources in Zambia

Power station	Installed capacity (MW)
Kariba North Bank (KNB)	1080
Iteshiteshi	120
Kafue Gorge	960
Victoria falls	100
Lusiwasi	12
Luzuwa	14
ShiwaNg'andu	1
Lusenfwa	50

3. State of Smart Grid Technology in Zambia

Zesco is a vertically integrated power utility company wholly owned by the government of Republic of Zambia. The primary functions of Zesco are to generate, transmit, distribute and supply electricity to local and international markets through its Strategic Business Units (SBU) of Generation, Transmission and Distribution and Customer Services. The Distribution and Customer Services (D&CS) SBU has customers spread throughout Zambia and is responsible for the development, operation and maintenance of the distribution network which currently serves a customer base of over 500,000 units. Operationally, D&CS SBU is divided into four operating divisions that have Lusaka, Copperbelt, Southern and Northern Divisions. Each division is subdivided into areas of responsibilities called Regions which are further subdivided into Areas, Branches, Zones and townships. The extent of the grid penetration in the country is as shown in Figure 1.

Apart from the power grid network Zesco owns and operates an advanced communication network on the optical fiber backbone, as shown in Figure 2, on which much of its Supervisory Control and Data Acquisition (SCADA) operation subsists.

3.1 SCADA system at Zesco

Currently, Zesco has over 90% visibility of Lusaka Division and Kitwe Region Substations and Distribution network via a somewhat aged SCADA/Demand Management System (DMS) system branded as Micro SCADA and Opera ++ installed in 2002. The Micro SCADA solution monitors and controls over 52 substations in Lusaka Division and 13 substations in the Kitwe Region whilst the Opera ++ (DMS) covers a radius of 150km in Lusaka.

The SCADA/DMS is not integrated with the Information Management System (IMS), an enterprise-wide outage management, system which is an integral module of an integrated enterprise-wide Business

Information Systems (BIS) implemented in 2004. Other applications comprising the BIS include Customer Management System (CMS), Design and Construction System (DCS), Plant and Equipment Maintenance System (PEMS), Stores and Procurement Management System (SPMS), Transport Management System (TMS), Payroll and Human Resource Management System (PHRIS) and Oracle Financials.

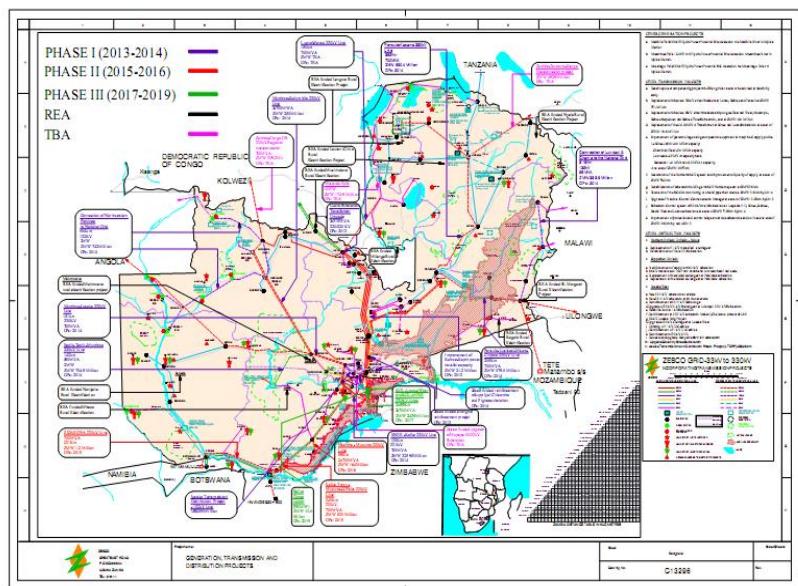


Figure 1: Power grid network in Zambia

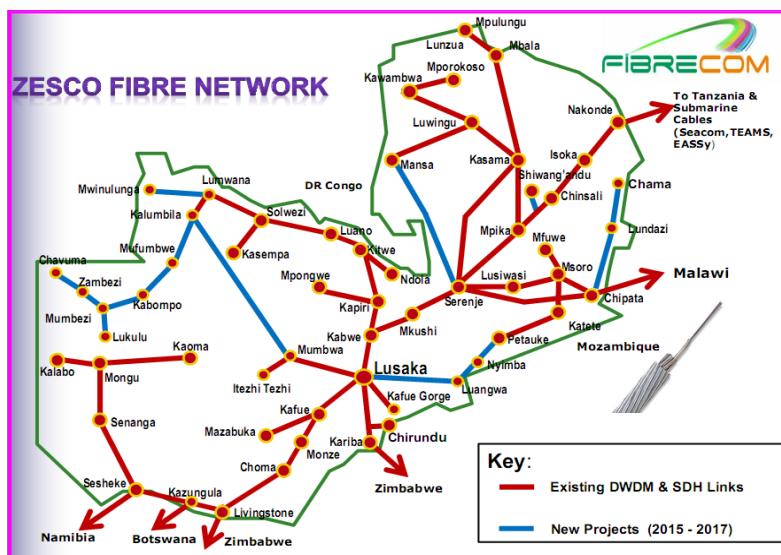


Figure 2: Optical fibre network of Zesco

This lack of integration between SCADA/DMS and IMS has resulted in customer dissatisfaction because of delayed outage restoration times, lack of accurate outage information updates during the outage restoration process and duplicity of effort in maintaining the different network models in SCADA/DMS and OMS.

To improve operational efficiencies and the quality and reliability of electricity supply, Zesco intends to replace the existing SCADA/DMS with an integrated SCADA/DMS/OMS which is offered as single product solution to support business operations on real time basis. To further improve operational efficiencies, Zesco intends to implement a MWFM and a GIS system (asset management) as the foundation to provide a one network model to all enterprise applications. These solutions shall be integrated with existing third party solutions such as CMS, PEMS, IVR and AMI using a standard based (or SOA) enterprise integration bus to enhance interoperability by unlocking information silos.

The implementation of the integrated solution shall first be piloted in Lusaka and Copperbelt Divisions and will thereafter be rolled out to the rest of the divisions.

4. Smart Technology: The way for Zambia

The current national grid in Zambia is old and has been supplying power to consumers in the traditional one-way delivery, manually reading the meters and sending bills once a month, an arrangement that worked well when the population was small, but became increasingly more difficult with heightened industrialisation and rapid urban population growth. Zesco, the sole national electricity supplier, began to lose control and could not account for a good percentage of the generated power. This led to the implementation of the prepaid meter project that has seen installation of meters in industrial, commercial and residential houses and is still ongoing. Zambia also has a fairly well-equipped SCADA system based at the national control centre that monitors fault conditions on the grid. This arrangement has worked well for the utility company in providing rapid response to faults. However the one-way interaction still poses response challenges in the face of increased demand.

This observed shortcoming leads to the need for a smart grid. This smart grid arrangement can be applied in the existing power generation, transmission, distribution and management of the existing infrastructure. In particular, if such a system were in place, there would be an effective two-way exchange of information between consumer and supplier. This would afford the utility greater visibility, control and management of the grid.

4.1 Function of smart technology for a power grid

Power demand constantly changes during the day, requiring utilities to switch units on and off depending on the power needed at loads at different times. Power is more costly at peak demand times due to the additional requirements, and in Zambia this may have to be imported at higher cost, failure to which load shedding is instituted. Smart grid can enable utilities to manage and moderate electricity usage with cooperation of the customer especially during peak demand times, a measure that can limit load shedding and reduce utility operating costs, as customers can defer electricity usage away from peak hours by having devices run at other times. This makes electricity usage to be more evenly distributed throughout the day.

Where there are no energy storage facilities, power is used at the same moment as generation and thus at each instance the amount of electricity generated must equal that consumed across the grid. This means that lower demand results in power wastage as power cannot be stored and a higher demand than supply can result in load shedding. Smart grid technologies provide detailed information that enables operators to see and manage electricity usage in real time. The more intelligent understanding and management of the resource reduce outages and avoids the need for peak power facilities. Utilities can manage electricity usage by well-defined discriminatory load shedding, thus reducing the need to import more costly power from elsewhere.

Distribution facilities route power to consumers through power lines, switches and transformers, utilising complex power distribution schemes and manual switching to keep power flowing. Accidents can result in a break in the power flow and cause outages. Smart grid, through advanced monitoring, can counter energy fluctuations and outages by automatically identifying problems and automatically rerouting and restoring power delivery through alternative switching to other sources and isolating the faulted distribution point.

Other vital functions performed by smart grid are in the capacity to integrate, monitor and control DER and mini grids based on the resource of a variable nature like solar and wind. Smart grid technology also allows for shielding against cyber attacks. In summing, the deployment of smart grids results in utility grid reliability, operating efficiency, resilience to threats and favourable impact on the environment. The indicated beneficial factors however require substantial investment in technology and infrastructure of smart grid.

4.2 Smart grid technology and architecture

The smart grid implementation is based on an object-oriented software model with well-defined utility grid classes containing attributes and methods in its overall application, guided by strict standards at all levels. The concept of a smart grid is that detailed knowledge of what is happening in all parts of the network is known as much as possible at all times. Measurements of physical phenomenon is made continuously and communicated to other parts of the grid, thus requiring an effective telemetry system. Measurements required to be made must relate to the conditions of the grid and mainly these are voltage, current, power, frequency, phase angle and temperature. The measured information has specific attributes like identity, value, time taken, units, instrument used in taking the measurement, how the data is moved from measurement source to multiple destinations and information reliability. These measurements are given a tag name that identifies them by the various meta values that are assigned to them. The collected time series data is important for analysing the operation of the system and is used to optimise and troubleshoot the system.

The basic architecture of SCADA system, as illustrated in Figure 3, is comprised of computer system domiciled in a control room or a central monitoring location over a communication network that is interfaced to the remote field devices that take field data measurements. The field instrumentation is anchored on the programmable logic control (PLC) systems and remote telemetry units (RTU) which are located in remote substations.

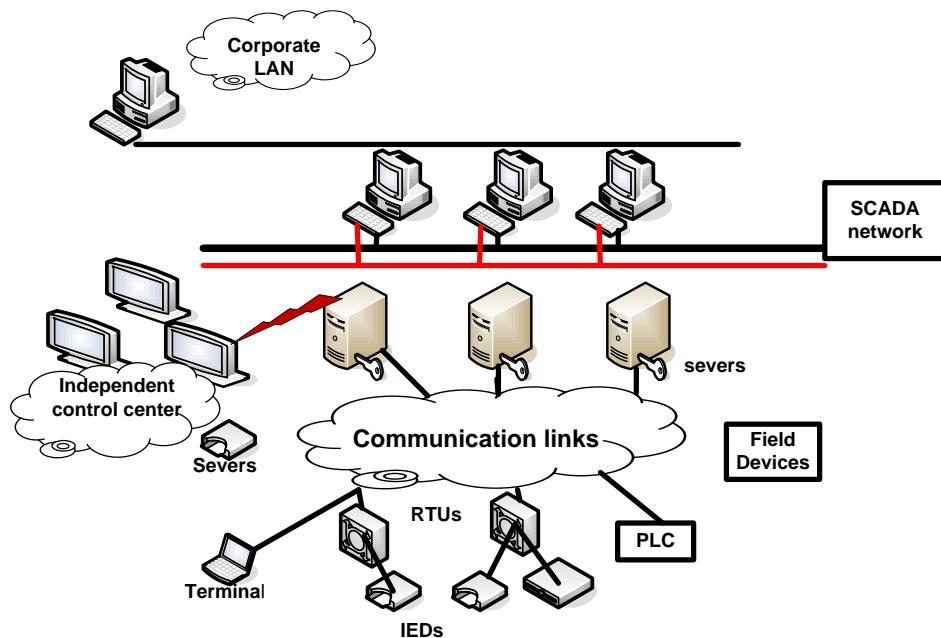


Figure 3: Basic SCADA architecture

The collection of the measured information is done by instrumentation that converts real world analogue information to digital data for processing and transmission, so-called A/D converter. The main application of the A/D converter at the inputting point uses current loops to interface field instruments to digital transmittal, computing and processing systems. The principal measured parameters on the grid are voltage and current. One of the main important instrumentation utilised in the implementation of the smart grid is the smart meter, which is in essence a computer system with functionality that not only measures power but also supports bidirectional information and control data communications and other tagging functions. Smart meter instrumentation capacity includes capability to implement communication either by radio or wired communications to points where the data may be required. In the smart grid situation this destination may be a SCADA system located in a secure perimeter.

5. Is Smart Grid Implementation possible in Zambia?

The challenges of adverse weather patterns in Zambia has been felt more in recent years than before as the repeating short rainfall seasons over a number of years has resulted in reduced water levels in the reservoirs that form the main electricity generation source in the country. This has currently resulted in load shedding schemes that have not been considered before and affected the economic performance of many sectors. It has become imperative that alternate sources of power be exploited to mitigate the shortfall of power. The technology is now available that can be utilised to better supply and manage electricity supply, without building expensive power generation stations. By using smart grid technology, the integration and control of the remote-based distributed energy sources like wind and solar farms is easily possible, coupled with the facility for customer-utility interaction which increases efficiency of utilisation of the resources. From the findings reviewed, it is recommended that Zambia should seriously look into smart grid solutions for its power problems. Zesco is currently planning to upgrade the existing SCADA system (Nswana *et al*, 2014) and the gaps that remain to be investigated further are the costs of

the technology and the implementation strategies. While the cost of the smart grid technology and the implementation strategies seem to be holding back the deployment, other considerations such as geopolitical justification in terms of increased potential generating capacity which also satisfies power needs of other neighbouring countries need to be brought into the picture. Smart grid deployment would also encourage generation of power at household level which would contribute to the total generated power nationally.

6. Conclusion

This paper has reviewed the current state of the power generation facilities in the context of power needs of the current situation. Increased load growth coupled with adverse weather patterns has colluded to make the demand exceed the generation. One way to overcome this adverse scenario is to adopt smart grid technology which will facilitate an augmentation of sources of energy on to the grid and enable better utilisation of energy by consumers.

Zambia has capability to implement smart grid in a short time given the existing utility infrastructure of fibre optics and the national control centre SCADA systems. With the enhanced grid visibility and client participation, utilising networks of communications, control, computers and automation, grid operation can become more efficient, reliable, secure and greener, as customers not only cooperate with the utility in power usage but participate in power generation.

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DII-2016-025

Evaluation of Infrastructure Development of Roadway New Technologies for Renewable Energy Generation: Lessons Learnt

Adewole S. Oladele¹

Abstract

The aim if this paper is to review and evaluate development of a novel Roadway Wind/Solar Hybrid Power Generation and Distribution System (RHPS) towards energy-plus roadways, where energy-plus stands for annual energy consumption that is less than production. The RHPS is known to be a low footprint, intelligent, and multilayer power system designed for integration into urban and suburban areas, which reduces the need for new distribution networks. The RHPS represents a dramatic change in the role of the public right-of-way from an energy consumer to an energy producer, and therefore will aid in reducing transportation system operating costs.

The paper concludes by highlighting the benefits of developing technology that could lead to transformational changes in the way that the public right-of-way is used to harvest and utilize renewable energy.

Keywords: infrastructure, renewable energy, roadway development, right of way, sustainable transportation

1. Introduction

The challenges of energy globally have affected the economy and cut across all sectors of society, including, commercial, transport, industrial and residential. Researchers are finding alternatives to reduce reliance on fossils fuel which are not only depleting but serve as a harmful catalyst in destroying our environment and ecosystem. There are advances in technologies and improvement for a more efficient method for energy generation are currently underway such as combination of two or more ways to generate electricity. This paper studies the hybridization and use of wind/solar in electricity generation for roadways.

The use of wind/solar hybrid power generation is a smart road generation in the energy sector. This provides improvement in operation of an independent energy supply for public lightings, monitoring and aid in powering traffic lights. The solar panel is made of array of solar cells and electronic sensors, which are programmed along with the photovoltaic cell. This mode of power generation has limited impact on the environment and is more sustainable compared to the conventional fossil fuels.

¹Lecturer; Department of Civil Engineering; Botswana International University of Science and Technology; Private Bag 16; Palapye, Botswana; Email:oladelea@biust.ac.bw

2. Literature Review

2.1 Wind/solar hybrid power generation

Wind/Solar Hybrid Power generation in roadway of recent has become a new technology in renewable energy. This technology consists of an interconnectivity of a wind tunnel and a solar panel to power roadways. The system can also be linked to others neighbouring panels and create a large network for the entire region. Electrical energy generated is used to power the RHPS and excess are thereby supply to the communities or use by the national grid. Energy efficient and LED light are embedded in the Wind/Solar hybrid system for efficiency and to support the development structure such as illuminated or reflected paints use on road lines beneath the road surface. Kulkarni (2013) emphasized that using solar road panels can heat snow and remove ice in northern climatic conditions.

Wind/solar Hybrid power system provides safe driving conditions at night and subsequently preventing accidents. There are numerous benefits of using RHPS, this include the establishment of an off-grid build in model for energy supply. This approach also creates employment opportunities as well as economic and social improvements. One of the most important advantages of solar/wind hybrid generation is the ability to produce electricity for safe driving at night thereby preventing accidents. Furthermore, excess electrical power is distributed to other business and home. Environmentally, there is no harm, no production of greenhouse gases and a clean renewable energy source. This is a good means of decentralizing power generation and integration on renewable energy into the energy mix of any country. It promotes infrastructural development along roadways.

Mehta *et al.* (2015) defined solar roadway as an infrastructure which generates electricity by either photovoltaic or technologies which includes solar panels and LED signage to empower roadways. The study focused on improving energy generation and reduces dependency on fossil fuels. Implementing the use of RHPS along roadways such as drive ways streets lights, packing lots are suitable targets for solar panel and at intersections. The study noted some advantages of using solar as in military and rescue emergencies, environmental disasters and no production of harmful gases (Mehta, 2015). However, the study highlighted some challenges as high maintenance cost, seasonal efficiency and a need to conduct a town planning for the smooth distribution of interconnectivity from, businesses, school, clinics and homes.

2.2 Sustainable infrastructural development

The concept of sustainability according to this paper shows that people and their communities are made up of social, economic and environmental systems. There is a constant interaction in sustainability that people and the environment are at the core of sustainability. Sustainable development, according to Brundtland Commission, is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Deakin, 2003). It is a term referring to the need to encourage economic growth but at the same time conserve the world’s resources. Deakin (2003) explained further that sustainability is also applicable to transport roadways, that is, “sustainable transportation is seen as transportation that meets mobility needs while also preserving and enhancing human and ecosystem health, economic progress, and social justice now and for the future”. Sustainable development term first came into general use in 1987 in the report of the World Commission on Environment and Development. Sachs (2014) explained that the issue of sustainable development has been on the global agenda for more than forty years at least and the world is far off course for achieving

sustainable development. A viable economy of a country is essential to sustainability. Mobility is one of the most fundamental and important characteristics of economic activity as it satisfies the basic need of going from one location to the other, a need shared by passengers, freight and information. All economies do not share the same level of mobility as most are in a different stage in the transition.

Transport roadways play a very important role in the economic development of a nation and development increases transport demand. Sustainable development is at the central concept for the current age and the introduction of Wind/Solar Hybrid Power generation in roadway will reduce congestion, save lives and improve public mobility by addressing the three dimensions of sustainable infrastructural development.

3. Methodology and Evaluation

The challenges of energy management are felt in all areas of the economy and various measures are continuously being explored for better improvement and more efficient means of conserving energy and the environment. LED lighting is now a common means for reducing energy consumption in homes and at work places. LEDs have longer life span and less energy consumptions in comparison to the conventional incandescent and fluorescent tubes. In a study conducted students of Sam Houston State University, it identified several energy projects for conservation (Yildiz, 2014). The project was divided in different stages as planning- focus on the technology and where to implement (LED parking and street lighting), the design – 2D and 3D models were created using Auto-CAD and dimensions as shown in figure 1.

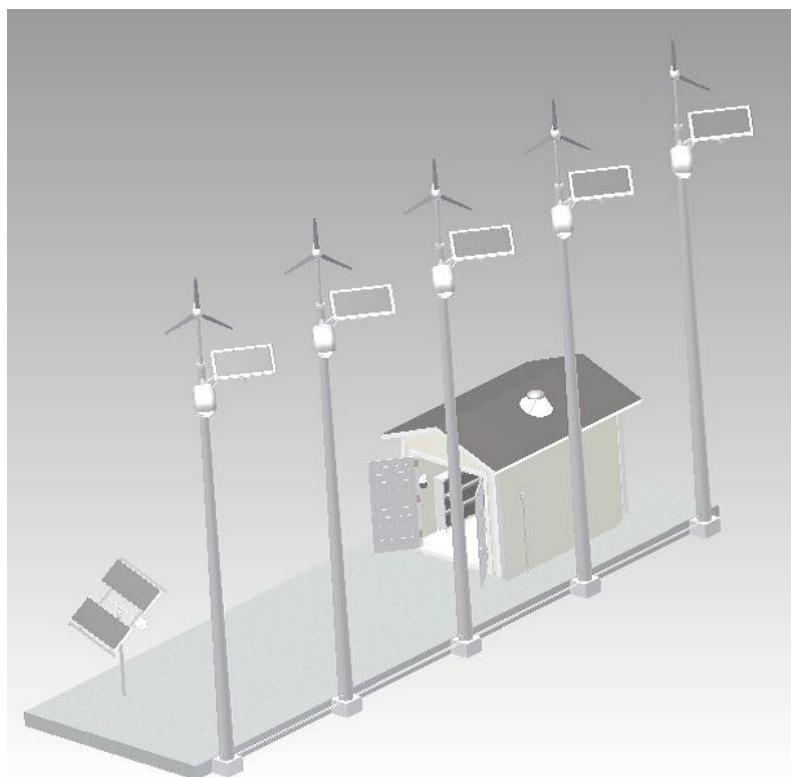


Figure 1: Hybrid system designed (Yildiz, 2014)

The projects were implemented by installing LED, changing old poles with concrete, integrating the system components by wiring and interconnecting all identified points with solar panel and wind tunnels. This demonstrated the sustainability of renewable/clean energy on the environment and savings on energy consumption (Yildiz, 2014). Figure 2 shows a completed installed roadway hybrid system for sustainable renewable energy generation in infrastructural development.

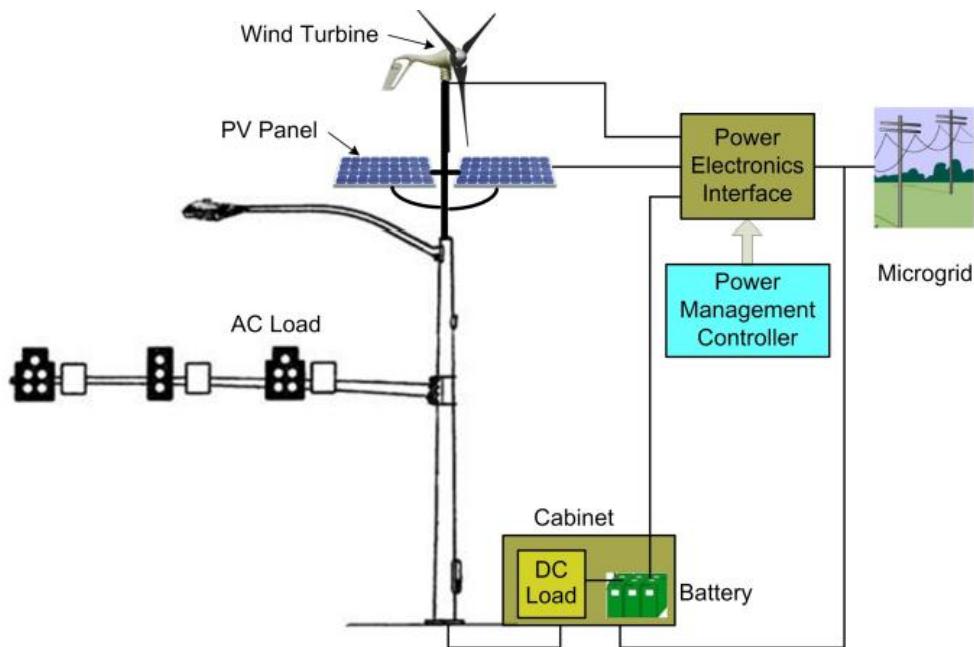


Figure 2: Completed installed roadway hybrid system (Qoai et al, 2016)

4. Lessons Learnt

Sustainable infrastructural development once again is the “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. Therefore, sustainability encompasses a holistic consideration of economic, social, and environmental progress with a long-term perspective, in both a present (intra-generational) and future (intergenerational) context (Paige-Green, 2015).

The benefits of a street lighting application developed utilizing a hybrid power-generation technology that combines solar and wind energy into a single, unified power generation system is significant in infrastructural development of roadways. Moreover, developing technology that could lead to transformational changes in the way that the public right-of-way is used to harvest and utilize renewable energy is highly required.

Kwon *et al.*, (2008) pointed out lessons for adoption in developing countries from the hybrid technology which solved the timely problem of shortage of electricity by integrating photovoltaic (PV) power generation with wind power generation which suggested that the shortage of electricity caused by a lack of solar energy could be readily supplemented by wind energy. Another complementing weather factor is that winter and/or summer storms generally produce stronger winds, while they reduce solar radiation. This is another complementing relationship between solar and wind energy. Therefore, solar and wind resources complement each other and utilizing them into a single electricity generation system could result in producing more constant rate of electricity, providing a higher power reliability under various weather conditions as infrastructural development strategies for developing countries.

5. Conclusion

The objective of this paper was to review and evaluate a wind/solar hybrid renewable street light system that can self-sustain without a connection to an electric grid. This was further investigated whether such a system is economical and practical to provide a street lighting application. Then finally lessons learnt were drawn on how the wind and solar energy sources complement each other under field test conditions. A self-sustainable solar/wind hybrid light system was successfully designed and constructed using off-the-shelf components (Kwon *et al.*, 2008). In conclusion, a solar/wind hybrid generator along with sufficient battery storage should be adopted in developing countries to provide a reliable renewable power source. From the review and evaluation, it is recommended that the RHPS designed to maximally utilize the resources by analyzing the availability of annual wind and solar radiations along the roadways should be adopted in achieving solutions for renewable energy and sustainable development. Improved public safety and reduced congestion during power outages; travel time savings; accident cost savings; vehicle operational cost savings; gaseous emission reductions are the tremendous benefits of adopting Roadway Wind/Solar Hybrid Power Generation and Distribution System (Qiao *et al.*, 2016).

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DII-2016-029

An Evaluation of the Development of Renewable Energy Sources in South Africa

Olebogeng David Daw¹

Abstract

The structure of South Africa's energy market is mainly coal-based. The country is ranked among the highest per-capital coal consumers in the world, and this will not change for the foreseeable future. The challenge that South Africa now faces is how to deal with its growing energy demand, while reducing the dependence on coal used to produce electricity. South Africa is in the process of reforming its energy supply structure towards the procurement of cleaner and renewable energy. Like other countries in transition from economies with high carbon emissions to lower emissions, the country faces the dual challenge of pursuing economic growth and while achieving environmental protection and sustainable energy systems. South Africa has rich coal resources and also well non-depletable resources, notably solar and wind. The country has an average of more than 2,500 hours of sunshine per year and average direct solar radiation levels range between 4.5 and 6.5kWh/m² per day, placing it in the top three in the world. The objective of this paper is to look at how renewable energy source can make contribution towards improving the energy mix of the country. This paper is literature-based. The study uses available secondary material to respond to existing knowledge about Renewable energy development in South Africa. Findings show that alternative sources of energy such as wind, solar, and hydropower can be harnessed to improve the energy base in South Africa. This will enable increased economic growth and environmental protection.

Keywords: electricity generation, renewable energy, reform, South Africa

1. Introduction

In economics, the environment is viewed as a composite asset that provides a variety of services. It is a very special asset to be sure, since it provides the life support systems that sustain our very existence, but it is an asset nonetheless. As with other assets, the desire is to prevent undue depreciation of the value of this asset so that it may continue to provide aesthetic and life-sustaining services. The environment (figure 1) provides the economy with raw materials, which are transformed into consumer products by the production process, and energy which fuels this transformation. Ultimately, these raw materials and energy return to the environment as waste products (Tietenberg, 2005).

¹Associate Professor; North West University, South Africa; david.daw@nwu.ac.za

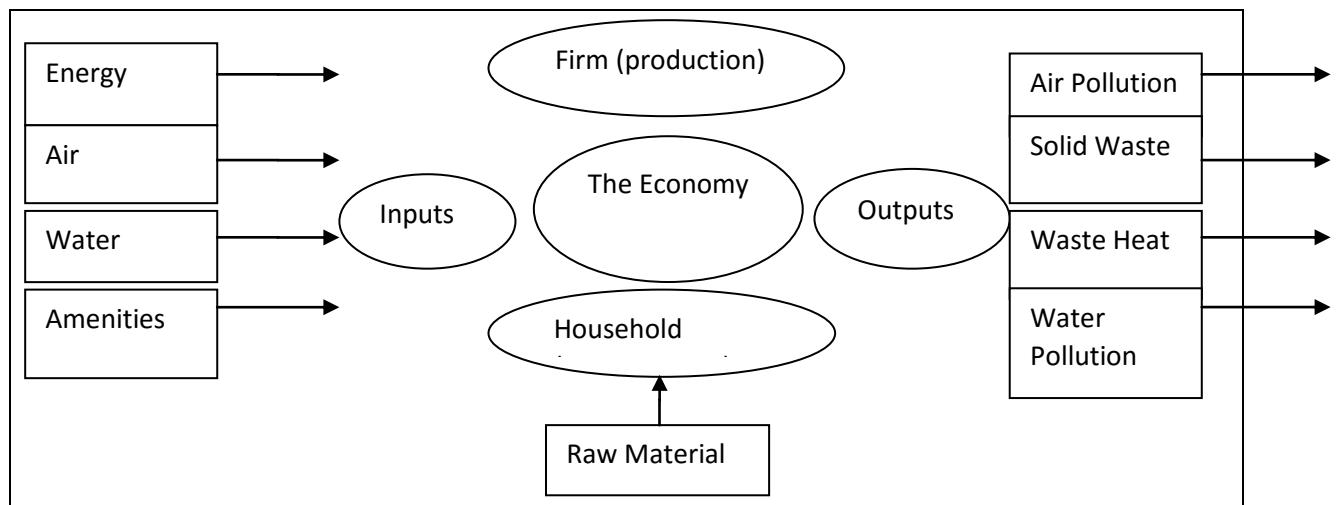


Figure 1: The environment (Source: Tietenberg, 2005)

1.1 The development of renewable energy policy in South Africa

South Africa government has developed three policy papers which is the foundation for Renewable Energy (RE) programme, the United Nations Environment Programme (UNEP) ranked the country among the top-10 renewable energy investing countries in 2014 and by breaching the 500MW of utility scale solar power , the country became the 10th biggest solar market in the world for installations sized 5MW and above, the introduction of renewable energy into the country's electricity mix has developed over the key policy development stages the basic being from the Constitution (1996) and Bill of Rights, White Paper on Energy Policy (1998), Renewable Energy White Paper (2003), National Climate Change Response Policy White Paper (2011).

The first policy document was the 1998 White Paper on Energy Policy (Renewable Energy, 2015). Its objectives were listed as:

- Increasing access to affordable energy services;
- Improving energy governance;
- Stimulating economic development;
- Managing energy-related environmental impacts; and
- Securing supply through diversity

There are a number of reasons for the adoption of Renewable Energy by South Africa. However, growth in demand cannot be identified as the sole reason that alternative energy supply options have now been adopted by the government because firstly, current energy supply in South Africa is primarily coal – based and although these resources will last for more than a century if used at current rates, the country large power plants will need to be replaced within the next 30 years. Secondly, coal has many other uses, and will therefore need to be conserved for future use. Thirdly, Coal and other fossil fuels produce Carbon Dioxide when burned to produce energy, it is now widely accepted that climate change, partially caused by human-generated carbon dioxide, represents an extremely serious environmental threat to the world as evidenced through rising global temperatures. Climate change is blamed for the higher-than usual incidence of extremely damaging weather experiences e.g. storms, droughts, melting polar ice-caps.

Advantages of renewable energy are employment creation, proximity to point-of-use and in many cases, less reliance on concentrated sources of energy. Greater use of renewable energy would reduce the country economic vulnerability to the variable and escalating costs of imported fuels. International and local communities are increasingly trying to find ways to shift economies towards greater reliance on renewable energy (Banks and Schaffer, 2006). This paper therefore seeks to examine how renewable energy sources can be increasingly harnessed in South Africa. A review of literature was conducted based on South African context.

2. Renewable Energy Sources in South Africa

The White Paper on Renewable Energy (2003) has set a target of 10 000GWh of energy to be produced from renewable energy sources (mainly from biomass, wind, solar and small-scale hydro) by 2013. Following Cabinet approval of the White Paper, the Department of energy proceeded with the development of its renewable energy strategy. The vision of the Department of Energy (DoE) is to make adequate and affordable energy available to developing communities through a mix of providing alternative energy resources at a reasonable cost. The aim is to satisfy the basic needs of the developing sector and at the same time promote the effective utilisation of South Africa's vast alternative energy sources. Challenges of energy in South Africa are:

- South Africans are well aware of the problem of the cost of electricity has skyrocketed in just the last three years. Selective blackouts are growing. The low energy rates the nation had taken for granted are gone. And the country is very close to utilising the entire grid.
- The problem stems from the fact that ninety percent of electricity in South Africa comes from burning coal, and building new coal-fired power plants are mammoth, expensive projects. The government has set a target to reduce dependence on coal by the year 2050.
- Price rulings issued by the South Africa National Energy Regulator 2008/2009 to 2012/2013 have increased the average electricity price by 25 %from 18 cents/kWh in 2007 to 66 cents in 2013.

In South Africa wind and solar photovoltaic (Solar PV) power plants have been the first power plants from the RE portfolio to start operations

2.1 Direct solar energy

This form of energy relies on the nuclear fusion power from the core of the Sun. This energy can be collected and converted in a few different ways. The range is from solar water heating with solar collectors or attic cooling with solar attic fans for domestic use to the complex technologies of direct conversion of sunlight to electrical energy using mirrors and boilers or photovoltaic cells. Unfortunately, these are currently insufficient to fully power our modern society. Solar energy is used to power equipment such as watches, calculators, cookers, water heaters, lighting, water pumping, communication, transportation, power generation and many more. Solar energy, like all other renewable energies, is very safe and environmentally friendly. There are no emissions as the source of fuel is the sun, unlike coal-powered stations (Alternative Energy, 2015a).

There are four major types of solar energy technologies:

- Solar thermal, which includes both active and passive heating of buildings, domestic and commercial solar water heating, swimming pool heating and process heat for industry. The three most promising solar thermal technologies are the parabolic trough, the central receiver or tower and the parabolic dish.
- Photovoltaic (PV) electricity generation via direct conversion of sunlight to electricity by photovoltaic cells.
- Concentrating solar power (CSP) electricity generation by optical concentration of solar energy to obtain high-temperature fluids or materials to drive heat engines and electrical generators.
- Solar fuels production methods, which use solar energy to produce useful fuels.

Most areas in South Africa average more than 2 500 hours of sunshine per year, and average solar-radiation levels range between 4.5 and 6.5 kWh/m² in one day. The Southern African region, and in fact the whole of Africa, has sunshine all year round. The annual 24 hour global solar radiation average is about 220 W/m² for South Africa compared with about 150 W/m² for parts of the USA, and about 100 W/m² for Europe and the United Kingdom. This makes South Africa's local resource one of the highest in the world.

The use of solar energy is the most readily accessible resource in South Africa. It lends itself to a number of potential uses and the country's solar-equipment industry is developing. Annual photovoltaic (PV) panel-assembly capacity totals 5 MW, and a number of companies in South Africa manufacture solar water-heaters.

A pilot programme has been launched to establish a limited number of public-private sector institutions in conjunction with the relevant municipalities to provide electricity services on an integrated basis. The service-provider will own and maintain the systems, allowing longer term financing to ameliorate monthly payments. It will provide the service against a monthly fee.

Once the underlying managerial and funding issues have been resolved the process will be expanded to cover all rural areas. Solar power is increasingly being used for water-pumping through the rural water-provision and sanitation programme of the Department of Water Affairs and Forestry.

2.1.1 Promotion of concentrate solar power

The South African national Department of Science and Technology has recognised the need to enable an emerging solar energy industry, which can address the challenge, and also contribute to energy resources diversification in the country. Concentrating solar power to generate bulk electricity is one of the best suited technologies to help mitigate climate change in an affordable way, as well as reducing the consumption of fossil fuels. This will also benefit the following:

- Life Environmental Sustainability
Cycle assessment of the emissions produced, together with the land surface impacts of CSP systems, shows that they are ideally suited to the task of reducing greenhouse gases and other pollutants, and without creating other environmental risks or contamination.
- Economic Sustainability
The cost of solar thermal power is falling. Experience from the Solar Electric Generating Systems (SEGS) in California shows that impressive cost reductions have already been achieved, with generation costs ranging today between 10 and 13 US cents / kWh.

2.2 Hydropower

Is a renewable energy source where power is derived from the energy of water moving from higher to lower elevations? It is a proven, mature, predictable and cost-competitive technology.

This form uses the gravitational potential of elevated water that was lifted from the oceans by sunlight. It is not strictly speaking renewable since all reservoirs eventually fill up and require very expensive excavation to become useful again. At this time, most of the available locations for hydroelectric dams are already used in the developed world.

The mechanical power of falling water is an old tool used for various services from the time of the Greeks more than 2,000 years ago. The world's first hydroelectric station of 12.5 kW was commissioned on 30 September 1882 on Fox River at the Vulcan Street Plant in Appleton, Wisconsin, USA. Though the primary role of hydropower in global energy supply today is in providing centralised electricity generation, hydropower plants also operate in isolation and supply independent systems, often in rural and remote areas of the world.

2.2.1 Hydropower in South Africa

Energy from water can come from waves, tides, waterfalls and rivers and will never be finished as long as we have water. In South Africa, we have a mix of small hydroelectricity stations and pumped water storage schemes. In a pumped water storage scheme, water is pumped up to a dam.

Pumping the water uses some electricity but this is done in off-peak periods. During peak hours, when extra electricity is needed, the water is released through a turbine that drives an electric generator. Peak hours are usually between six and eight in the morning and evening.

South Africa used to import electricity from the Cahora Bassa hydropower station in Mozambique and will do so again when the transmission line is repaired. There is also the potential to import more hydropower from countries such as Zambia and Zimbabwe.

In South Africa 247MW potential for new small-scale Hydro development exist in the rural areas of the Eastern Cape, Free State, KwaZulu Natal and Mpumalanga. The country's hydro potential has an installed capacity of 38MW.

The advantages and attractiveness of these plants are that they can either be standalone or in a hybrid combination with other renewable energy sources. Advantage can be derived from the association with other uses of water (water supply, irrigation, flood control, etc), which are critical to the future economic and socio-economic development of South Africa.

2.3 Wind power

The movement of the atmosphere is driven by differences of temperature at the Earth's surface due to varying temperatures of the Earth's surface when lit sunlight. Wind energy can be used to pump water or generate electricity, but requires extensive a real coverage to produce significant amounts of energy.

A number of different wind energy technologies are available across a range of applications, but the primary use of wind energy of relevance to climate change mitigation is to generate electricity from larger, grid-connected wind turbines, deployed either on land ('onshore') or in sea or freshwater ('offshore'). Continued advancements in on and offshore wind energy technology are expected, however, further reducing the cost of wind energy and improving wind energy's GHG emissions reduction potential.

2.3.1 Wind energy in South Africa

For thousands of years people have used windmills and the energy derived from wind to pump water and to grind corn. After a breakthrough by scientists, wind can now also be used to generate electricity. Wind energy, like solar energy, is a free renewable energy source and will never run out.

The amount of energy that can be extracted from the wind depends on its speed. The higher the wind speed, the more energy can be harnessed to generate electricity on a large scale. However, this requires large tracts of land to install enough wind turbines or generators, which are also noisy.

Wind as an energy source is only practical in areas that have strong and steady winds. South Africa has fair wind potential, especially along the Coastal areas of Western and Eastern Cape. Currently, the Klipheuwel wind farm is operating near Cape Town and the Darling wind farm.

2.4 Biomass energy

It is the term for energy from plants. Energy in this form is very commonly used throughout the world. Unfortunately the most popular is the burning of trees for cooking and warmth. This process releases copious amounts of carbon dioxide gases into the atmosphere and is a major contributor to unhealthy air in many areas. Some of the more modern forms of biomass energy are methane generation and production of alcohol for automobile fuel and fuelling electric power plants.

2.4.1 Biomass energy in South Africa

According to the Department of Energy (2014; n.d.), in December 2006 a draft Biofuels Industrial Strategy was approved by Cabinet to go for public consultation. The public consultation process involved workshops and meetings at both national and provincial level, and consultations with organised industry, farmers, communities, non-governmental organisations and provincial government departments. Comments from stakeholders were duly considered and incorporated into the draft Strategy and in December 2007, Cabinet approved the National Biofuels Industrial Strategy. The approved Strategy suggests a 2% biofuels penetration to the current fuel pool by 2013. The 2% will slightly contribute to energy security, create 25 000 jobs in rural farming, and achieve a balance of payments saving R1.7 billion. Subsequent to the approval of the Strategy, the Licensing Criteria were also published on the departmental website to enable the licensing of biofuel manufacturing facilities.

2.5 Solar energy technology roadmap (SETRM)

A solar energy technology roadmap has been developed for South Africa. The roadmap lists a number of technology systems that fulfill three requirements from a South African perspective:

- They have clearly been demonstrated or commercialised
- A local industry could be stimulated including the potential to export, with associate socio-economic growth; and the other requirements of government can be met in terms of improving energy security and access, and addressing climate change.
- They have a medium to high research and development intensity, in terms of available capacity and associate resources needed to support the further development of the technological systems.

The solar energy technology roadmap (SETRM) primarily aims to highlight key strategic research and development (R&D) focus areas, and the required interventions by various role players to enable such R&D. The goal of the SETRM is not to provide insight in terms of where the solar energy sector of South Africa should be heading, but where the national system of innovation (NSI) should place its

emphasis to support and expand the emerging industry. The SETRM specifically focuses on active solar energy systems and excludes passive solar energy systems.

The complete solar energy roadmap which started in 2010 when completed will consist of three components, the Concentrated Solar Power (CSP), Solar PV and Solar Thermal Technologies. The draft roadmap currently estimates that 40GW of Solar PV and 30GW of CSP can be developed by 2050 in the country (Renewable Energy, 2015).

Table 1: Successful project of RE in South Africa (Source: Renewable Energy 2015)

Project	Capacity				Annual Production
eThekwin landfill gas –to–electricity project		7.5MW			45GWh
PetroSA Biogas –to-Energy		4.2MW			31GWh
Darling Wind farm		8MW			
Bethlehem hydro		7MW			38GWh
Bronkhorstspruit Biogas Project		4.4 MW			36GWh

2.5.1 Market size

In 2008, the South African government launched a plan to install a million solar water heaters by 2013 (Electricity + Control, 2013). However, the market did not cooperate, despite the incentives. Only 400 000 systems have been installed, according to Eskom (Steyn, 2015). Still, South Africa is approaching 100 000 high pressure systems a year and perhaps twice as many low pressure systems. The market is divided between flat plate collectors installed on upper and middle class residential homes and lower cost evacuated tubes installed on the South African government's social responsibility programmes or social corporate investment programmes. While as many as 600 companies are members of Sustainable Energy Society of Southern Africa (SESSA), only a third of them are focused primarily on solar alone. Less than fifty companies could be considered major solar players in South Africa (Electricity + Control, 2013).

2.5.2 Market growth

Like elsewhere in the world, new building regulations have helped drive the market; but South Africa has another advantage for its solar thermal businesses; insurance. Water heating systems are insured if they meet the insurance company's minimum requirements. Naturally, insurance policy standards are strict, and require due diligence to select better products.

Nothing drives sales better than building codes. New building codes are in place requiring 50% of the heating of water in any new building to use non-electric resistance – which includes solar thermal, heat pumps or heat carriage. Solar Reserve's game-changing technology captures and stores the sun's power to reliably provide electricity whenever it is needed most, powering more than 200 000 South African homes during peak demand periods, even after dark, with zero emissions (Solar Reserve, 2015).

Active solar technologies are employed to convert solar energy into usable heat or electricity, cause air movement for ventilation or cooling, or store heat for future use. Active solar systems use electrical or mechanical equipment, such as pumps and fans, to increase the usable heat in a system. Passive solar technologies convert sunlight into usable heat, cause air-movement for ventilation or cooling, or store heat for future use, without the assistance of other energy sources (Colorado Solar Energy, 2014; Putney Energy Committee, 2016).

2.5.3 Development of world's first combined CSP and PV solar park

The Redstone Solar Thermal Power Project is located near Postmansburg, Kimberly in the Northern Cape Province adjacent to the 75 MW Lesedi and 96b MW Jasper photovoltaic (PV) solar power projects. Together, the three projects will deliver 271 megawatts of peak generation, enough to power more than 350 000 South African homes. The Redstone project brings additional value to South Africa with the introduction of Solar Reserve's world leading molten salt energy storage technology – In addition the project's delivered electricity price is the lowest of any concentrating solar power in the country to date (Yaneva, 2016).

The 100 MW project with 12 hours of full load energy storage will be able to reliably deliver a stable electricity supply to more than 200 000 South African homes during peak demand periods, even well after the sun has set (Anon., 2015). Fuelled completely by the sun, with no back up fuel required, the project also features dry cooling of the power generation cycle as an important element to minimize water use.

The fully integrated thermal energy storage, the plant will provide dispatchable power on-demand, just like conventional coal, oil, nuclear or natural gas-fired power plants, but without the harmful emissions or hazardous materials and without any fuel cost (Solar Reserve and ACWA Power, 2015).

2.5.4 Successful market creation policy measures

A clear, visible market for solar thermal power must be defined in order for a project developer to seriously consider getting involved. Just as with any other investment, the lower the risk to the investor, the lower the costs can be for supplying the product.

The most important measures for establishing new solar power markets are therefore those where the market for solar electricity is clearly embedded in national laws, providing a stable and long term investment environment with relatively low investor risks and sufficient returns.

As already outlined, a key benefit of a growing solar thermal energy market is job creation. It is estimated that direct and indirect employment in the industry worldwide, not including the production of components and equipment, could rise to about 100 000 jobs by 2020 (International Renewable Energy Agency (IRENA), 2013).

In order to attract solar thermal power plant suppliers to establish manufacturing facilities, markets need to be strong, stable and reliable, with a clear commitment to long term expansion.

2.5.5 The future of solar thermal power

Because solar thermal power currently leads the way as the most cost-effective solar technology on a large scale, the leaders in solar thermal technology have an ever-growing market. Solar thermal technology will have emerged from a relatively marginal position in the hierarchy of renewable energy sources to achieve a substantial status alongside the current market leaders such as hydro and wind power.

The global projections are that solar energy technologies will, overall play a significant role in the future energy supply and demand landscape, especially beyond 2040. The contribution of solar thermal applications may remain relatively small but it is expected that solar power applications will, eventually overtake the combined contributions of all other energy resources (Brent and Pretorius, 2011).

3. Conclusion

South Africa needs to return to a state of continued and uninterrupted electricity supply, this is to be achieved by increasing the electricity generation reserve from 1% (2014) to 19% in 2019, which will require the development of 10GW of additional electricity capacity by 2019 against 2010 baseline of 44GW, five of the 10GW are to be sourced from RE.

South Africa has taken a sustainable growth and development energy strategy, since 2011 the country has introduced a good competitive bidding process, which to date has delivered 92 independent power Producers who will contribute in excess of 6,327MW. Solar PV bid tariffs had decreased by around 75% from the first bid window 4, making it a cost competitive contributor to the RE portfolio.

The Northern Cape host to 48 of the 92 IPP project in the country is expected to contribute 3,566MW to the total procured of RE capacity once construction is complete. The Eastern Cape has attracted 17 of the 92 IPPs, totaling 1,509MW, the Western Cape contributing 592MW to total procured capacity, 6 wind (458MW) and 5 Solar PV (134MW) and the 16 IPP projects are distributed among the other provinces.

This concluded that the renewable energy sources can make a contribution towards improving the energy mix of South Africa.

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Strategic Direction to Sustainable Electricity Generation in Zambia: A Critical Comparison of Electricity Generation Options

Simon Tembo¹, Mubiligi Ngendo², Henry Mwenda³, Alec Malichi⁴

Abstract

Zambia's over dependence on hydropower generation is vulnerable to climate change and drought. The 2014/2015 drought which the country experienced has revealed the risks, uncertainties and consequences involved in over dependence on the hydropower generation. This has led to electricity load shedding throughout the country thereby affecting every sector of the country's social-economy. The impact of load shedding has been increasingly severe and diverse on all spheres of the country's economy. There is an urgent need for Zambia to switch over from conventional hydropower generation to create a diverse electricity generation (called source mix) by promoting the use of other energy technologies that are sustainable and can meet the present and projected country's electricity demand. Taking into account these experiences, the need for creating an optimal electricity supply-demand structure for Zambia is reviewed. This paper reviews literature on electricity generation technologies and analyzes the need to consider daily electricity demand patterns which must be used to arrive at the optimal electricity generation source mix (i.e. energy source mix) to meet the electricity demand. Different electricity generation models used worldwide, along with a few emerging models, and how to find a solution by assessing the situation in details and making strategic and pragmatic suggestions to resolve Zambia's power generation issues are explained. In other words, there is no magic way to find appropriate solutions by taking a haphazard approach in the energy policy. In order to strategically handle the impact of climate change and drought situation, Zambia has to implement energy strategic plans based on the long-term, comprehensive and systematic perspective.

Keywords: climate change, drought, energy source mix, generation options, hydropower

1. Introduction

The robustness and resilience of the hydro-electricity generation technology used in Zambia has been tested and the revelation is that Zambia can no longer over depend on this technology alone anymore. The effects of drought and climate change have caused massive hydropower deficit leading to extensive

¹Head; Department of Electrical & Electronic Engineering, School of Engineering; University of Zambia; simon.tembo@unza.zm

²Lecturer; Department of Electrical & Electronic Engineering, School of Engineering; University of Zambia; dmngendo@unza.zm.

³Senior Lecturer; Department of Mechanical Engineering, School of Engineering; University of Zambia; hm.mwenda@unza.zm.

⁴Lecturer; Department of Electrical & Electronic Engineering, School of Engineering; University of Zambia; amalichi@unza.zm.

electricity load shedding across the entire country and thus affecting all sectors of the Zambian economy. Zambia's economy growth rate between 2006 and 2013 remained steady at an average growth domestic product (GDP) annual growth rate of 6.5% (*BOZ Annual Report, 2015*) as illustrated in Figure 1 below.

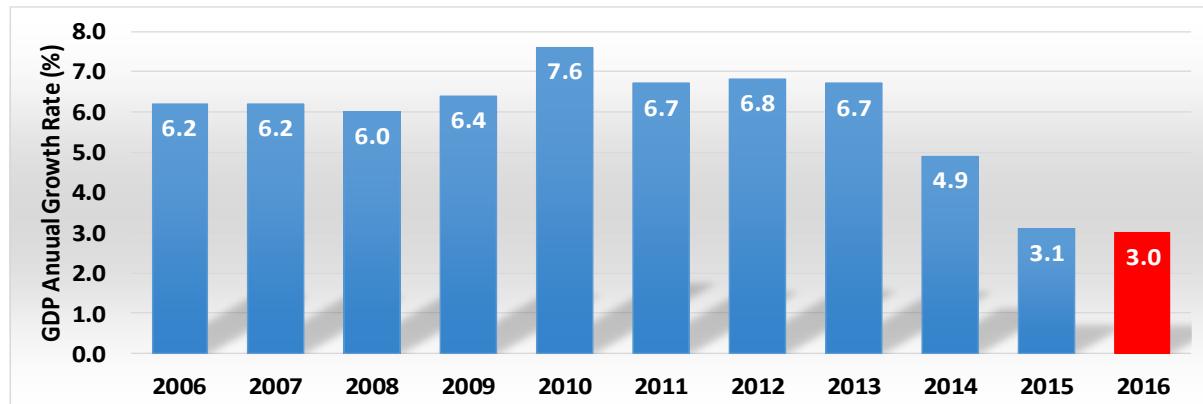


Figure 1: Zambia's GDP Annual Growth Rate (BOZ Annual Reports, 2006-2015)

The effect of drought and climate change in 2014/2015 has caused low water levels in the dams of the hydroelectric power stations of Kariba, Itezi-Tezi and Kafue triggering off electricity shortage. The simultaneous impact of electricity shortage and decline copper prices during the 2014/2015 fiscal years have strained the Zambian economy, to the effect that the GDP growth rate declined to 4.9% in 2014 and in 2015 fell up to a low level of 3.1%. It is further projected that the GDP may stay on to about 3.0% in 2016 due to prolonged power deficits as illustrated in Table 1.

Table 1: Power Generation Deficit for Period between June 2015 - December 2016

Power Generation	June - December 2015		January - December 2016	
	Monthly Average (MW)	Monthly Average (MW)	Average	Monthly Average (MW)
	Deficit without Imported Emergency Power	Deficit with Imported Emergency Power	Deficit with Imported Emergency Power	Deficit with Imported Emergency Power
ZESCO Hydropower	987.5	987.5		950.8
Lunsemfwa Hydro	22.0	22.0		22.0
Ndola Energy	41.0	41.0		41.0
Imported - DAM	0	38.0		44.0
Imported - EDM	0	27.0		0
Imported - Aggreko	0	107.0		40.0
Imported – Karpower Ship	0	0		241.7
Itezhi-Tezhi	0	0		70.0
Maamba	0	0		150.0
Total Generation	1,050.5	1,222.5		1559.5
Transmission Losses	63.1	73.4		89.9
Total Demand	1,740.0	1,740.0		1,905.0
Total Deficit	752.6	590.9		345.5
Total Deficit (%)	43.25	33.96		22.86

Source: ZESCO and World Bank (World Bank Group, 2015)

Note: DAM - Day Ahead Market; EDM - Electricidade de Mozambique

$$\text{Deficit} = \frac{\text{Demand} + \text{Transmission_Loss} - \text{Generation}}{\text{Demand}} \times 100\% \quad (1)$$

The low water levels in the hydroelectric power dams have been due to the poor rainfall experienced during the 2014/2015 rainy season. Using equation 1, the electricity deficit without and with imported emergency power stood at 43.25% (762.9MW) and 33.96% (590.9MW) respectively, between June – December 2015 whilst it stands at 22.86% (345.5MW) in 2016 as illustrated in Table 1.

Zambia's electricity generation is mainly dependent on hydroelectric technology, (at present Maamba power company, a coal fuel power plant is now operational generating only 50% of its installed capacity, i.e. generating 150MW into the grid) thus giving the hydro fuel electric production standing at 94% of the total as illustrated in Table 2 below. The deficit has caused ZESCO to initiate stringent measures of load shedding to preserve water in the reservoirs to avoid a complete shutdown of the power plants. Further, the short term and medium term measures were initiated which resulted in ZESCO importing emergency power as illustrated in Table 1 for the period from September to December 2015 (*Ministerial Statement, 2016*).

Table 2: Existing hydropower plants in the Zambezi river basin

No.	Power Station	Fuel Type	River	Hydro Type	Capacity(MW)
1.	Victoria Falls	Hydro	Zambezi	Run-of-River	108
2.	Kariba North	Hydro	Zambezi	Reservoir	1,080
3.	Itezi-Tezi	Hydro	Kafue	Reservoir	120
4.	Kafue Gorge	Hydro	Kafue	Reservoir	990
5.	Mulungushi	Hydro	Mulungushi	Reservoir	20
6.	Lunsemfwa	Hydro	Lunsemfwa	Reservoir	18
7.	Lusiwasi	Hydro	Lusiwasi	Run-of-River	12
8.	Maamba	Coal	N/A	N/A	300
Total Capacity					2,648

Source: Zambezi River Authority; (ZDA, 2014)

2. Risk of Over Dependence on Hydroelectric Technology and the Impact of Power Deficit and Low Copper Prices

During the same period of power deficit, copper prices declined by 33% to \$4,595/ton in the early of 2016 (World Bank Group, 2015). Thus Zambia had faced the “double-edged sword” of economic challenges; on one hand the decline of copper prices which can be considered as an external headwind and on the other hand the domestic pressures of power deficit which lead to some Mining companies having to shut down some of their operations. The combination of these pressures caused the mine closures in 2015 leading to the job losses of over 8,550 jobs (World Bank Group, 2015; Zambian Economist, 2015) as shown in Figure 2, just in the mine industry alone. The jobs losses have increased to over 10,000 people. The mining job losses illustrated in Figure 2 can be said to be an underestimate of the scale of job losses. It is not just the mining workers that have been laid off, but the mining contractors also lost a lot of businesses which had resulted in more job losses in other areas. The mining job losses

illustrated in Figure 2 got worse in 2015 when the mine companies decided to scale down their operations due to electricity shortages and higher production costs (due to increased electricity tariff for emergency power). Some parts of the mining operations had to be shut down or scaled back for the mine companies to cope with the load-shedding. Power is used not only in mining and processing, but also in maintenance, especially in old underground mines where power is an extremely high overhead operation cost. Due to electricity deficit, which had risen to over 590 MW in September 2015 the Zambian electric companies decided to cut power supply to the mines by 30%, which lead to some Mining companies having to shut down some of their operations. The combination of these pressures caused the mine closures in 2015 leading to the job losses of over 8,550 jobs as illustrated in Figure 2.

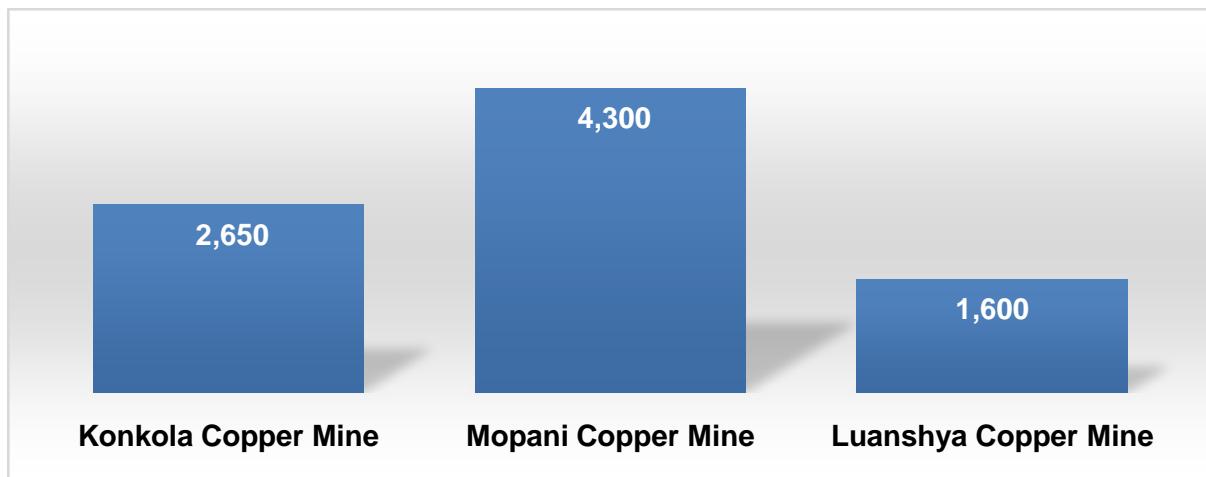


Figure 2: Mining job losses caused by electricity deficit and low copper prices (Zambian Economist, 2015)

Zambia's installed power capacity (including 300MW from Maamba`s Coal fuel power plant) stands at 2,648 MW with the bulk being the hydroelectric power. However due to the continued low water levels in the dams of the hydroelectric power stations, Zambia resorted to importing power from Mozambique and the Southern African Power Pool which has proved to be more expensive to run the mines. The actual total monthly power generation stood at 1,222.5 MW between September - November 2015, whilst the nation`s monthly demand stood at 1,740 MW during the same period resulting in a deficit of 590.9 MW (33.96%) after taking into account the transmission losses standing at 73.4 MW. The overall picture resulting from the electricity deficit and low copper prices has proved economically not viable for the mines to continue operating, which ultimately threatened normal mining production output, causing job losses and suffocating the country`s economic growth as depicted in Figure 1 above.

2.1 Impact of drought and climate changes on hydroelectric technology

Research (Masih et. al, (2014)) has demonstrated that Africa has recorded 219 droughts and has the highest number of droughts compared to other continents in the world during the period between 1900 and 2013, as illustrated in Figure 3 below. Zambia has had 8 events of drought in total during the period from 1980 to 2013 of which 1991/1992 event was the severe one. In Zambia the periods of these events are: 1981/1982, 1983/1984, 1991/1992, 1994/1995, 1997/1998, 2000/2001, 2001/2002 and 2004/2005. Beifuss (2012) explained that the Zambian hydroelectric power generation technologies (Reservoir and Run-of-River), both existing or proposed have not incorporated considerations of drought or climate

change into their plant designs or operations and as a result, the effects and consequences of such hydro electricity generation methods which our country is currently experiencing during the poor rainfall of the 2014/2015 rain season is evident. The lessons learned from the current electricity shortage in the country, which are indeed true, are that:

- we ought to acknowledge to understanding the hydrological variability in the Zambezi River Basin is fundamental to assessing the risks, uncertainties, and consequences of depending on hydropower systems (see Figures 3 and 4).
- climate change is affecting the amount of water available to produce hydropower to meet increasing daily and season peak demands especially during drought periods (see Figure 3).

For instance, during 1991/1992 rain season (see Figure 4) Zambia experienced a severe drought. Magadza (2006) illustrates that Zambia had hydropower shortages which had caused similar economic consequences, just like the current ones (see Figures 1 and 2) the country is experiencing due to poor rainfall during in the 2014/2015 rain season, such as:

- a) US\$102 million reduction in GDP;
- b) \$36 million reduction in Export Earnings
- c) Loss of 3,000 jobs

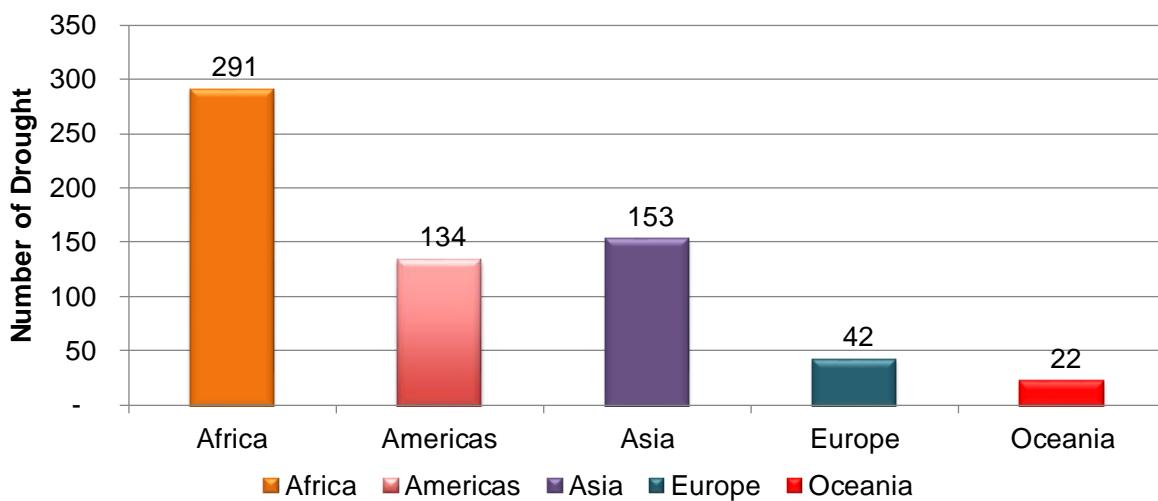


Figure 3: Droughts across the World during 1900–2013 (Masih et al., 2014)

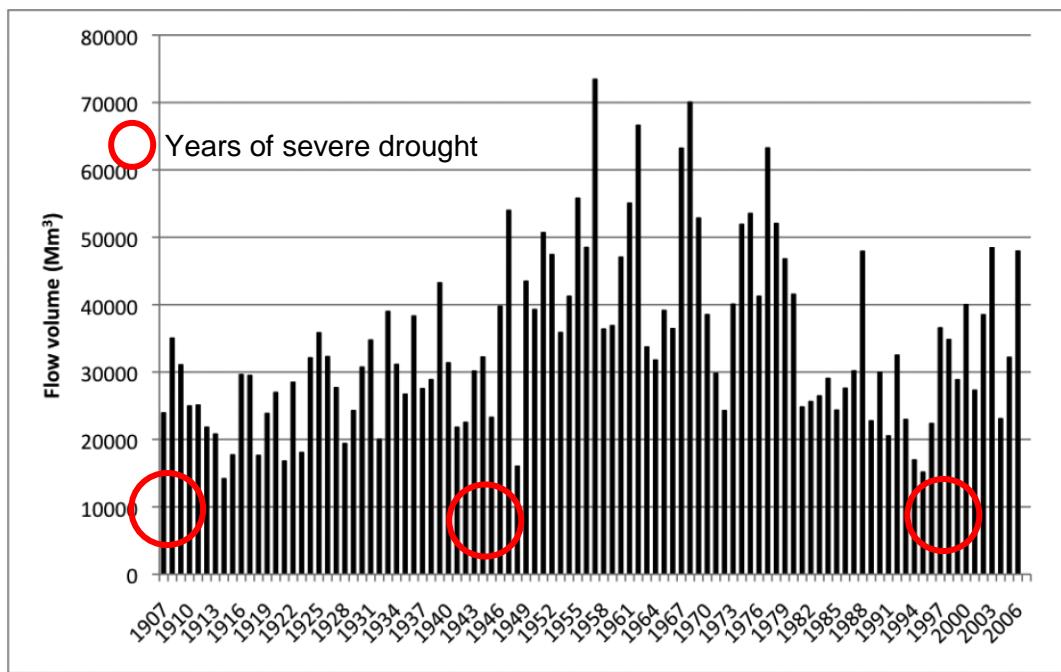


Figure 4: Variation in mean annual runoff on the Zambezi River Basin at Victoria Falls between 1907-2006 (Beifuss, 2012)

Research by Beifuss (2012) has indicated that climate changes have profound implications for future hydropower in Zambia. Beifuss (2012) further stated that climate change had the potential to affect hydropower operations in the following ways:

1. Reduced reservoir inflows, due to decreased basin runoff and more frequent and prolonged drought conditions, will reduce overall power output.
2. Delayed onset of the rainy season could result in less predictable power production and more uncertainty and complications in using reservoirs for flood management.
3. Increased surface-water evaporation could reduce power production.

Thus, this paper underpins the fact that climate changes have profound implications for future hydropower production, for Zambia to begin to review her plans and refrain from over dependence on hydroelectric technology.

2.2 Impact of power imports in 2016

To address the electricity deficit in the country, due to drought and climate change which has caused low water levels at the hydroelectric power dams, ZESCO has been compelled to negotiate for power purchase agreements (PPAs) with various Independent Power Producers (IPPs) and utilities in the Southern African Power Pool (SAPP) (*Ministerial Statement, 2016*) as illustrated in Table 3.

Table 3: Emergency Power PPAs Negotiated by ZESCO

Source	Type	Capacity (MW)	Contract Period	Tariff (US\$c/kWh)
EDM	Hybrid	80 - 150	Jan. 2016 – Dec. 2017	14.00
Aggreko	LNG	148	Sep. 2015 – Dec. 2015	18.86
Aggreko	LNG	40	Jan. 2016 – Dec. 2017	18.86
Karpowership	HFO	100	Jan. 2016 – Dec. 2017	16.73
ESKOM	Hybrid	50 - 300	Jan. 2016 – Dec. 2016	6.00 - 19.00

Source: National Assembly of Zambia (Ministerial Statement, 2016)

The cost at which ZESCO is buying the emergency power (see Table 3) is higher than at which it is selling the same power at an average of US\$ cents 5/kWh to ordinary citizens and 10.35/kWh to the mine companies (*Ministerial Statement, 2016*). The selling price of imported power by ZESCO is not cost reflective, causing great strain on its operations in terms of revenues and profits. At the current tariff rate of US\$ cents 5/kWh, the government will need to provide financial support to ZESCO of over US\$340 million in 2016 to meet the cost of imported emergency power as illustrated in Figure 5. However, if the price of electricity is increased say to US\$ cents 11/kWh, the subsidy that the government will need to provide support to ZESCO will be reduced to US\$148 million. The most important fact worthy noting here is that although it is necessary for ZESCO to revise and adopt economical tariffs which are cost reflective. However, this will only be short and mid-term solutions. The long term solution required for Zambia is to diversify by using a *Source Mix* method to generate electricity to meet the country's hourly demand of electricity, and whilst selling it at cost reflective tariffs.

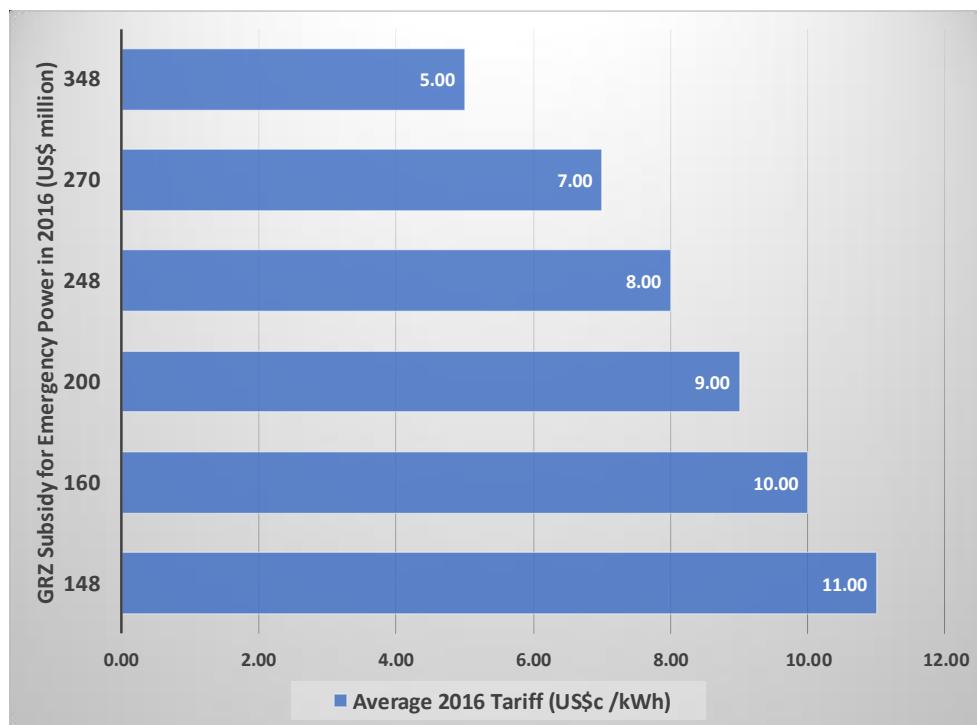


Figure 5: GRZ Subsidy for Emergency Power in 2016; (World Bank Group, 2015)

3. Electricity Generation Options

Bazmi *et al.* (2011) have explained that energy systems engineering does provide a methodological approach to arrive at realistic solutions to energy problems, when planning and making decisions. Bazmi *et al.* (2011) analyzed the role of modeling and optimization in the energy sector for future prospective of optimization modeling as a tool for sustainable energy systems. Using such methodological approach, planners and decision makers are able to have an in-depth understanding and allowing them to make decision from broader aspects of view. Different electricity generation technologies and the importance of using several fuel types to generate electricity and avoid over dependence on hydroelectric technology are presented hereunder.

3.1 Comparison of electricity generation technologies

Bazmi *et al.*'s research (2011) indicated that to achieve a truly sustainable energy future in a decarbonized environment, we need to combine options to lower the energy per unit of the GDP and carbon intensity of energy systems. Greenhouse gas (GHG) emissions which is related to the energy sector are a by-product of the conversion and delivery sector including extraction/refining, electricity generation and direct transport of energy carriers in pipelines, wires, ships, etc., as well as the energy end-use sectors i.e. transport, buildings, industry, agriculture, forestry and waste. Sims *et al.* (2007) demonstrated the complex interactions between primary energy sources and energy carriers see Figure 6) to meet man's energy requirements as utilized in transport, buildings, industry, etc.

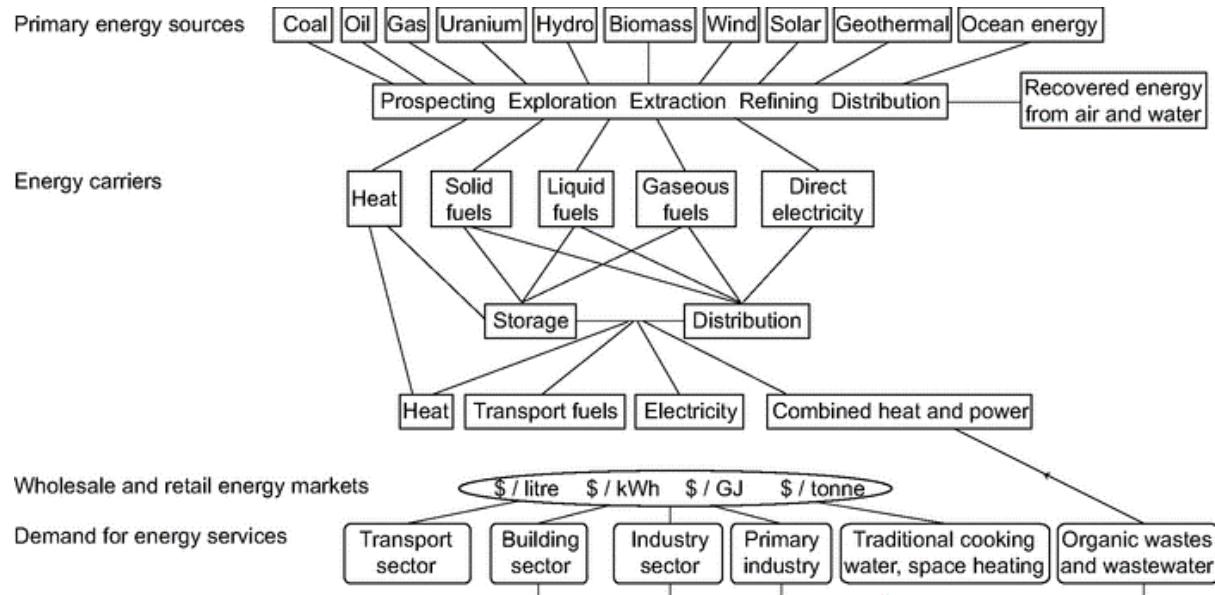


Figure 6: Complex interactions between primary energy sources and energy carriers to meet societal needs for energy services (Sims *et al.*, 2007)

In Lenzen (2010)'s paper, eight (8) electricity technologies have been discussed. Seven (7) of these are generating technologies and they are: hydro-, nuclear, wind, Solar PV, concentrating solar, geothermal and biomass power. The eighth technology is carbon capture and storage, but remains to be demonstrated

for large commercial scale, by 2020. Figure 7 illustrates the comparison of Capacity factor of the different types of electricity generation technologies used in the USA (Hankey et. al., 2016).

Capacity factor is a measure of how often an electric generator operates over a specific period of time, using a ratio of the actual output to the maximum possible output over that time period. The capacity factor for a particular fuel/technology type is given by equation 2 as adopted from Hankey *et al.* (2016):

$$\text{Capacity_Factor} = \frac{\sum_{x,m} \text{Generation}_{x,m}}{\text{Capacity}_{x,m} \times \text{Available_Time}_{x,m}} \quad (2)$$

Where:

x = generators of that fuel/technology combination, and

m = the period of time (month or year).

Generation and capacity are specific to a generator, and the generator is categorized by its primary fuel type as illustrated in Figure 7. Although, nuclear power has greater capacity factor as illustrated in Figure 7, its current major disadvantage is that the nuclear accident in 2011 at the Fukushima Nuclear power plant are still fresh in the minds of many people all over the world. Further, this technology faces many barriers such as waste disposal, proliferation, and thus public acceptance is almost impossible. However, the advantage of this technology is that it is one of best base-load electricity generation method with competitive generation costs as shown in Table 4. Illustration in table 4 provides a comparison among these technologies in terms of annual generation, CO₂ emission, generation cost and the major barriers in deployment each of these technologies.

Lenzen (2010) discussed that about 90% of hydropower is generated by large hydro dams, whilst the remainder is generated by small and run-of-river plants. In Zambia we have similar scenarios with about 78% of installed capacity is by large hydro reservoirs as illustrated in Table 2. The long-term resource for large hydro electricity generation is becoming limited as most large rivers have already been dammed. Wind turbines have improved to be able to generate several megawatts per device. The advantage with these developments is promoting wind farms being deployed off-shore.

In Figure 7, it is illustrated that Solar PV power has good values of capacity factor compared to Concentrating Solar power. However, literature (Lenzen, 2010) states that improvement is possible with concentrating solar power when combined with storage function such that the capacity factor outperforms that of Solar PV power. Table 4 further illustrates that the generating costs of both Solar Power generating methods ranges between US\$c10/kWh and US\$c25/kWh which generally on the high side compared to other technologies.

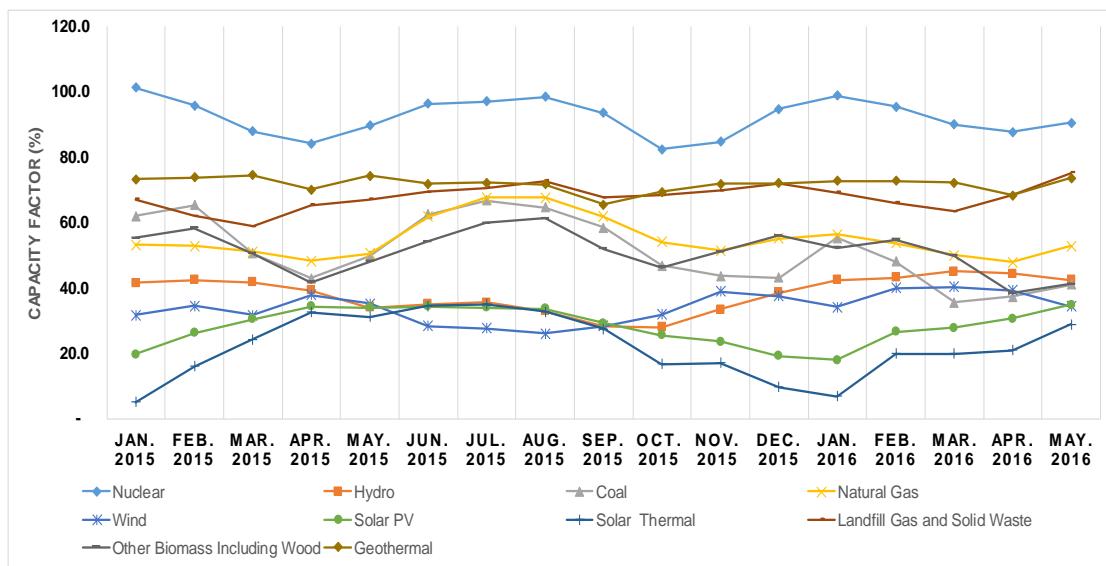


Figure 7: Comparison of capacity factors for electricity generation technologies (Hankey et. al., 2016)

Table 4: Current generating technologies (Adopted from Lenzen, 2010)

Technology	Annual Generation(TWhel/y)	CO ₂ emissions(g/kWh el)	Generating cost(US\$c/kWh)	Barriers
Coal	7755	900	3 – 6	Greenhouse gas emission
Oil	1096	700	3 – 6	Resource constraints
Gas	3807	450	4 – 6	Fuel price
Carbon capture & storage	-	170 - 280	3 – 6 + 0 - 4	Energy penalty, large-scale storage, late deployment
Nuclear fission	2793	65	3 – 7	Waste disposal, proliferation, public acceptance
Large hydro	3121	45 – 200	4 – 10	Resource potential, social and environmental impact
Small hydro	~250	45	4 – 20	Resource potential
Wind	260	~65	3 – 7	Variability and grid integration
Solar-PV	12	40/150 100/200	– 10 – 20	Generating cost
Concentrated Solar	~1	50 – 90	15 – 25	Generating cost
Geothermal	60	20 – 140	6 – 8	Uncertain field capacity
Biomass	240	35 - 85	3 - 9	Efficiency, feedstock availability, cost

4. Strategic Direction to Generating Electricity in Zambia

4.1 Example of electricity source mix generation - Ontario power system

Ontario power system is Canadian energy company operating in Ontario province. It has a diverse power supply mix (See Figure 8). Its generation fleet continues to evolve to meet the province's changing electricity needs. The Independent Electricity System Operator (IESO) oversees Ontario's electricity

system. Ontario power system operates real-time mechanism to forecast daily electricity demand to ensure an adequate supply is always available. IESO operation includes managing all fuel types of Ontario's generation technologies, making sure all power generating units are ready to start on and shutdown production as needed (*Ontario Power System, 2016*).

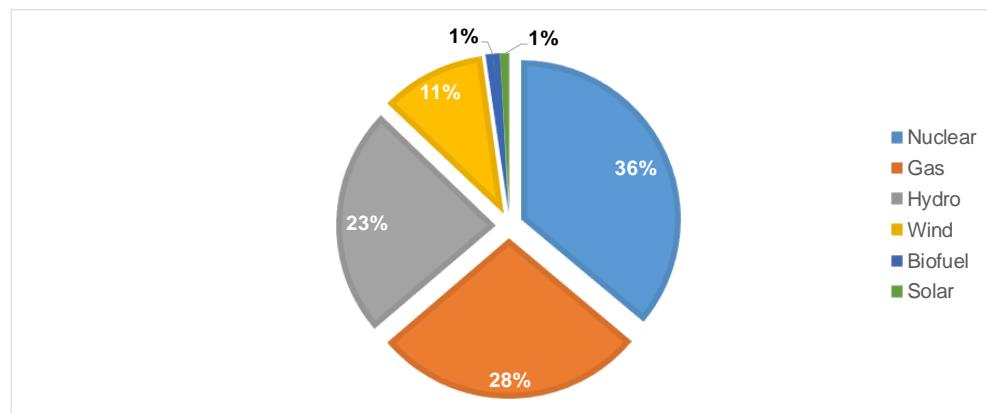


Figure 8: Installed Energy Capacity by Fuel Type as at June 2016 (Ontario Power System, 2016)

There are 35,951 MW of installed generation in Ontario's electricity grid. The amount of power available at any given time depends on the availability of fuel, whether a generator is on line or off line for maintenance and operating limitations of the facility. Figure 9 illustrates that each generation type has a role in Ontario's energy source mix generation. The nuclear and large hydroelectric power stations operate 24/7 providing a steady output known as base-load generation, whilst other generation types stations ramp up production during peak periods of demand, variable generation, such as wind and solar, produce energy depending on how much wind and sunlight is available. Figure 10 illustrates the total characteristics of Total Demand versus Total Generation - Hourly as at August 15 2016 (Ontario Power System, 2016).

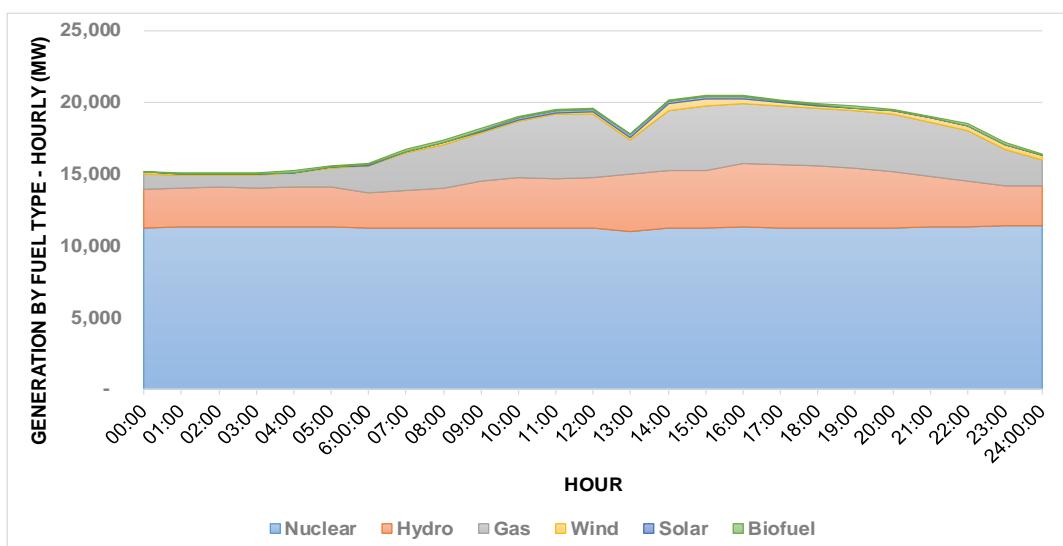


Figure 9: Generation by fuel type - hourly as at August 15 2016 (Ontario Power System, 2016)

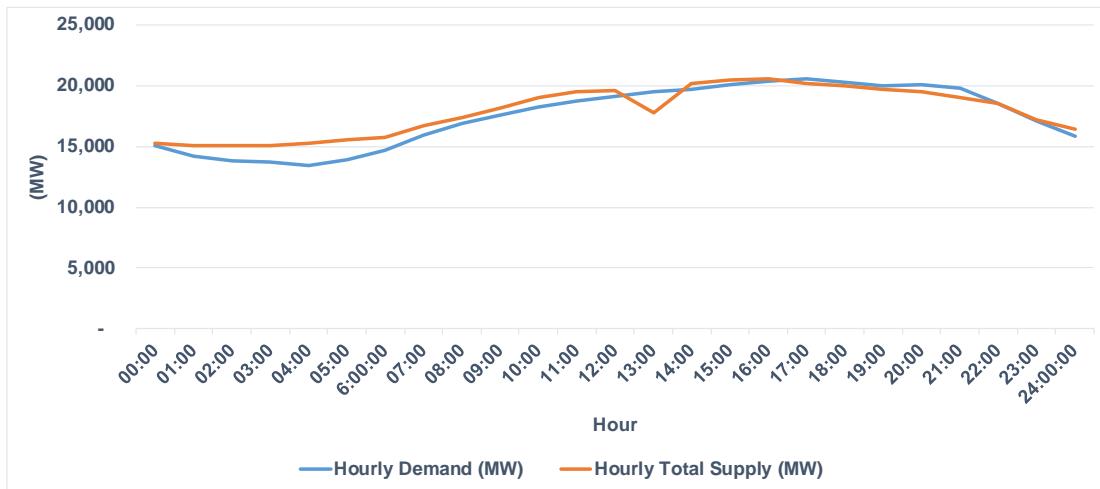


Figure 10: Demand versus total generation - hourly as at August 15 2016 (Ontario Power System, 2016)

5. Proposed Zambia's Electricity Source Mix Generation Model

Following the 2016 electricity requirement projected for Zambia for 2016 as shown in Table 1, we develop Table 5 in which we calculate the total deficit power without imported emergency power. The new total deficit equal is 581.3 MW or 30.31% of demand.

Table 5: Emergency power imports for 2016

January 2016 to December 2016	Monthly Average (Mw)
ZESCO Hydropower Generation	950.8
Lunsemfwa Hydro	22.0
Itezhi-Tezhi Power Station	70.0
Ndola Energy	41.0
Emergency Imports -Agrekko	0.0
Emergency Imports - Karpower Ship	0.0
Emergency Imports - Day Ahead Market	0.0
Maamba Coal	150.0
Total Generation	1233.8
Transmission Losses	89.9
Total Demand	1,905.0
Total Deficit	581.3
Total Deficit (%)	30.31

Source: ZESCO and World Bank (World Bank Group, 2015)

Equation 3 provides the hourly generation required to meet the hourly demand. Assuming that the actual demand plus transmission loss put together be considered as gross demand to summarize and derive equation 4. Using equation 4 we can therefore state that at each particular hour we need n generation units connected to the grid to meet the hourly demand as illustrated in equation 5.

$$Demand + Transmission_Loss \leq Generation \quad (3)$$

$$Demand \leq Generation \quad (4)$$

$$Demand \leq \sum_1^n G_n \quad (5)$$

6. Conclusion

Zambia as a country needs to address the electricity deficit problem by first scientifically understanding the true cause of the current problem. The analysis in this paper clearly demonstrates that there is an urgent need for Zambia to switch over from conventional hydropower generation to employ a diverse electricity generation method the energy source mix, but which technologically sustainable and can meet the present and projected country's electricity demand in a long term. Therefore, to attain energy independence and guarantee energy security for Zambian's now and in future, we must first acknowledge that energy systems engineering does provide a methodological approach to arrive at realistic solutions to energy problems, when planning and decisions making just like what other countries have done as discussed in this paper. Taking into account these revelations, we as Zambians need to research and calculate an optimal electricity supply-demand structure for Zambia. Thereafter, decide which fuel types to build for generation and connect to the national grid to supply and meet national electricity demand on an hourly basis. We must decide the fuel type to use for base-load generation, taking to consideration the capacity factor as discussed in the earlier section and also for variable generation for use during peak period. Suffice to reemphasize the point again that wind and solar have varying characteristics in electricity generation, considering the fact that they produce energy depending on how much wind and sunlight is available. Solar and Wind power technologies are not therefore suited for base-load generation. Zambia therefore must invest in base-load electricity generation plants which must have a good lifespan, emissions-free, and can operate 24/7 with steady power output level. And most importantly it must be independent of seasonal water availability, weather conditions or fluctuating gas prices.

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4

INTEGRATIVE INFRASTRUCTURE PLANNING AND MANAGEMENT

DII 2016-034

Critical Success Factors for Managing Infrastructure Projects in Africa: A Critical Review and Lessons Learned

Nicholas Chileshe¹

Abstract

Despite significant improvements in the application of development strategies for construction across a number of development areas as agreed by the ‘research agenda of W107’, there still remain a number of challenges affecting the delivery of infrastructure development and investment in Africa. The synergies between effective implementation of risk management and undertaking the best practices of infrastructure projects are well acknowledged in literature. This research is focused on identifying the critical success factors (CSFs) associated with managing infrastructure project in Africa, as well coping mechanisms and strategies for dealing with risk management practices. A systematic literature review of studies undertaken on infrastructure development in Africa will be conducted. This will be complemented by previous empirical studies undertaken on critical success factor for risk management related studies in selected Sub-Saharan African countries such as Zambia, Tanzania and Ghana which have recorded significant developments in achieving some of the nine development areas as identified by the ‘research agenda of W107’. Furthermore, content analysis (CA) was employed to analyse the remaining trends and emergent research gaps. Some advocated solutions and roadmap for addressing the identified bottlenecks will be put forward. This study has a number of implications for policy makers as the identified CFSs and lesson learned can be tailored in mitigating some of the challenges in implementing risk management practices. In so doing, unlocking the dormant and unsustainable potential thus delivering projects that could harness the huge investment and development. Finally, stakeholders and practitioners can through effective implementation of risk management maximize the benefits from infrastructure development in Africa. Notwithstanding the noted contributions, the study is limited by the number of empirical studies due to the fewer countries achieving the significant developments as defined by ‘research agenda of W107’.

Keywords: critical success factors, risk management, systematic literature review, Sub-Saharan Africa, lesson learned

1. Introduction

Despite existence of programs such as Programme for Infrastructure Development in Africa (PIDA) which are aimed at boosting intra-African trade through the improved infrastructure, and supporting financial support from financial institutions such as the African Union and African Development Bank (AfDB), as well as being underpinned by strategies and programmes developed by organisations such as The New Partnership for Africa’s Development (NEPAD) (Makayi, 2014), Africa as a continent continues to be faced by number of challenges affecting the delivery of infrastructure development and

¹Senior Lecturer, Construction and Project Management, School of Natural and Built Environments; nicholas.chileshe@unisa.edu.au

investment. However, in spite of these challenges, the potential offered by Africa to overcome its challenges by continuing with its infrastructure development projects is evidenced by funding measures announced on a yearly basis. For example, as recent as 2015, African Nations have renewed their efforts to accelerate their priority projects under the Programme for Infrastructure Development, which began in 2012, need \$68 billion by 2020 and an additional \$300 billion for those planned to 2040 (Davison, 2015). There is also support from international funding bodies such as the World Bank for continued investment in Africa.

Given the broader definition of infrastructure, this paper focus more on the sector of construction to illustrate the number of challenges and what lessons can be learned can be tailored in mitigating some of the challenges in implementing risk management practices. The rationale for selecting ‘risk management’ as a concept to illustrate the synergies with infrastructure project performance is supported by a number of studies (Mehta, 2015, Chileshe and Kikwasi, 2014a). For example, Mehta (2015) identified two factors such as political instability and other economic factors like weak infrastructure in some African countries among the questions that prey on people’s mind when thinking of investing in Africa. Similarly, Chileshe and Kikwasi (2014a) study albeit focussed on Tanzania reviewed a number of studies in selected African and developing countries such as Zwika (2009); Ghana (Agyakwa and Chileshe, 2010); South Africa (Nkado, 2010); India (Tabish and Jha, 2011) as well as developed economies such as Australia (Zou *et al.*, 2010) which provided evidence to the close alignment between implementation of risk management and assessment practices with improved overall project performance.

As with other developed and developing countries, the importance of infrastructure is evidenced by the amount of spending on a number of projects. For example, Infrastructure spending in Africa is estimated to reach \$93 billion per year, facilitated by tax revenues and other domestic resources (Mehta, 2015) and within sub-Saharan Africa, infrastructure spend is estimated to reach US\$180 billion per annum by 2025 (PwC, 2014). To improve the competitiveness of the East African Community (EAC) states, in 2014 the World Bank committed \$1.2 billion to support infrastructure development within those EAC states (The World Bank, 2014). In addition to the World Bank, according to Mutiso (2016), China has also risen to become the single largest trade partner for many African countries. The same report by Mutiso (2016) acknowledged China as being a major source of financial support for various development projects being undertaken on the continent. According to the study by PwC (2014), Chinese involvement in the region spans project funding to direct construction. The underpinning rationale being that Infrastructure development is a key pillar of the China-Africa relationship. The significance and importance of infrastructural development are nested within its impact on raising the productivity of humans and physical capital leading to economic growth (Mehta, 2015).

According to Enakrire and Onyenanria (2007), infrastructure has the potential to improve and develop economic, social academic, moral and environmental background in our contemporary African society. Similarly, Mehta (2015) in citing NEPAD has pointed to infrastructural development as the key to all aspects of social and economic transformation. However, despite the strides and gains registered in improving regional infrastructure connectivity across the continent since the establishment of the African Union along with NEPAD, Africa still faces serious infrastructure shortcomings across all sectors, both in terms of access and quality (Makayi, 2014). Therefore, the aim of this research was to identify the critical success factors associated with managing infrastructure project in Africa by drawing upon extant literature, propose some coping mechanisms and strategies for dealing with risk management practices.

Drawing upon the study by Chileshe and Kikwasi (2014), a good starting point for identifying the CSFs and investigating the challenges affecting the delivery of infrastructure development and investment in Africa would be an understanding the factors affecting the internal and external environments in which the construction industry operates. Against that background, this study has opted for selecting a few countries in Sub-Saharan Africa (Zambia, Ghana, Tanzania and Nigeria) to act as a reference point of departure for future identification of CSFs on infrastructure projects as well as prevailing risk management practices. The structure of this paper gives an overview of the definitions and background to a number of concepts such as CSFs, infrastructure projects, Lessons learned and Risk management, with the next section summarising and presenting brief discussions on the extant literature on CSFs and risk assessment and management practices associated with infrastructure projects. It provides the conceptualisation of CSFs and discusses the CSFs (drivers or enablers) and a brief discussion of the gaps in knowledge. This is followed by the methodological approach adopted and a discussion of the findings. The implications of the study follow after the methodological approach. The final section addresses recommendations in form of the proposed coping mechanisms and strategies for dealing with risk management practices, and conclusions.

2. Definitions and Background

Before considering the critical success factors (CSFs) associated with managing infrastructure project in Africa, as well coping mechanisms and strategies for dealing with risk management practices, it is necessary to define the terms ‘critical success factors’, ‘infrastructure projects’, ‘Lesson learned’, ‘ and ‘Risk management’.

2.1 Critical success factors

The following extract and definition of CSF is taken from earlier study by Chileshe and Kikwasi (2014), “Oakland (1995 cited in Salaheldin, 2009) defined CSFs as the critical areas which organizations must accomplish to achieve its mission by examination and categorization of their impacts. The importance of CSFs has also been highlighted by Johnson and Scholes (1999) through acknowledging that one of the major shortcomings of strategy implementation in organisations is a failure to translate statements of strategic purpose”. Based on the provided definitions, the approach thus undertaken is, within the context of this study, CSFs are defined as drivers or enablers for successful risk assessment and management practices implementation of infrastructure projects based on the prevailing conditions and assumptions within the African context.

2.2 Infrastructure (projects)

While there are numerous definitions of ‘infrastructure’ and ‘projects’ in literature, the definition and explanation adopted for ‘infrastructure’ is one provided by Ngowi *et al.* (2006, pp. 46) as follows: “Infrastructure refers to industries such as turnpikes, canals, tramways, sanitation systems, provision of electricity, communications, and railways that are quite themselves diverse..”. The same study by Ngowi *et al.* (2006) further highlighted the proximity of the construction industry stakeholders to infrastructure projects, couples with the possibility of direct participation in some phases of the projects as making them potentially important investors” In addition to the definition as provided by Ngowi *et al.* (2006), the importance of clarifying what ‘infrastructure’ really means is nested in the observations by the Chairman of Infrastructure Australia,Sir Rod Eddington AO (cited in Beeferman and Wain, 2016), that “infrastructure is critical to our economy, our community and our pursuit of a sustainable environment.

But what do we mean by the term “infrastructure” and do different understandings of that term confuse our attempts to decide on our future investment and development priorities?” The statement made is crucial and applicable to the African context if the number of challenges affecting the delivery of infrastructure development and investment are to be clearly understood, and interpreted.

2.3 Lessons learned

The main definitions associated with ‘Lessons learned’ are extracted from the Shokri-Ghasabeh and Chileshe (2014) study which was aimed at identifying barriers to effectively capture lessons learned in Australian construction industry and how knowledge management can benefit from lessons-learned application. Accordingly, Rezgui *et al.* (2010, cited in Shokri-Ghasabeh and Chileshe (2014) described lessons learned as one of the main sources of knowledge in construction industry, alongside recorded documents, experiences and interactions. In contrast, the Project Management Institute (PMI) Project Management Body of Knowledge (PMBOK), (2013) defines *lessons learned* as the learning gained from the process of performing the project. Formally conducted *lessons learned* sessions are traditionally held during project close-out, near the completion of the project.

3. Literature Review on Challenges, Critical Success Factors and Risk Management Practices for Infrastructural Projects

3.1 Challenges for managing infrastructure projects

A number of studies have identified the importance skilled manpower in managing infrastructure projects (Leautier, 2011). For example, Leautier (2011) among others, identified focused organizations and effective institutions for macroeconomic management as being critical put in place in large part, by the efforts of key stakeholders involved in capacity development. Within the context of Ghana, a study by Badu *et al.* (2010) aimed at exploring strategic issues underpinning innovative financing (IF) of infrastructure identified the following three factors as impediments to IF: (1) investment capacity; (2) implementation; and (3) revenue mobilization. Similarly, in other sectors such as banking, issues such as the intersection of private and public (including governments) interests; and the blurred nature of the formal and informal sectors were found to impact performance (Acquaah *et al.* 2013). Similarly, recent studies such as Rwelamila and Ogunlana (2015, pg. 7) conducted a review of the challenges facing the built environment in developing countries (which encompasses infrastructure) and classified the failed projects into the following four dimension: (1) Inefficient projects; (2) Weak impact on customer / stakeholders; (3) Unsuccessful business / or unsuccessful development strategy; and (4) Unsustainable potential.

A number of studies have examined the causes and effects of cost escalation and schedule delays in road construction projects across developing and developing countries. However, the majority of these studies have been within the context of developed countries. A study by PWC (2014) found the following obstacles affecting African countries in delivery of construction projects: (i) inadequate regulatory frameworks; (ii) internal capacity limitations; (iii) political instability; (iv) policy incoherence; (v) reported corruption; (vi) the time taken to secure project financing can be excessive and (vii) legal uncertainties. Table 1 presents a summary of selected studies on these factors contributing to construction project delays. It must be noted that the summary is by no means exhaustive. By contrast

the context of this study is focused on where there is massive infrastructure development fuelled by mega projects currently funded by China.

Table 2 presents a summary of the 8 out of the 10 top projects in Africa. The main focus here is to highlight some of the projects that might fall under the umbrella of ‘infrastructure projects’ as defined in sub-section 2.2.

3.2 Risk management critical success factors for undertaking infrastructure projects

As indicated in the abstract, this study is complemented by previous empirical studies undertaken on critical success factors for risk management related studies in selected Sub-Saharan African countries such as Zambia (Manelele and Muya, 2008), Tanzania (Chileshe and Kikwasi, 2014a, b) and Ghana (Agyakwa-Baah and Chileshe, 2010).

Table 1: Summary of selected studies on challenges affecting the delivery of infrastructure

Researchers ¹ / Context	Findings
Aibinu and Jagboro (2002)- General survey of contractors' attitudes in Nigeria	Acceleration of site activities coupled with improved owner's project management procedures and inclusion of an appropriate contingency allowance in the pre-contract estimates were recommended as a means of minimizing the adverse effects of construction delays
Frimpong <i>et al.</i> (2003), Ghana	Identified 26 factors with significant ones being planning and scheduling deficiencies, delays in work approval, inspection and testing of work, frequent breakdowns of construction plant and equipment, escalation of material prices, slow decision-making and difficulties in obtaining construction materials at official current prices.
Kaliba <i>et al.</i> (2008) - literature review, structured interviews and questionnaire surveys in Zambia	Investigated the causes and effects of cost escalation and schedule delays in road construction projects in Zambia. The following were identified: inclement weather due to heavy rains and floods, scope changes, environmental protection and mitigation costs, schedule delay, strikes, technical challenges, inflation and local government pressures
Kikwasi (2012) in Tanzania.	Identified causes as design changes, delays in payment to contractors, information delays, funding problems, poor project management, compensation issues and disagreement on the value of works.
Mundia <i>et al.</i> (2013) – Perception of clients, consultants, contractors and financiers in Zambia	Investigated the major causes of cost escalation, schedule overruns and quality shortfalls in the context of the Zambian construction industry. Identified the following (1) insufficient initial analysis of costs; (2) change orders; (3) financial difficulties on the part of the contractors; and (4) ‘poor financial management among’ among the most common and severe factors.
Alinaitwe <i>et al.</i> (2013) in Uganda.	Reviewed 20 causes and identified the following five as most important: (1) changes to the scope of work, (2) delayed payments, (3) poor monitoring and control, (4) the high cost of capital and (5) political insecurity and instability.
Seboru (2015) in Kenya.	Observed the following as top five causes of project delays: (1) Payment by client, (2) slow decision making, (3) bureaucracy in client organization, (4) inadequate planning and scheduling, and (5) rain.

Notes: ¹The studies are arranged in chronological order.

Table 2: Summary of 8 of the 10 mega infrastructure projects in Africa funded by China (Source: PWC, 2014).

No.	Country	Cost (Billion)	Description
1	Nigeria	\$12	The railway project is 1,402 km in length and upon completion; it will link Lagos, the nation's economic capital, with the eastern city of Calabar, passing through 10 states.
2*	Tanzania	\$10	Coastal Railway - The port being built in Bagamoyo, a coastal town in Tanzania. It will be able to handle about 20 million containers annually and will be the largest port on the East African coastline, bigger than the Port of Mombasa in Kenya. Its construction started in October, 2015, but was halted earlier this year due to financial constraint facing the Tanzanian government.
3	South Africa	\$10	Modderfontein New City Project - A Chinese company, Shanghai Zendai, is building the city which will be home to at least 10,000 residents upon completion. The city will have finance and trade facilities, an industrial zone, sports and recreation facilities and an African heritage theme park.
4	Kenya	\$3	Standard Gauge Railway - This is the biggest infrastructural project in Kenya since independence. It is worth \$3.8 billion. China Exim Bank has funded 85 percent of the project (about \$ 3.1 billion). Construction on the 609 km rail line began in October 2013. The first phase connecting the port city of Mombasa to the capital Nairobi is set to be complete by December, 2017. The railway line will ease transport of passengers and cargo between the two cities. It is part of a modern standard gauge railway that will connect Kenya to Uganda, Rwanda and South Sudan.
5	Congo	\$6	Infrastructure for Mines barter deals- The deal was to develop the mine fields in Mashamba and Dima basins and Kolwezi. In return for the loan, the Democratic Republic of Congo government was to give copper mines, with approximately 10.6 million tonnes of copper for exploration and mining by Chinese companies.
6	Chad	\$5.6	Chad-Sudan Railway -The 1,344 km railway is being constructed in three phases and will also link the two nations with Cameroon. Its construction started in October, 2014. China Export-Import Bank has funded \$2 billion with the rest coming from Chinese loans from government.
7	Nigeria, Ethiopia, Kenya, Zambia, Senegal, Mali, Cameroon and Ivory Coast	\$4.34	Dangote Plc Cement Expansion – This project will increase cement production by 25 million metric tonnes and boost the overall production to over 70 million metric tonnes annually.
8	Mozambique	\$3.1	Mphanda Nkuwa Dam and Hydro electric station project - The project also covers the construction of Moamba-Major Dam that will supply drinking water to the residents of Maputo.

The countries in bold (including Angola) are registered as the fastest growth rates in the last year, exceeding SADC's 7% growth rate target.

The following 10 CSFs emerged as the basis for identifying the coping strategies and lessons learned: (1) Management style; (2) Awareness of risk management processes; (3) Co-operative culture; (4) Positive human dynamics; (5) Customer requirements; (6) Goals and (strategic) objectives of the organisation; (7) Consideration of external and internal environment; (8) Effective usage of methods and tools; (9) Teamwork and communication; and (10) Availability of specialist risk management consultants.

4. Research Methodology

This paper employed a systematic literature review (SLR) to identify and expand the existing body of knowledge on the CSFs associated with managing infrastructure projects in Africa. According to Hastings (2007 cited in Buyucek *et al.* 2016), SLR provide the mechanism for closing the gaps between theory and practice, and a better approach for the identification of trends and gaps. The SLR has also been deemed as an essential scientific activity (Denyer and Tranfield, 2009). The SLR process is summarised in Figure 1.

As illustrated in Figure 1, the SLR was comprised of the following three stages: 1) Planning and searching the literature; 2) Screening, extraction and synthesis the review; and 3) Documenting the review. Due to the space limitation, only the abridged versions of the explanations for the SLR are provided here. The Emerald and Association of Researchers in Construction Management (ARCOM) database search using the ‘Infrastructure projects’ as the initial Keyword ‘1995-2016’ yielded a total number of 24,576 articles. The time frame chosen for the present study was January 1995 to May 2016. Using the ‘forward’ and ‘backward’ searches through the subsequent utilisations of keywords such as ‘Africa’, ‘sub-Saharan Africa’ and ‘Critical success factors’ resulted in N = 4477; N= 750 and N = 373 respectively. This search demonstrates that there were quite a significant number of studies with those ‘phrases’ or ‘keywords’ undertaken. However, given the broad description ‘infrastructure’ and the decision to focus more on ‘construction’ specific studies, and restricted to a number of the sub-Saharan African countries, the search criteria was further refined to accommodate the following keywords: 1) ‘Construction industry’, ‘Zambia’, ‘Nigeria’, ‘Ghana’, ‘South Africa’ and ‘Risk management’. This further narrowed the scope and resulted in an acceptable and reduced number of articles as follows: ‘Risk management (N = 241)’; ‘Zambia (N= 44)’, ‘Kenya (N=63) as the only number of articles from the two countries’.

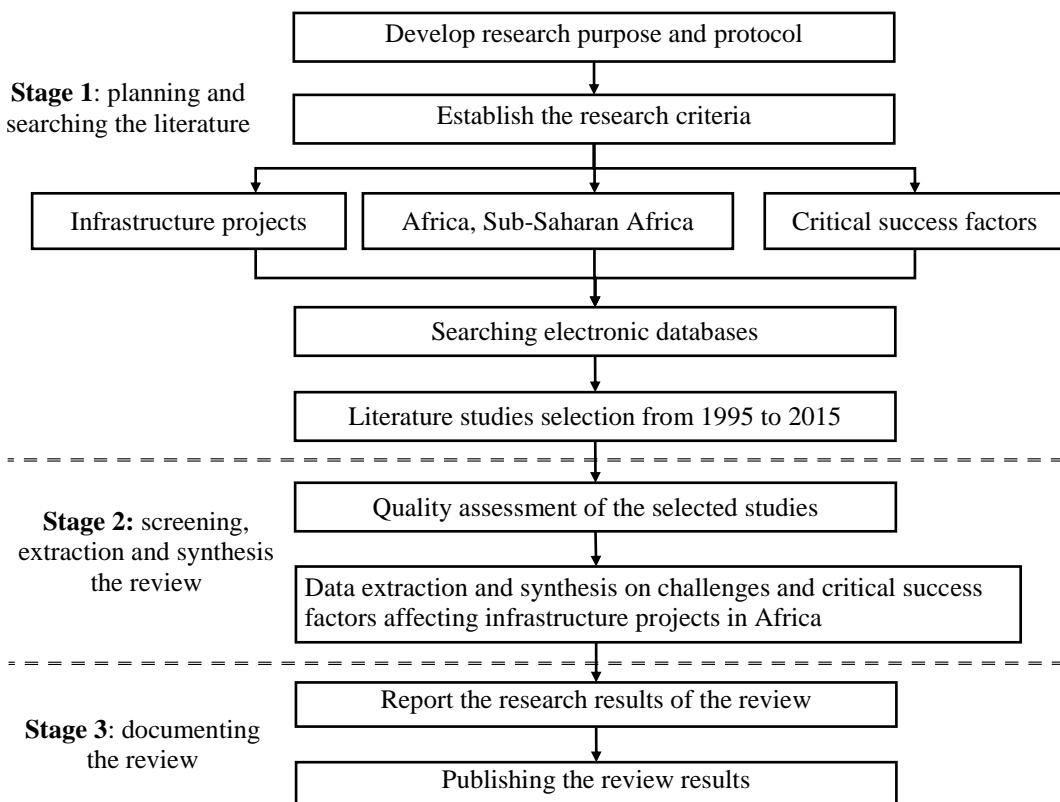


Figure 1: Research stages and processes framework

5. Advocated Solutions and Coping Strategies

Having provided the conceptual definitions of the key terminologies (viz a viz ‘critical success factors’, ‘infrastructural projects’ and ‘lesson learned’) and reviewed the literature, some advocated solutions that could be used to overcome these challenges are summarised in Table 3. The identified solutions can also be considered as ‘lessons learned’. The majority of the coping strategies are drawn from the following empirical risk management related studies: Chileshe and Kikwasi (2014a; 2014b); knowledge management studies, Shokri-Ghasabeh and Chileshe (2014); and the development strategy and research agenda, Rwelamila and Ogunlana (2015). It should further be noted that some of the challenges and corresponding coping strategies proposed in Table 3 are in alignment with the recommendations of Rwelamila and Ogunlana (2015).

5.1 Recommendation for further research

Drawing upon previous risk management studies undertaken within the Ghanaian context (Chileshe and Yirenkyi-Fianko (2012), and Tanzania (Chileshe and Kikwasi, 2014), the following recommendations which will be of benefit to policy makers, industry and academia for the usage of an effective risk assessment and management practices across within the Zambian constructional related organisations (as an example) are suggested:

- *Awareness campaign* - The relevant regulating boards such as the Engineering Institution of Zambia (EIZ), Architects and Quantity Surveyors Registration Board (QSRB), and Engineers Registration Board (ERB) representing the contractors, ‘architects and quantity surveyors’ and engineers

professions respectively, should introduce training programs associated with risk management practices. This might be through mechanisms such as workshops and seminars) that are aimed at sensitization of their members on the benefits of implementation of risk management practices.

Table 3: Advocated solutions to the identified bottlenecks in managing infrastructure projects in Africa

No.	Bottlenecks (Challenges)	Solutions (Coping Strategies) ¹
1	Inadequate funding; funding problems; revenue mobilization	Joint venture mechanisms, innovative procurement practices such as partnering, PPP, project alliance; *Private capital participation; Concerted effort by governments, private businesses; Capitalisation on international demand for local sovereign debt (i.e. Eurobond for Zambia).
2	Technical challenges	Joint ventures and knowledge transfer.
3	Information delays	Adoption of alternative procurement strategies such as partnering, ICT platforms such as Building Information Modelling (BIM); Strive towards becoming a learning organisation; Sustainable education.
4	Poor project management; Project delays and cost overruns; *Procurement /performance	Regulatory bodies such as in respective developing countries should be at the forefront in providing clear guidance or best practice studies for risk management.
5	Lack of skills and risk management knowledge; *lack of internal capacity among state organisations to plan, procure, manage and implement capital infrastructure projects	Stakeholders (particularly contractors) should be encouraged to collaborate with foreign contractors (see Table 2) on infrastructure and mega projects through joint ventures
6	Availability of specialist risk consultants	Usage of external risk management consultants.
7	Variations from original specifications	Effective risk and project management skills
8	*Internal capacity to handle major capital projects, political risk and interference.	Good governance
9	Risk management implementation costs.	Clear project scope and improved clarity in the recognition of risk

Source: PWC (2014)

- *For researchers* – There should be renewed efforts on undertaking risk related management studies should be made. The literature review established that with the exception of the Manelele and Muya (2008) study, there are limited studies undertaken within the Zambian context that have explored the awareness, usage and benefits of risk management for infrastructure projects.
- *Benchmarking of best practices* – The National Construction Council (NCC) as the main statutory body whose remit is to promote and build the capacity of the Zambian construction industry (ZCI) should further play a proactive role in this endeavour. Some suggested or advocated solutions for the NCC would be to benchmark best practices within the Southern African Development Community (SADC) countries by examining successful implementation of risk management in the SADC region. This approach would lead to the identification of the CSFs that helped them succeed and the challenges they faced and how they overcame them. The resultant findings could then be customised for deployment within the ZCI. The same approach could be extended to other developing economies where risk management is still in its infancy stage.

5.2 Implication for policy

Relative to the challenges affecting the delivery of infrastructure development and investment in Africa, the study has a number of managerial implications for the researchers, policy makers and practitioners (top management) within the specific African construction related organisations. The following can be singled out as having major implications: The findings may help stakeholders and practitioners through the effective implementation of risk management in order to maximize the benefits from infrastructure development in Africa. Furthermore, the identified CFSs and lesson learned can be tailored in mitigating some of the challenges in implementing risk management practices. For example, Ofori and Mui Mui (2012) identified the absence of ‘institutions to champion steer the Zambian construction industry’ in the implementation of recommendations that have arisen from numerous studies affecting the industry.

6. Conclusion

The study investigates the critical success factors (CSFs) associated with managing infrastructure project in Africa. Secondly, it proposes some coping mechanisms and strategies for dealing with risk management practices. This study used a systematic literature review of studies undertaken on infrastructure development in Africa and complemented by previous empirical studies undertaken on critical success factors for risk management in selected countries such as Tanzania and Ghana. Most importantly, the review established that despite the unprecedented level of infrastructure projects in Africa, including mega-projects funded by China (Table 1.2), there still remained a number of challenges affecting the delivery of infrastructure development and investment in Africa. To that end, the following coping mechanisms and strategies for dealing with risk management practices, and lessons learned were proposed based on the resultant CSFs associated with managing infrastructure project in Africa: (1) Joint venture mechanisms; (2) adoption of best practice; (3) Need for buy in by regulatory and professional bodies in respective developing countries; (4) Some advocated solutions and roadmap for addressing the identified bottlenecks will be put forward. The emergent main contribution of the study is that, the synergies between effective implementation of risk management and undertaking the best practices of infrastructure projects (and hence investment & development) will emerge. Some limitations of the study should nevertheless be noted. The advocated solutions are more theoretical and future research should be undertaken within the respective Sub-Saharan African countries regarding the effectiveness of the risk management practices. This could then be supplemented with empirical data to test the effectiveness of the proposed solutions.

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Modeling Optimisation of Tire Traction Force for Wheeled Construction Vehicles Traversing in Off-road Terrain

Franco Muleya¹, Sunday Nwaubani², David Reid³

Abstract

This paper presents the results of an investigation into the effect of terrain conditions on tire traction at each given vehicle speed selection in wet clay and sand terrain beds. This experimental modeling based investigation was carried out using a modified and instrumented wheeled mobility scooter called MOBILITY SF-3713. This vehicle was run on non-deformable pavement in order to obtain benchmark results. It was then run on sand and clay terrain test beds under controlled laboratory conditions. Results from this experiment indicated that terrain type, applied load, velocity and tire inflation pressure all have significant effects on net traction output of the vehicle. Paved ground was found to have the best traction followed by wet clay terrain. Wet sand terrain was the least favorable terrain in terms of traction optimisation. Dry sand produced negligible traction compared the wet sand. The results suggest that reliable prediction of this relationship can assist earth moving and deformable haulage road engineers in making economic operational decisions that affect tractive efficiency of wheeled plant. These results provide valuable insights on the influence of applied load and vehicle velocity on the generation of optimum traction. This is particularly important for projects that are time-related such as those in the construction industry that deploy medium and heavy duty wheeled earthmoving machinery/plant operating in deformable haulage roads.

Keywords: drawbar-pull, natural terrain, traction, wheel-soil interaction

1. Introduction

The output of a wheeled vehicle traversing in wet and deformable terrain is measured using velocity, wheel rut depths and pulling power measured in form of net traction or drawbar-pull, Muleya *et al* (2014). This paper presents the effect of generated wheel velocity and the respective applied load on the ultimate performance of the vehicle measured in net traction usually referred to as drawbar-pull. This research was achieved through laboratory experimental modelling with the aim of establishing the most economic factor combinations required to generate optimum wheel net traction for a wheeled vehicle traversing through natural wet terrain.

¹Lecturer, The Copperbelt University, School of Built Environment, Department of Construction Economics and Management, Jambo drive Kitwe, Zambia. (corresponding author) E mail: muleyaf@yahoo.co.uk

²Former Senior Lecturer and Pathway Leader for Civil Engineering, Department of Engineering and the Built Environment, Faculty of Science and Technology, Anglia Ruskin University, Cambridge and Chelmsford, CM1 1SQ

³Retired, Senior lecturer and Deputy Dean, Faculty of Science and Technology, Anglia Ruskin University, Cambridge and Chelmsford, CM1 1SQ, UK

2. Background and Literature Review on Traction

This section defines traction and its application in different sectors. Traction is considered to be a critical part of off-road vehicle engineering, according to Wong (2010). From the Bekker theory, traction, sometimes referred to as drawbar-pull, is defined as the difference between soil thrust and motion resistance and that it defines trafficability (Muleya, 2014). According to Ishigami *et al.* (2011) the net traction force called drawbar-pull is obtained as the difference between the thrust and the resistance force. Saarilahti (2002) defines drawbar-pull, thrust or net pull as the lateral forward force a wheel can develop when moving. It is also defined as the difference between tractive effort and translational resistance (Reid, 2000). Grahn (1991) states that the maximum drawbar-pull is the difference between traction force and rolling resistance. Drawbar pull is the force a vehicle can exert on a load in addition to the force required to propel itself according Parker Hannifin Corporation (2004). This means that if the drawbar-pull value is 0N (Zero Newtons), the vehicle may propel itself but without power to pull any additional load at the tow bar.

Wheel rutting is also known to significantly impact the pulling power of the vehicle in terms of traction or drawbar-pull (Muleya, 2014). Favaedi *et al.* (2011) explains that in planetary exploration, the tractive force produced from the interaction between the wheel and the ground determines the rover's ability to accelerate, climb slopes and cross over obstacles. In an agricultural related study on engine power requirements of movers in the Malaysian oil plantation, Pebrian and Yahya (2010) stated that field performance of any off-road vehicle traversing on unprepared terrain depends on the ability of the vehicle to move with the available torques on the drive wheels without constraints under the required drawbar-pull. According to Madsen *et al.* (2013) and Wong (2010), net traction analysis has been used in military reconnaissance and intelligence in the 'go' or 'no go' movement of military vehicles traversing across deformable terrain. The forestry industry has also used net traction or drawbar-pull analysis in economic management of logging operations. The construction industry is yet to fully utilise this study in the reduction of costs associated with operation of wheeled plant in wet natural terrain. Both wheeled and tracked vehicles have their own merits with respect to their mobility on unprepared terrain. According to Bygdén and Wästerlund (2007), at low speeds, tracked vehicles are said to be more superior to wheeled vehicles due to better floatation, hence the need to focus on the wheeled vehicles in consideration for optimized tyretraction generation.

3. Importance of the Study

Positive traction is essential in vehicle mobility because it defines the economic efficiency of vehicle mobility in a particular terrain. When wheeled vehicle get into off road deformable terrain, the tyres experience rutting which result in motion resistance thereby affecting the tractive efficiency of the vehicle. The results from this laboratory based experiment model provide valuable insights on the influence of applied load and vehicle velocity on the generation of optimum traction available. This is particularly important for projects that are time related such as those in the construction industry that deploy medium and heavy duty wheeled earthmoving machinery/plant in deformable haulage roads.

4. Aim and Objectives of the Study

The main aim of this study was to model and quantify the effect of off road terrain on net tyre traction output on the wheeled vehicles or plant. The study was specific to vehicles operating in wet and deformable terrain but using the laboratory experimental approach.

The following were the objectives of the study:

- a) Model and quantify the tyre net traction based on different tyre inflation pressures, different velocities and different applied loads on three different terrain beds.
- b) Measure and determinethe net traction output on non-deformable pavement used as control measurements.
- c) To establish the most efficient terrain in terms of net traction generation between wet clay and sand beds.

5. Research Method and Experiment design

5.1 Modelling

In Jordan and Lategan (2010), modelling is referred to as simulation that describes the representation of an actual situation by a mathematical model or alternatively by laboratory apparatus in the case of a physical model. According to Gerda (2001), mathematical modelling is the use of mathematics to describe real-world phenomena, investigate important questions about the observed world, explain real-world phenomena, test ideas and make predictions about the real world. A physical model typically consists of a scaled down in some cases scaled up version of the complete system or specific portions thereof, which this paper adopted.

The research design took a quantitative modelling approach in order to obtain values that would be used for comparative andisolated analysis. Isolated analysis is a method of holding all variables constant while manipulating one variable in order to determine the influence ofthat one particular variable under manipulation. In order to interpret the results from the clay and sand terrain bed, the special modified vehicle was run on pavednon-deformable terrain in order to establish benchmark or reference results. Laboratory experiments were adopted because of the existing restrictive health and safety regulations that govern plant manufacturers testing sites and earth moving contractors. Velocity, applied load and drawbar-pull values were obtained by means of instrumentation and recording of physical measurements. Scaling and correction factorsmust apply to the simulated results for full scale running of wheeled plant. In addition, laboratory experiments have the advantage of controlling the consistency of the multiple runs that have to be done by changing the measurable values of the research outputs. The laboratory conditions provide more control of the experimental procedures such as protection from external factors which include weather and temperature. Soil test bed re-building is another advantage of laboratory experiments. Sand and clay terrains were selected for this experiment because they constitute the most common terrain profiles. In addition these two types of soil have engineering properties that can be easily defined and measured.



Figure 1: Modified and instrumented vehicle



Figure 2: Tyre inflation in progress using
compressed air

6. Traction Laboratory Experiments based on MOBILITY SF-3713

The new sovereign mobility scooter shown in figure 1 was disassembled, redesigned and rebuilt to meet the objectives of the study. A frame and platform were designed and built to carry the varied weights of 20kg for each unit. The frame was designed to carry a maximum of 80kg. The various loads were critical for isolated analysis procedures.

The special vehicle was run on inflatable pneumatic tyres of size 260 x 85mm to enable the change of tyre inflation pressure intended for adjusting the tyre/terrain contact area. The tyre pressure was measured with a special instrument called PCL tyre gauge. The two tyre inflation pressures selected in pounds per square inch (PSI) were 10PSI and 45PSI. These two tyre inflation pressures were used on the three terrains, various applied loads and various velocities. The advantage with this special vehicle is that it moved freely without guided rails in contrast with what has been presented in many other studies as seen in Iagnemma *et al* (2004) and Ding *et al* 2010). This approach gave more credible results in terms of attaining practical patterns of running the experiments as they would be during the live onsite experiments. This was very critical in the establishment of drawbar-pull values from the unrestricted movement of the vehicle which simulated the live running of a wheeled vehicle.

The net traction values were measured in Newtons as units on all experiments encompassing different tyre pressures, weights and velocities. A slack-less chain was securely attached to the machine in order to obtain the maximum and accurate drawbar-pull values available with the given restricted conditions. The drawbar-pull values were obtained and recorded using a special load cell dynamometer and the PCE-1000 force gauge shown in figures 3 and 4. The load cell had a maximum capacity of 100Kg or 1000N and was connected to a digital gauge/reader via a cable.



Figure 3: Dynamometer load cell and PCE-1000 force gauge Figure 4: Dynamometer load cell in use

7. Soil Bed Parameters

The timber and steel formwork used for the sandy and terrain bedswas 3 metres long, 1 metre wide and 0.20metres high. The sand ordered had moisture content of 6.3% in order to obtain the credible results that would be consistent with the outlined objectives. The sand bed mould was filled with sand in layers of 50mm which was gently compacted just enough to simulate a realistic natural terrain that would be representative of the moist dense sandy terrain. The sand and clay terrain beds were prepared before each experiment in order to create a bed with undisturbed terrain. Sand was much easier to manage in preparation, handling and disposal due to theless-cohesive nature of the sand.

The internal friction angle of sand was found to be 31° which is consistent with the average for the soil of this nature. The clay material used was equally compacted enough to represent natural terrain. It had moisture content of 31% and a bulk density of 1.98Mg/m^3 . The soil cohesion established through tri-axial machine was 74KN/m^2 .

8. Results and Discussion from the Experiments

8.1. Drawbar-pull/Traction results based speed selection 1

Figure 7 presents the pattern of the power performance of the machine and tyre in terms of net traction measured in drawbar-pull under the lowest speed selection. On the hard ground generally all combinations of tyre pressure and applied load produced significant drawbar-pull. Maximum loaded tyres (800N) produced the highest drawbar-pull due to larger contact areas resulting in better grip and traction. In clay was very interesting to record that the tractionvalues for all combinations remainedsignificant though slightly lower than the results from the pavedterrain bed. The lowest traction output for clay was for the combination of 45PSI/0N which had reduced drawbar-pull due to reduced contact area between the tyres and the terrain. It is clear from the results that additional load helps less inflated tyres to have more traction on the ground, whether hard or deformable. In sand terrain the drawbar-pull reduced significantly for all combinations except the 800N/3PSI tyre pressure which resulted in high tyre/terrain contact area thereby producing significant traction. The combination of highly inflated tyres and heavier loads provided the least desired results in the sand bed due to the deep tyre rutting in sand terrain as seen in figure 5. It can therefore be deduced that wider tres or reduced tyre pressure with significant load ae suitable for sandy terrain in order to optimisetyre traction.

8.2. Drawbar-pull/Traction results based on speed selections 5 and 7

Figures 8 and 9 present the pattern of the power performance of the machine and tyre in terms of drawbar-pull for the highest speed selection of 7. On the hard ground, generally, all combinations of tyre pressure and applied load produced significant drawbar-pull. The lower values of these combinations are for the 0N applied loads for both 45PSI and 3PSI. The reduction in traction was much more significant in speed selections 5 and 7 due to higher velocities. Despite the reduction in drawbar-pull in clay compared to hard ground, the output was still acceptable. It is clear that additional load help less inflated tyres to have more traction on the ground be it on hard or deformable ground. In sand terrain however the drawbar-pull reduced significantly for all combinations except the 800N/3PSI tyre pressure. This exception was attained by the increased contact area between the tyres and the terrain. Sandy terrain provided the poorest and lowest drawbar-pull of all the three terrains under study. Figure 5 shows the low traction attained from maximum load and high tyre inflation combination. Figure 6 on the other hand show the significant traction and reduction rutting attained from the maximum load by minimum tyre inflation pressure.



Figure 5: 800N/45PSI combination with maximum rutting and lowest traction in the sand bed



Figure 6: 800N/3PSI combination with minimum rutting and highest traction in the sand bed

9. Conclusions and Recommendations

From the experiment results presented in this study, the following conclusions and recommendations were drawn regarding optimization of net traction effort of tyres operating in wet deformable terrain:

- The net traction was successfully modelled through the laboratory experiments with results being consistent. The results were based on specified terrain beds, tyre pressures, velocities and applied loads. This model was a verification of mathematical modeling results produced much earlier.
- The net traction obtained from the non-deformable pavement presented the optimum traction results compared to the clay and sand beds. This therefore created a credible and well defined control measurements which were used reference points.
- The wet clay terrain bed produced lower traction than in pavement terrain but higher than in the wet sand bed. In some cases the traction output was much closer to the pavement benchmark results. The sand terrain bed produced the lowest traction output for all combinations. The optimum output for sand bed was the 800N/3PSI representing maximum load/minimum tyre

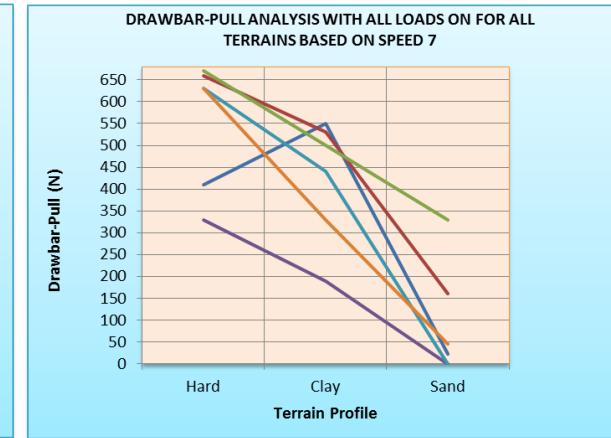
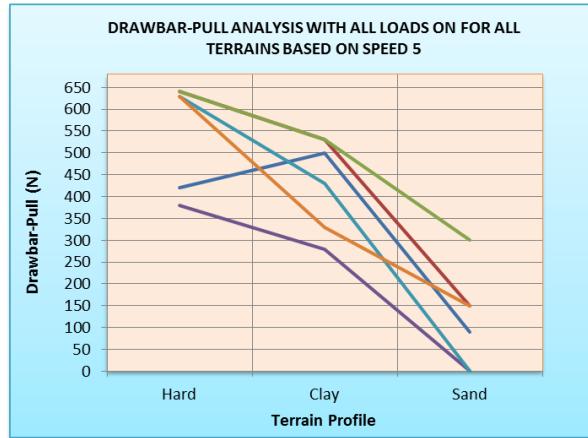
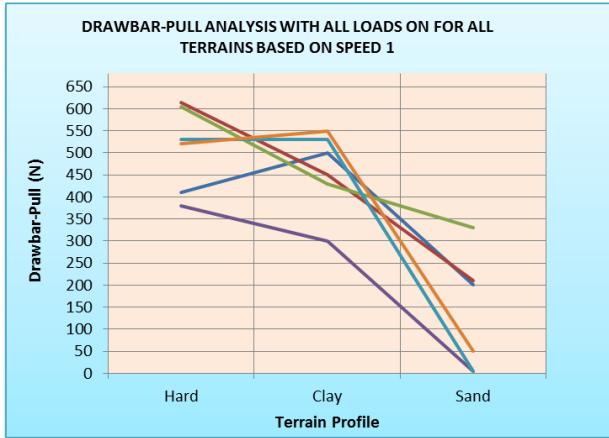


Figure 7: Traction output under speed selection 1

Figure 8: Traction output under speed selection 5

Figure 9: Traction output under speed selection 7

- pressure for maximum tyre-terrain contact area. The results suggest that there is better traction in wet clay terrain than in wet sand terrain. This in turn affects the velocity and duration of projects associated with such deformable terrain.

The experiment however did not consider the effect of various moisture contents, effects of various tyre sizes and combination of sand and clay terrain beds. Despite these limitations the original objectives of the study were successfully achieved. Scaling and correction factors are required when the models are applied to full scale analysis. The paper recommends extending the study to manufacturers' plant testing sites for live experiments as a way of validating the laboratory and mathematical model results.

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Investigating Factors Leading to Project Abandonment in the Zambian Construction Industry: A Case of the Public Sector

Danstan Bwalya Chiponde¹, Christopher Nondo², Lawrence Punda Mutale³, Nonde Lushinga⁴, Bwalya Mwamba⁵

Abstract

This research explored ways of improving delivery of infrastructure projects by identifying factors that lead to project abandonment in the Zambian Construction Industry (ZCI). A questionnaire survey was used to collect data from respondents and involved both qualitative and quantitative research methods. Only two (2) provinces out of the ten (10) were targeted and this was noted as a limitation since 2 provinces may not be representative. It was established that the factors that lead to project abandonment can be associated to the client, contractor and consultants. Some of those related to the clients and the consultants include; client's financial difficulties, delayed payments, inefficient feasibility studies, change orders due incomplete designs and malpractices practices. Contractors related factors included financial problems and their limited technical and operative capacity. Hence if the ZCI and the world at large is to achieve sustainability in infrastructure, it is imperative that factors that lead to project abandonment are identified and mitigated at the earliest stage through planning and conducting a conclusive feasibility study. Ultimately adequate feasibility studies coupled with accurate estimates and detailed designed, enough fund allocation for the infrastructure projects, must be established before a project commences. Additionally local contractors' capacity in terms technology, equipment and finances must also be enhanced.

Keywords: project abandonment, factors, Zambian construction industry

1. Introduction

The construction industry plays a significant role in any country's economy. In many countries, the sector employs up to 10% of the nation's work force and contributes to the Gross Domestic Product (GDP). For instance in Zambia, the industry employs about 3.4% of the total labour force in the formal sector and contributes about 29% to the GDP (ILO 2014). Besides that, the industry also provides necessary infrastructure such as roads, housing, health and education facilities which are needed for the improvement of people's livelihood. Realising the importance of the construction industry, special attention need to be given to overcome the challenges. One such challenge is the abandonment of

¹(Corresponding author)The Copperbelt University, School of the Built Environment, Department of Construction Economics and Management, P.O. Box 21692, Jambo Drive, Riverside, Kitwe. Tel.: +260212225086; E-mail: chiponded@yahoo.com

projects. For developing countries like Zambia, this is important because the government does not have enough resources to meet the huge cost of projects. For instance, the cost of public sector infrastructure in Zambia was US\$3.3billion in 2010, increasing to US\$4.33billion in 2011 (Bank of Zambia, 2011). With such huge investment, it is important then that projects are completed instead of being abandoned. Therefore, the aim of this research was to establish factors that lead to project abandonment in the Zambian Construction Industry (ZCI) and establish ways in which they can be mitigated.

2. Causes of Abandoned Construction Projects

Project abandonment is a challenge across a number of countries. According to Ayodele and Alabi (2011), a project is classified as abandoned when the expected activities to be performed for the completion of the development is stopped due to difficulties. While Hoe (2013) defines an abandoned project as a project which has either been totally abandoned or indefinitely delayed. World over, the construction industry continues to suffer with the challenge of project abandonment due to many reasons a situation which is also common in Zambia. Several causes have been identified and major ones can be grouped as follows:

2.1 Problems related to finances

2.1.1 Lack of adequate fund allocation to the project

Where such is insufficient or inappropriately allocated; the projects are abandonment (Odenyinka and Yusuf, 1997).

2.1.2 Financial difficulties faced by the owner and contractor

This could be due to delay of payments by the owner or because of inadequate cash flow due to contractors' financial limitation (Yan and Murli, 2007; Dissanayaka and Kumaraswamy 1999).

2.2 Management problems

2.2.1 Contractors poor site management practices

This is a significant causeof project abandonment involving both poor people and finance management. This leads to delays in responding to the issues relating to the site and affects the overall work progress (David *et al*, 2002).

2.2.2 Contractors poor financial management

Poor financial planning by most contractors also leads to incompletion of projects or even being of substandard (Mubita, 2007).

2.2.3 Poor human resource management

Managing operatives and staff is critical for the success of any project because construction is a labour-intensive industry.

2.2.4 Inexperienced consultants

This includes lack of cost experience, design experience, lack of funds for staff job training, lack of time available for continuous and effective communication between parties and poor planning of workload.

2.2.5 Variations

Bring in new scope of works (positive or negative) such that the contractor performs a massive amount of change orders and extra works which the current budget cannot meet (Hicks, 2008).

2.3 Political-related factors

This grossly affects planning, budgeting, implementation and overall project delivery through inconsistency government policies which may be due to change in government (Efenudu, 2010). New governments in most observed scenarios abandon previous government's programs with the hidden understanding of embracing self-conceptualized projects (David *et al*, 2002). Furthermore, the poor and highly uncertain funding of the project also creates additional complications (David *et al*, 2002).

Other causes of project abandonment noted by scholars include, malpractices, inappropriate project risk allocation, lack of proper supervision, incorrect estimation, continuous community disruption and interference, improper project costing, and project manager incompetence (Ihuah and Fortune 2013; Ihuah and Benebo 2014; Ayodele and Alabi 2011). Hussin and Omran, (2011) also cited disputes and availability of materials as major causes. Notably, from the various number of causes identified, it can be appreciated that factors stem from all the parties involved in the construction process; contractor, consultants and clients. Hence, in mitigating the above factors, all the key stakeholders must be involved.

3. Project Delivery and Abandonment Overview in the Zambian Construction Industry

The ZCI is a composition of small to medium and large scale contractors. Small scale contractors (SSC) account for about 89% of the total registered contractors with the NCC, while 11% representing large scale (NCC, 2014). The ZCI is further divided into five main sub-sectors; the design, assembly, manufacturing, supply and clientele which participate in delivery and maintenance of building and infrastructure projects (Shakantu, 2000). On an average, public works in Zambia accounts for over 80% of all projects procured annually, with the road sector accounting for a bigger percentage. Projects are either fully financed by the government or through the help of other cooperate partners. In order to ensure successful completion of projects in the public sector, the government uses internationally recognized conditions of contracts for adherence by all the parties. These include; FIDIC, JLC, and other government forms of contracts. In addition, other standard procedures have also been instituted such as guidelines on procurement of works, registration and selection of contractors and consultants.

3.1 Causes of public projects abandonment

Many of the construction projects are not completed on time due to the fact that the industry is crippled with a number of problems. Public projects are mostly government driven, hence vulnerable to political factors. This is more prominent especially during the year for elections, since in many circumstances, the new government abandons previous government's policies (NCC, 2006). In some cases the elections are given priority by relocating the funds needed to finance construction works to financing elections (Chimwisa, 2011). Other factors include high interest rates (Auditor General's Report, 2009). Community interference has also been cited (Bwalya 2014). The Auditor General's Reports (2005, 2007 and 2012) have also shown that the reasons for the increase in the number of projects being abandoned are as follow:

3.1.1 Delayed payments

The government being the major client for public projects, it has been observed and acknowledged that, the government constantly delays in making payments to consultants and contractors thereby affecting production on most public sector works

3.1.2 Inadequate fund allocation and management

Budgetary allocation and releases towards the abandoned projects were often inadequate to meet contractual obligations during the period of project implementation (Auditor General Report 2009).

3.1.3 Inexperienced consultants and contractors on public works

This is due to the limited resources government as a consequence the government is forced to pick the lowest bidder

3.1.4 Technical and management capacity of local contractor

This includes plant capacity, financial capacity, method of construction and personnel training and experience. This is prominent among SSC in the road sector.

3.1.5 Procurement method

The procurement method used, mainly the traditional method leads to failure of projects (Mukumbwa 2008). Essentially, under the traditional procurement, the services of the contractor are not fully utilised in the design process and lack of the contractor's expertise results in unworkable designs leading to failure of most projects.

3.2 Mitigation of project abandonment

Some of the measures that have been put in place can be classified into non-contractual provisional measures and contractual provisional measures.

3.2.1 Non-contractual provisions

These can be categorised as follows:

3.2.1.1 ZPPA standard procedures for procurement of works

All public works procurement in Zambia is regulated by the Zambia Public Procurement Agency (ZPPA). It ensures fair and equal opportunity and financial requirements by those participating (Mukumbwa, 2008). Tender procedures for public sector procurement have also been adapted from the World Bank procurement procedures (World Bank, 2004; ZPPA, 2008).

3.2.1.2 NCC Registration/Grading Systems and selection of Contractors

NCC rates contractors according to their capacity and specialisation both local and international. They also request relevant professional bodies to provide a list of their registered members.

3.2.2 Contractual provisions

These come from the common forms of contracts used on public projects. Clauses guarding against project abandonment include the following:

3.2.2.1 Advance payments bond

This helps contractors with their cash flow and also protects the client from the contractor abandoning the project soon after getting paid an advance payment(Ramus *et al*, 2008).

3.2.2.2 Performance bonds and guarantees

This aims at ensuring satisfactory performance by the contractor, or by a contractor to ensure performance of a sub-contractor. In the event of non-performance, the guarantor provides financial compensation (Ramus *et al*, 2008).

3.2.2.3 Retention and defect liability period

The whole purpose of this period is to compel the contractor to rectify all defects as identified by inspection, in order to insure that the project is delivered to the full satisfaction of client without any uncompleted works (Ramus *et al*, 2008).

As much as the above measures have been implemented, they are still limited due to the fact that most of the above mitigation measures usually focus on the preconstruction/tendering stage. However from the causes discussed earlier, a number of factors can lead to the abandonment of a project during construction. Hence emphasis must not only be on selecting the contractor but also ensuring that the factors that may lead to abandonment during construction are mitigated. This may include the application of risk management which may identify and eliminate risks that may lead to project abandonment. The contractual approach also focuses mainly on the contractor related factors without addressing consultant and client related factors. NCC contractor's registration system also lacks electronic data capturing mechanisms in validating the information provided by the firm such as the use of same key personnel's by more than two firms and the lack of routinely physical inspection by the NCC technical team on the contractors asserts when grading or upgrading them.

4. Research Methodology

The research adopted an exploratory approach to the study since it aims at getting an insight into the phenomena surrounding the problem. This was fitting to assess the phenomenon of abandonment of public projects. Triangulation of quantitative and qualitative methods was applied in order to reinforce the limitations in each (Naoum, 2007).

4.1 Sampling method size and population

The study areas were restricted to Lusaka and Copperbelt province because much of construction activities are in these provinces. Most government departments, contractors and consultants are also based in the two provinces. Stratified method was used in selecting the contractors and consultants since they had sub groupings. Targeted respondents comprised of 41 registered contractors in Grade 3 and 4, and consultants (41) the feedback being 25 and 26 respectively. Regulatory (2) and government bodies (4) were selected using judgemental sampling since government funded (public) projects were targeted. A total of 56 questionnaires were retained giving a response rate of 64.8%.

4.2 Data collection tools and analysis techniques

Questionnaire surveys coupled with interviews were used because they are comparatively convenient for such a research. However, they have a disadvantage of not probing further, (Kumar 2005). The analysis included descriptive analysis, reliability testing with Cronbach's α and the mean. The reliability analysis was done prior to ranking the causes of abandoned construction projects using Cronbach's alpha of reliability to check for internal consistency within the set of 26 variables/causes of project abandonment identified from literature review.

4.3 Research limitation

The research only collected data from 41 contractors from Grade 3 and 4 and this may not be representative. The other limitation to the study is that only two provinces out the 10 provinces were targeted for data collection.

5. Findings and Discussion

5.1 Reliability analysis

The result from the test for chronbach's alpha was 0.814. This meant that with 0.817 value for standardized chronbach's alpha, all the identified factors or variables causing project abandonment were within acceptable limits.

5.2 Funding and occurrence of abandoned projects

Majority of projects were publicly funded (56.4%), 34.5% were privately funded and 9.1% were jointly funded. Abandoned projects were largely dominated by non-residential and civil works at 58.2%. Residential was 16.4% and that of special trade and others was 41.8%. This gave a higher representation of Civil and Non-residential projects being abandoned.

5.3 Causes of project abandonment

Respondents were asked to indicate how much they agreed to the given 26 factors as being the causes of abandoned construction projects. The ranking of factors in order of importance is shown in table 1. Financial difficulties faced by the contractor were ranked the highest, followed by financial difficulties faced by the client. Difficulty in design interpretation was ranked the lowest in causing abandonment of construction projects. Causes ranked 3rd, 5th, 7th, 21st, and 22nd correspond also with what other research works have established as being factors for project abandonment and relate to both the contractor and the client (Ihuah and Benebo, 2014). Other causes identified which are closely related to those found in the literature, are those ranked 8th, 10th, 14th, 18th and 22nd, i.e., technical and operative capacity of the contractor, problems associated with planning and scheduling, lack of appropriate dispute resolution method, level of supervision for the works and level of experience with the consultants.

A number of other important causes include those ranked 4th, 6th, 8th, 9th, 11th, 12th, 16th, 17th, 19th and 20th i.e. malpractices practices, suitability in the mode of financing the project, unexpected bad economic conditions, unavailability of materials, labour and equipment, problem of communication and coordination, inappropriate risk allocation among project team members, project control problems, contractor pre-qualification selected for works, efficiency of subcontractors, suitability of site workers and community disruption and interference. These findings clearly emphasize the inclusion of all stakeholders since a number factors lead to project abandonment. Importantly findings from the ranking indicate that the client is also responsible for the abandoned construction projects because a number of factors can be attributed to the owner (2nd, 3rd, 4th, 5th, 6th, 7th, 14th, 15th, 21st); as well as the contractor (1st, 8th, 10th, 12th and 19th). Hence, in trying to mitigate project abandonment, everyone has a role to play.

5.4 Consultants' and clients' perspectives on contractor-related factors

This section was aimed at assessing how contractor-related factors can be mitigated.

5.4.1 Selection of contractors

When asked to rank the most important factors considered when selecting a contractor, qualified technical personnel was ranked the highest with 76.9% followed by experience in relevant works (71.1%) while financial capacity (61.5%) was ranked third. Specific construction experience 53% and organisation management (53.8%) were third. Construction equipment (38%) and history of non-performing contracts (30.8%) ranked the least among factors influencing contractor selection.

Table 1: Causes of abandonment of construction projects

Causes of Project Abandonment	Rank	Mean	Std D.
Financial Difficulties Faced by Contractor	1	4.618	0.4903
Financial Difficulties faced by client	2	4.582	0.832
Delayed interim payments	3	4.4	0.6555
Fraudulent practices and bribery	4	4.109	0.9939
Problems related to feasibility study	5	4.073	0.9973
Suitability in the mode of project finance	6	4.055	1.0259
Problems related to variations	7	3.927	1.0338
Technical and operative capacity of contractor	8	3.873	1.0193
Unexpected bad economy	8	3.873	1.0193
Unavailability of materials, labour and equipment	9	3.6	1.132
Poor planning and scheduling	10	3.509	0.9976
Communication and collaboration	11	3.455	1.0856
Inappropriate risk allocation among project team	11	3.455	1.0856
Project control problems	12	3.436	1.014
Unexpected poor site conditions	13	3.346	1.2652
Lack of appropriate dispute resolution method	14	3.218	1.2721
Poor contract administration	15	3.2	1.1288
Contractor pre-qualification	16	3.109	1.1812
Efficiency of subcontractors	17	3.091	1.0412
Level of supervision for the works	18	3.091	1.0933
Suitability of site workers	19	3.055	1.1614
Community disruption and inference	20	3.055	1.1453
Change of policy during construction	21	3	1.2172
Selected procurement method	21	3	1.2172
Consultant level of experience and competence	22	2.782	1.004
Difficult in design interpretation	23	2.182	1.0731

5.4.2 Short listing contractors using the NCC register

Respondents were asked to indicate how successful the short-listing of contractors using the NCC register had been in their experience. 50.1% indicated that the NCC register can be used successfully in short listing contractors. While 23% of the respondents were not sure and 26.9% of the respondents disagreed. This indicated that the registers at NCC can be used in short listing contractors for public works.

5.4.3 Portrayal of actual competence of contractors by NCC register

Respondents were asked if there were any limitations with regard to portrayal of contractors' competence in the NCC register and the following were indicated as being limitations. Technical personnel not belonging to the firm being registered as belonging to the firm was ranked highest (62.2%) followed by construction equipment not belonging to the firm being registered as belonging to the firm (53.8%). The last was exaggeration of experience by firms (15.4%). Poor monitoring and inspection by NCC to confirm capacity of contractors or consultants (30.8%) was also cited. Consequently most contractors are not registered according to their capacity. This finding corresponds with the findings in table 1 which showed that cheating on the technical personnel, equipment's and exaggeration of their experience is a

common practice and leads to abandonment of projects. This has been attributed to the lack of electronic data capturing mechanism by the NCC during contractor registration for validation purposes.

5.4.4 Effectiveness of conditions of contracts

According to the consultants' responses, 61% regarded the current condition of contracts effective enough for public works. Only 15.4% were undecided about their effectiveness, while 23% regarded them as not being effective at all. On the other hand 75% of the respondents from the clients regarded the current contract condition used for public works effective, while 25% considered them as not been effective. The findings from both the consultants and clients established that the current conditions of contract have adequate measures to guard against the abandonment of public works. Thus the focus for the industry must be handling client, contractor and consultant causes and apply tools such as risk management and use alternative procurement methods.

5.5 Contractors' perspectives on strategies to mitigate project abandonment

This section focused on assessing how the client and consultant measures are effective in trying to mitigate project abandonment.

5.5.1 Frequency of consultants' visits to site

5.5.1.1 Rural Projects

72% respondents indicated that they rarely visit the sites, 16% indicated often. 12% indicated sometimes. From the above findings, it can be deduced that projects which are more likely or being abandoned are located in rural areas due to low level of site inspections.

5.5.1.2 Urban Projects

40% indicated sites are visited often by consultants, 28% indicated rarely while 32% indicated sometimes. It can therefore be concluded that consultants often carry out site visits for projects within the proximity of the towns, even though it is below average, compared to rural projects and it is one of the major causes of project abandonment. This has also been supported by literature which indicated that the most reported abandoned works are on the outskirts of the town (Auditor General Report, 2007).

5.5.2 Monitoring of public projects by the government bodies

Respondents were asked how they would rate the monitoring of projects by the government bodies. 28% of the respondents indicated fair while 24% indicated monitoring to be good with 8% regarding it as very good. 40% regarded the action very poor. From the findings, it is clear that there is poor monitoring of public projects. Lack of capacity (limited manpower) within building departments which undertake all the roles on certain projects from design; costing to monitoring the execution of the entire public projects was cited. Thus capacity has to be built in all government institution that monitor and supervise public construction projects.

5.5.3 Abiding to standard contract procedures

Respondents were asked to indicate how strictly they kept to standard contract procedures. 44% of the respondents indicated that they routinely followed contract contractions in the execution of the works,

22% followed them strictly while 30% followed them very strictly. Such low level consideration of contract conditions by the contractors can be attributed to the low levels of supervision and monitoring by the consultants and government bodies.

6. Conclusion

The importance of the construction industry to any economy is unquestionable realizing that it provides various infrastructure projects. Therefore, successful completion of infrastructure development projects is important for the Zambian economy and many other developing countries because this adds value to their economy. Hence, this research endeavoured to establish factors leading to project abandonment in an effort of mitigating them so as to attain sustainability in infrastructure. It was established that there is a high occurrence of project abandonment in the ZCI. Factors identified leading to this showed that there are client, contractor and consultant related factors such as financial difficulties, limited technical and operation capacity. Therefore, with a huge occurrence of project abandonment in the ZCI caused by the clients, consultant, contractors and external factors every party in the construction process has a role to play. Clients must ensure that financial difficulties are overcome and use appropriate mode for financing projects. The client must also ensure that, in conjunction with the consultants, they honour interim payments and adequate feasibility studies are conducted. The consultants should further improve contract administration, supervision and provide detailed designs and cost estimates. The contractor must also improve on their financing, technical capacity such as project planning and control, plant and equipment capacity. Essentially all stakeholders in the industry must also ensure that ethics are upheld to avoid malpractices. They must also ensure that disputes are avoided or appropriate dispute resolution methods are used since these factors were also found to be contributing to the persistence of project abandonment in the ZCI. Further, measures must be in place at all the stages of construction from tendering by selecting appropriate procurement routes, risk management tools and supply chain management to offset factors relating to external factors such as material availability.

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Modeling Uncertainty and Risk of Cost and Time in Infrastructure Projects: Theoretical Perspectives

Alireza Moghayedi¹, Abimbola Windapo²

Abstract

This paper examines the uncertainty and risks encountered in the construction process of infrastructure projects and its effect on cost and time underestimation using a literature survey, towards developing a model for counteracting such underestimation. The rationale for this examination stems from the view held by scholars that infrastructure construction projects are often plagued by cost overruns and time delays due to the estimation approach and/or inappropriate tools and techniques used to forecast possible risk or uncertainty in the construction processes. A review of extant literature in the area of construction estimation and risk management was undertaken to guide the direction of the study. It emerged that uncertainties and risks encountered in the construction process are underestimated and these impact on the total construction cost and time through a combination of the risk events of individual construction activities. In addition, three sources of uncertainty exist in infrastructure projects namely: variability in the construction process, correlations between construction costs and disruptive events were identified through analysis. A theoretical uncertainty model for counteracting the cost and time underestimation in infrastructure projects is developed using these three sources of uncertainty and the quantitative model of variability by employing probability distribution. Based on the findings, it is proposed that further research is undertaken to examine the uncertainty and risk encountered in the construction process based on historical data and probability distributions and whether these can be used in explaining the theoretical uncertainty model developed.

Keywords: cost, infrastructure project, time, uncertainty, underestimation

1. Introduction

This research examines the risks and uncertainty in the construction process and whether there are key uncertainties that impact on the estimated cost and completion time of infrastructure projects, using appropriate modelling techniques. The construction industry has been characterized by costs exceeding budgetary limits and completion times reaching further than what was set out initially (Flyvbjerg *et al* 2003, Poole and Sumuel 2011). Preparation of infrastructure project cost and time estimates is a difficult task because infrastructure projects are subject to risks and uncertainties, particularly in the early stages

¹Postgraduate Student; Department of Construction Economics and Management; University of Cape Town; Rondebosch 7701, Cape Town, South Africa; MGHALI001@myuct.ac.za.

²Associate Professor; Department of Construction Economics and Management; University of Cape Town; Rondebosch 7701, Cape Town, South Africa; abimbola.windapo@uct.ac.za

when very limited information about the project is available (Okmen and Oztas 2010). As an infrastructure project progresses, more information become available to allow costs to be calculated to a greater degree of accuracy (European Commission DG 2008). Cost estimation is the process of predicting the costs required to perform the work within the scope of the project. Accurate cost estimation is crucial to ensure the successful completion of a construction project (Wysocki 2014). A cost estimate at a given stage of project development represents a prediction provided by the cost engineer or estimator on the basis of available data. Cost engineering is defined as that area of engineering practice where engineering judgment and experience are utilized in the application of scientific principles and techniques to the problem of cost estimation, cost control and profitability (Hendrickson 2008).

Construction projects are often beset by cost overruns and time delays and the actual cost of an infrastructure project is affected by many variables and uncertainties that can influence the estimated cost significantly during the construction process (Flyberg *et al.* 2003). However, scholars such as Anderson (2007), Flyberg (2002), and Flyberg *et al.* (2007) view that the tools and techniques developed to counteract these variables and uncertainties lack an in-depth understanding of the construction process and its uncertainties, and the limitation of modeling risks only without capturing the cumulative effect of different sources of uncertainty. The focus of this research is on the development of strategies and management approaches that can be used in counteracting cost and time escalation on construction infrastructure projects.

This study identifies the uncertainty and risks encountered in the construction process and its effect on cost and time underestimation using a literature survey, towards developing a model for counteracting such underestimation.

2. Uncertainties and Risks in Infrastructure Projects

Uncertainty means an unknown phenomenon, besides uncertainty due to lack of knowledge, there is uncertainty due to randomness (Hirano 2014). Typically, in the estimation of construction projects several variables are not known since construction projects are populated by uncertainties. Uncertainty is an opportunity if it has a positive impact, and a threat if it has a negative impact on the project objectives (Kurowicka and Cooke 2006). The difference between risk and uncertainty is usually expressed in terms of whether it is possible to quantify the inexactness with which future quantifiable values of a particular event are known mathematically (Ayyub 2001). According to Yoe (2011), the uncertainty in construction projects considers three sources of uncertainty: the variability in construction process; the correlations between construction cost and time; and the occurrence of disruptive events.

2.1 Uncertainty in Infrastructure Projects – Variability, Cost and Time Correlations, Disruptive Events

2.1.1 Variability

The variability is the change in a variable under normal conditions. This variability is modelled with probability distributions: the lognormal distribution for the variability in cost variables and the triangular distribution for the variability in time variables. The lognormal distribution is the selected probability

distribution to model cost variables since it often underlies the distribution of construction cost variables (Fewings 2013). Time variables are modeled with the triangular distribution for four main reasons: it is closed-ended in the lower tail; it can be either be skewed to the left or skewed to the right; the minimum, mode, and maximum parameters can be relatively easily estimated; and it is often used in construction modelling (Fewings 2013; Cretu *et al.* 2011).

2.1.2 Cost and time correlation

The relation between two variables is expressed with a correlation: if the value of one variable is above average, the value of the second variable tends to be above average when they are positively correlated, while it tends to be below average when they are negatively correlated. The correlation varies between -1 (fully negatively correlated) and +1 (fully positively correlated), and for a correlation equal to 0, the two variables are uncorrelated. The correlation is measured with the Spearman correlation coefficient and it is modelled with NORTA (Okmen and Oztas 2010).

2.1.3 Disruptive events

A disruptive event is an event with a large cost and/or time impact and usually a small probability of occurrence (Howick *et al.* 2010). Due to the rare occurrence of disruptive events, there are in general no studies on the underlying distributions of cost and time impacts of such events. The occurrence of a disruptive event is modeled at every unit of the activity. If on the one hand the disruptive event occurs, the cost and time impact of the disruptive event is modelled within the construction process. According to Faber *et al.* (2011), the occurrence or non-occurrence of the disruptive event is modelled with a simple random number generation. If the generated number is larger than the probability of occurrence, the disruptive event does not occur, and the simulation proceeds to the next unit length. On the other hand, if the generated number is smaller or equal to the probability of occurrence, the disruptive event occurs in the unit of activity, and its cost and time impacts must also be simulated.

These are modeled using triangular distribution to generate the cost and time impacts of the disruptive events. These cost and time impacts are added to the cost and time of the activity unit. Since disruptive events have large cost and time impacts, the cost and time of the unit of activity, where the disruptive event occurs, can be significantly larger than the cost and time of a unit of activity where the disruptive event does not occur. The cost and time of all unit activity are summed to obtain the total activity cost and time for a simulation run, this being representative of one point in the cost-time scatter diagram. Since each simulation run is different, the occurrences of the disruptive event change: it may not occur, it may occur once or it may occur more than once.

2.2 Tools and techniques used in uncertainty and risk forecast in construction

Infrastructure construction projects are often plagued by cost overruns and time delays due to estimation approach and/or inappropriate tools and techniques used to forecast possible risk or uncertainty in the construction processes (Einstein *et al.* 2013; Clevenger *et al.* 2014). The current approaches to modeling uncertainty such as Anticipated Final Cost, Cost planning Model, Schedule Risk Analysis, Quantitative Risk Assessment Model show two limitations: first, the reliance on modeling risks without an in-depth understanding of the construction process that does not ensure that all uncertainties in the construction process are captured, second; modeling only risks rather than for example, the variability in the

construction process, the correlations between cost and time and the occurrence of disruptive events does not capture the cumulative effect of different sources of uncertainty (Molenaar *et al.* 2010).

To overcome these limitations, the construction model and the uncertainty model will be combined and applied to the construction of a highway construction project as a Case Study. The construction of all the main types of structures in highway projects (Culvert, Earthwork, and Paving) will be modeled from bottom-up from the single activity to the entire highway project with network activities while the sources of uncertainty will be modeled with probability distributions, NORTA model, and Markov processes. The impact of the different sources of uncertainty in highway projects will be compared and the cumulative impact of the sources of uncertainty will be analyzed from the expert interview. Through the application of the case study, the effectiveness of the proposed construction and uncertainty models will be validated.

3. The Effect of Uncertainty and Risk on Accurate Project Cost and Time Estimation

The review of literature (AASHTO 2009; Molenaar 2010; Yoe 2011) perspectives provides conceptual evidence that there is a relationship between infrastructure project characteristics, uncertainty and accurate estimation of cost and time of the infrastructure project. Cost estimates are comprised of two components: base cost and risk-base cost. Base cost is the likely cost of the project if no significant risks occur. Base cost is usually developed using historical data and/or cost-based estimating techniques together with the expert's judgment (Molenaar *et al.*, 2010). Risk-based estimating allows reasonable control over the project cost (not achievable using deterministic cost estimates) by employing the project risk management approach (AASHTO 2009).

4. Theoretical Framework for Estimation of Construction Cost and Time

This research is based in the field of construction economics, cost and time estimating of infrastructure projects and construction management. This study aimed to develop and refine a theory – the Modern Portfolio Theory, that reflects how to assess both the risk as well as the rewards of all possible item cost combinations and identify all efficient items cost combinations and hence discard all items costing that is instead found, by comparison, to be inefficient. For example, a previous study by Cattell and Bowen (2010) examined the relationship between risks and unbalanced estimation and developed a framework by which all risks of work item adopted the Modern Portfolio Theory (see figure 1).



Figure 4: Modern portfolio theory

5. Proposed Model for Counteracting Cost and Time Underestimation in Construction

Based on the literature reviews it is observed that risk-based cost estimations have two limitations, namely: the lack of an in-depth understanding of the construction process and its uncertainties, and the limitation of modelling risks only without capturing the cumulative effect of different sources of uncertainty. To overcome these limitations this study proposed the use of a construction model and an uncertainty model to accurate estimation of cost and time of infrastructure projects. The theoretical framework to be investigated in this research in relation to accurate estimation of cost and time is shown in Figure 2.

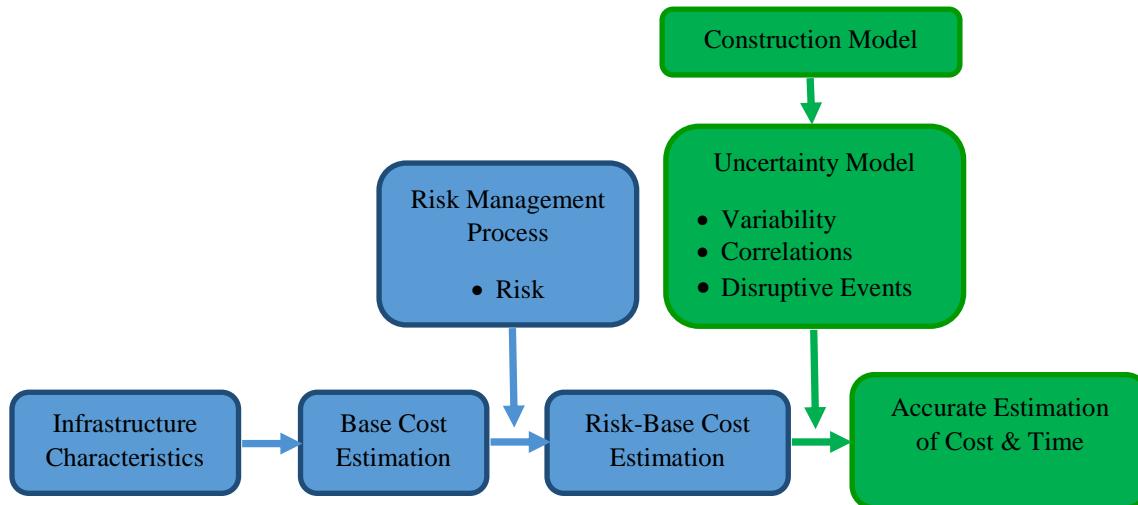


Figure 2: Theoretical framework of research

The process is hinged on integrating infrastructure project characteristics as variables used to upgrade the base cost estimate to risk-base cost estimate and accurate estimation of cost and time of infrastructure projects with risk management process and uncertainty model which three sources of uncertainty (the variability in the construction process; the correlations between construction cost and time; and the occurrence of disruptive events) for the purpose of developing the uncertainty model. Due to the peculiar nature of the risk, there is the need to undertake risk categorization using the risk breakdown structure by means of the risk management process to estimate uncertainties through the application of uncertainty model, whilst modeling cost and time duration in construction infrastructures.

The proposed methodologies would involve the collection of data from a case study project. This data will be analysed at the level of single activities and represented in activity network. The activity network of the main structures will be interconnected in a construction network that models the construction of a highway project. The highway activity network (see Figure 3) and their interconnection in the construction network represent the construction model.

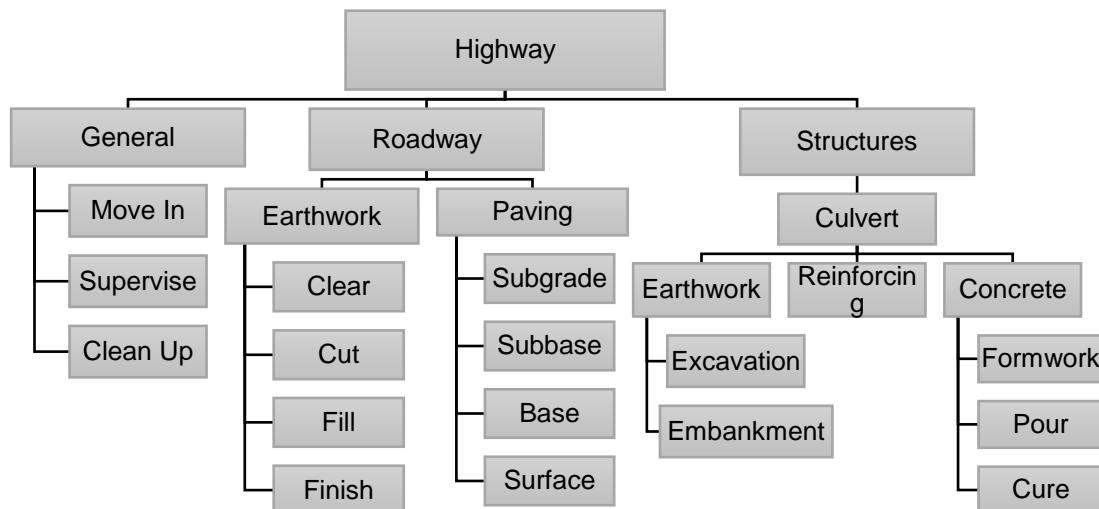


Figure 3: Highway activity network (Source: Moghayedi, 2013).

Sources of uncertainty in the construction process of infrastructure projects would be identified through analyzing the historical records and quantitative models of the sources of uncertainty will be developed based on expert's interview. The variability would be modelled with probability distributions. The lognormal distribution for the variability in cost variables and the triangular distribution for the variability in time variables (see Figure 4).

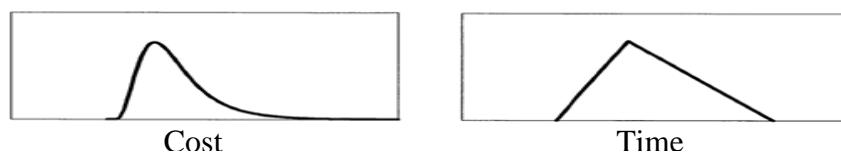


Figure 4: Lognormal and triangular probability distribution

Different types of correlations between each construction activity would be identified and their impact will be compared. The correlation with the largest impact will be analyzed further and modelled with the NORTA (NORmalTo Anything) method (see Figure 5). The occurrence of disruptive events will be modelled with Markov processes (see Figure 6) while the cost and time impacts will be modelled with probability distributions.

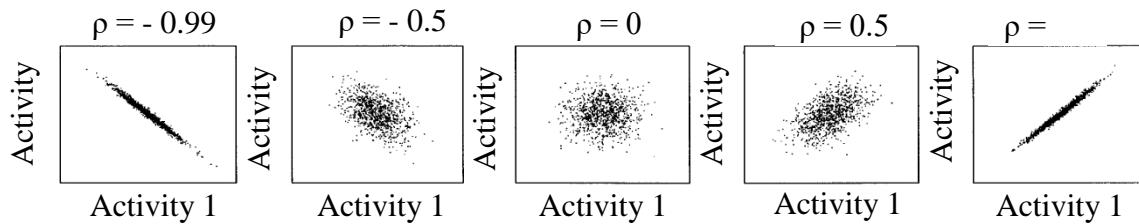


Figure 5: Varying degrees of correlation between activity 1 and 2

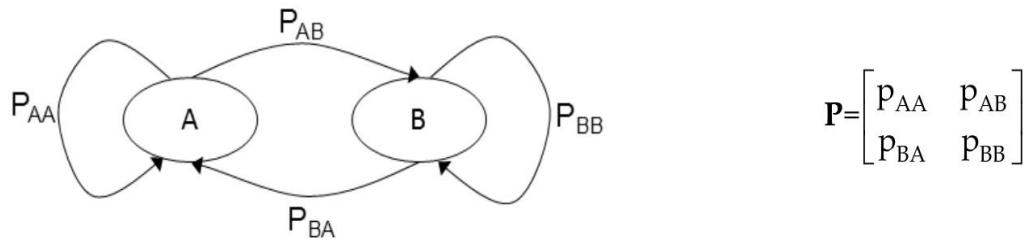


Figure 6: Markov Process

Since risk management involves a comprehensive consideration of risks by identifying the risk; quantifying their impact; and mitigating their impact throughout the project therefore the researcher realized risk management is a suitable tool for evaluating risk for this research. Risk management consists of five phases, which are repeated iteratively throughout the project development process (Molenaar *et al.* 2010; Kerzner and Belack 2010).

Risk analysis, the second phase of the risk management strategy, is the process of evaluating the project risks documented in the risk identification phase of the risk management strategy. Its objective is to systematically consider risks, their probability of occurrence (frequency) and the consequences of their occurrence (severity). Risk analysis tools are scalable in that they can be used to prioritize red flag items of relatively simple projects as well as estimate probabilistically the cost of complex projects (Molennar *et al.* 2010).

Three sources of uncertainty and their quantitative models (see Figure 7) represent the uncertainty model.

In a few cases, the identified risks are analyzed, usually qualitatively, using the product of P (Probability of occurrence) to I (Impact) matrices. In PxI matrices, the probability of occurrence of the risk is ranked, usually from 1 to 5; next, the impact of the risk is ranked, also from 1 to 5; then, according to the product of the probability rank and the impact rank, the risk is classified as high, moderate or low risk (see Figure 6) (McGeorge and Zou 2013, Windapo 2013).

PxI combines the qualitative evaluation of the probability of occurrence and the impacts of a risk in terms of cost and time of each activity of project. The goal of a PxI matrix is twofold: prioritize risks in infrastructure project to efficiently allocate resources and identify the risks that require further risk management attention.

The networks modelling the construction process and quantitative model of the three sources of uncertainty of infrastructure project will be combined in the Monte Carlo simulation tool. The required probability distributions, the NORTA method and Markov processes will be used in evaluating the cumulative impact of each source of uncertainty.

By simulating a project repetitively, it generates probability distributions for total cost and total time, and using the tornado diagram, the Monte Carlo simulation generates samples from the input distributions of the cost and time parameters, and sums the generated variables for cost and time to calculate the total cost and the total time for each simulation run.

PROBABILITY RANKING	
Ranking	Probability
1	Remote
2	Unlikely
3	Likely
4	Highly Likely
5	Nearly Certain

Probability	5	M	M	H	H	H
	4	L	M	M	H	H
	3	L	L	M	M	H
	2	L	L	L	M	M
	1	L	L	L	L	M
		1	2	3	4	5
Impact						

IMPACT RANKING		
Ranking	Cost	Time
1	Minimal	Minimal or No Impact
2	<5%	Able to meet with Additional Resources
3	5%-7%	Minor slip in key milestone
4	7%-10%	Major slip in key milestone
5	>10%	Unable to meet project milestone

Figure 7: PXI Matrix

6. Conclusion and Recommendation

The uncertainty model marks several advancements and makes several contributions to the field of cost and time estimation of infrastructure construction project. It gives a clear definition of uncertainty, it covers positive and negative aspects of uncertainty, it improves the quality of the data used, it quantitatively analyses the uncertainties and it is useful beyond just cost and time estimation.

The uncertainty model defines uncertainty as a condition whose outcomes is not known and where the outcomes can be positive or negative. This positive and negative description characterizes all three sources of uncertainty, which is variability, cost and time correlations, and disruptive events.

In the uncertainty model, uncertainties are modeled using two data sources that ensure the quality of the input data: historical data and expert opinions. Historical data stem from comparable projects while estimations are sought from experts. Modeling the uncertainties requires two steps: identification and quantification. Uncertainties are identified from the historical data of past projects and through brainstorming of the experts. The identified uncertainty variables are quantified depending on the relevant classification uncertainty type: variability is quantified by defining the probability distribution and the distribution parameters; cost correlations are quantified with correlation coefficients and the matrix type; a disruptive event is quantified with its probability of occurrence and the probability distributions of the cost impact and time impact.

The uncertainty model quantitatively analyses the overall uncertainty of the construction project with a Monte Carlo simulation: it calculates the distributions of the total cost and the total time; it aggregates uncertainties to model their cumulative impact on total cost and total time; it visualizes the project cost and time; and it gives insight on which uncertainties have the largest impact on project cost and time. The uncertainty model aggregates uncertainties to model the cumulative impact of all variabilities, of all cost and time correlations, and of all disruptive events. It visualizes the project cost and time in a cost-time scatter diagram that illustrates the cost-time relationship, finally, it offers insight on the impact of the different uncertainties.

Beside cost and time estimation and evaluation of uncertainty impacts, the quantitative analysis has further uses. Its results are the starting point for a mitigation strategy, which will focus on the uncertainties with the largest impact, as well as allowing *budget allocation*, which is based on percentiles of the total cost distribution. The quantitative analysis can be used again during the rest of the project to analyze new uncertainties, the effectiveness of countermeasures to mitigate threats, or to take into consideration that some uncertainties have been eliminated. In principle, it can be used iteratively during the construction of the project to model the changing uncertainties.

Differently from other tools developed for construction projects in general, the uncertainty model is particularly well suited for projects characterized as being complex. This degree of complexity is given by the type of structure, the number of interconnected activities and the sources of uncertainty.

6.1 Further research

Further research is undertaken to examine the uncertainty and risk encountered in the construction process of a highway project based on historical and probability distributions and whether these can be used in explaining the theoretical uncertainty model developed and the effectiveness of the proposed construction and uncertainty models will be validated.

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An Appraisal of Critical Risk Factors in Construction Projects in South Africa: Perspective of Contractors

Berenger Renault¹, Justus Agumba², Nazeem Ansary³

Abstract

The significant impact of construction projects on a nation has been characterized in literature in terms of infrastructure development and job creation. These projects are nevertheless associated with various risks that need to be managed to ensure successful delivery. Hence, the identification of these risk factors is of utmost importance. Therefore, this study aimed at assessing contractors' perception of critical risk factors in construction projects in Gauteng (South Africa). Explorative and questionnaire survey methods were employed to obtain data from literature and construction professionals all practising in Gauteng. Results revealed that supply of faulty materials, poor communication between involved parties, financial failure of the contractor, working at dangerous areas and closure were the five critical risk factors in construction projects. It is obvious from the results that the knowledge of the identified critical risk factors furnishes invaluable information to the construction contractor concerning what risk variables to focus attention on in construction activities. The paper contributes to the identification of critical risk factors in construction projects from an objective point.

Keywords: construction, contractors, risk factors, South Africa

1. Introduction

The great impact that the construction industry makes in terms of infrastructure development and job creation among economies is overwhelming in literature. The significant impact that is associated with its benefits is usually attached to critical risks that must be managed before achieving a successful delivering of the project. In order to meet the targeted objectives of project success (time, cost and quality), effective management tools must be put in place as risk may appear in many ways and could result in increased cost and time, decreased quality and many more failures (Keçi and Mustafaraj, 2013). One of the major reasons for this situation is not handling the risks, which is about thinking ahead, simulating and searching for better solutions (Keçi and Mustafaraj, 2013). Thus, the project can be achieved successfully

¹Postgraduate; Department of Construction Management & Quantity Surveying; University of Johannesburg; PO Box 17011, Doornfontein Johannesburg, South Africa; renault08@yahoo.fr.

²Senior Lecturer; Department of Construction Management & Quantity Surveying; University of Johannesburg; PO Box 17011, Doornfontein Johannesburg, South Africa; jagumba@uj.ac.za

³HOD;Department of Construction Management & Quantity Surveying; University of Johannesburg; PO Box 17011, Doornfontein Johannesburg, South Africa; nansary@uj.ac.za

by considering the risks where it normally tends to give positive and negative effect on the project (Ayyub, 2003).

In recent years, some exhaustive studies and development have concentrated on project risk management. Project risk management is acknowledged as one of the most critical procedures and capability areas in the field of project management (Mahendra *et al.*, 2014). This is undoubtedly the most difficult aspect of project management (Mahendra *et al.*, 2014). Managing risks in construction projects have been accepted as a very important process so as to meet project goals. Hence, risk management can be defined as a complete set of activities and actions aimed at dealing with any risk to maintain control over the entire (Van Well-Stan, 2004). To achieve the set objectives, a proper risk management is indispensable. For this reason, the identification of risk factors affecting risk management is a crucial step in the risk management process since if risks are not identified, it will be almost impossible to respond to them. Moreover, it is well recognized that in construction projects, contractors are the key players in carrying out construction works and are directly involved in the physical phase of the project. They are required to manage the risks that arise during construction activities to ensure the effective completion of projects (Tang, 2012). Therefore, this study investigates contractors' perception of the risk factors impact on construction projects in Gauteng, South Africa.

2. Literature Review

2.1 Risks in construction projects

The opinion that the construction industry is the most exposed to threats (risks and uncertainty) is an agreement among authors due to the nature of its activities. Still, diverse tactics in the literature regarding the factors and characteristics of projects that expose the CI to numerous risks were found. Zoo *et al.* (2007) made reference to long, complex environment, complicated process, and the need for investment-intensive, dynamic organizational structures, technological and organizational complexity and the diverse interests of stakeholders. In succession, Ghani (2009) pointed out as factors and essential features high life cycle design, size, complexity, location, the different parties implicated and familiarity with the performer's work to be done. Zeng and Smith (2007), found a persistent change of environment, direct exposure to hazards, the high pressure involved in the compliance of costs and deadlines, and increasing the complexity of construction techniques. Likewise, in a study conducted by Chapman and Ward (2003), the changeability in the performance objectives of cost, time and quality, the ambiguity related to various aspects such as lack of clarity owing to the behaviour of participants involved, as well as the lack of evidence and detail, are listed among the critical factors.

2.2 Risk management process (RMP)

Risk management systems are used to ensure the control of risks in the business process. In this study, the simplest possible approach to describing the risk management process is adopted due to the context of the construction sector. There is no common definition of the scope of risk analysis, risk management or the risk process in the literature, as each one has its own twist (Chapman and Ward 2003). The risk

management process in this study consists of the steps. It comprises the risk analysis followed by the risk response. Risk analysis includes risk identification and assessment, as depicted in Figure 1.

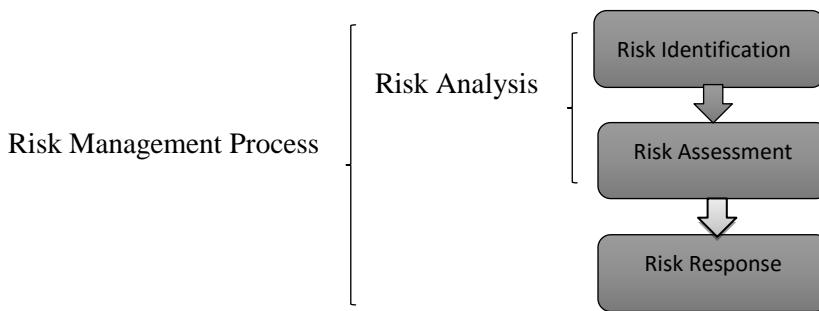


Figure 1: Risk management process (Adapted from Simu, 2006)

The first step of the RMP is risk identification. This is probably the most important and time-consuming step, because if risks are incorrectly identified, incorrect assessments and responses will follow (Simu, 2006). Several techniques are available for identifying risks; the most known in construction are brainstorming, interviews, Expert opinion, questionnaire, checklist, Delphi technique, Expert systems, past experience and documentation review (Khalafallah, 2002).

The second step is assessing the risks. It can be assessed based on the possibility of risk occurrence and severity of its impact (Lester, 2007) by developing risk matrix. It aims at assessing the risk to evaluate the effect of each risk on the project. Risk assessment is conducted in various ways. There are tools and techniques that have been developed to consider probabilities and consequences, using historical data, statistical data or estimated judgment translated to numerical information (Aven, 2003). Common are the estimation of probability and consequence and the usage of software tools to manage the data. Scoring techniques are developed checklists that include the judgment of both probability and consequence of a risk breakdown. This is a common technique for risk assessment in construction projects that is widely used due to its simple approach. In the risk response step, actions are taken to control the risks analysed in the first two steps. In this study, the response step includes both the planned and the monitoring responses. There are four different ways of responding to risks in a construction project, namely, risk avoidance, risk reduction, risk retention and risk transfer (Abu Mousa, 2005).

2.3 Risk factors

Some studies have identified risk factors for construction projects. In a survey conducted by (Mussa, 2005), it was revealed that financial failure of the contractor, working in the hot environment, closure, defective design and delayed payment on contracts were the most important risk factors. This was followed by difficulty to access the site, lack of consistency and inaccurate quantities which were also considered as high significant risks. The findings showed that there are some risk factors contractors could not allocate to the party that should bear these risk's consequences. Wong and Cheung (2005) also

stressed that the most significant risk occurred in design and built include time and cost overrun. The main reason for these risks is an employer or government delay, lack of information from the employer, the difficulty of following instructions, conflict of interest and variation to changes. Ibrahim *et al.* (2006) opined that construction projects are attributed to financial, technical, politics, act of God and social risks that may influence the projected profit. Therefore, for this study, a thorough review of existing literature was performed to identify common risk factor that may stand in front of construction projects. The current literature search identified forty-four factors categorized into nine groups including:

- Physical factors such as occurrence of accidents due to poor safety procedures, supplies of faulty materials, varied labour and equipment productivity;
- Environmental factors such as difficulty to access the site and adverse weather conditions;
- Design including defective designs, uncoordinated designs, Inaccurate quantities, Lack of consistency between bill of quantities, drawings and specifications, rushing designs, awarding designs to unqualified designers;
- Logistics, including factors such as unavailability of labour, materials, and equipment, undefined scope of working, high competition in bids, inaccurate project program and poor communications (the home and field offices);
- Financial, including inflation, delayed payments on contract, financial failure of the company, unmanaged cash flow, exchange rate fluctuations and monopolizing of materials;
- Legal factors including difficulty to get permit, ambiguity of work legislations, legal disputes during the construction phase, delayed disputes resolutions and lack of specialized arbitrators to help settle fast;
- Construction issues such as rush bidding, gaps between the implementation & specifications, undocumented change orders poor work quality in presence of time constraints, design changes and actual quantities which differ from contract quantities;
- Political factors such as new governmental acts or legislations, unstable security circumstances, closure and segmentation of Gauteng; and
- Managerial factors such as vague planning due to project complexity, poor resource management, changes in management strategies, information availability and poor communication between involved parties.

3. Research Methodology

3.1 Population and data collection

The targeted population for this study included large building contractors who have a valid registration with the Construction Industry Development Board (CIDB). The three highest gradings (7-9) were considered large and were selected from the contractor's list published by CIDB. The respondents included top management (mostly project managers, construction managers, and quantity surveyors) who were willing to participate in the study. Based on their positions, education, work experience and professional background, the authors inferred that the respondents had adequate knowledge of risk management as well as the activities associated with construction.

In order to fulfil the objective of the study, both secondary and primary data were employed to examine contractors' perception of risk factors. The secondary data was gathered through a comprehensive related literature review. Various sources were consulted including accredited academic and journals, books, the internet, theses, and dissertations. The primary data, on the other hand, was obtained from a well-structured questionnaire. The questionnaire was pilot-tested before being distributed to the respondents, to ensure simplicity, suitability, readability, understanding and time taken in answering the questions. Ratings regarding the impact of risk factors on construction projects were hence needed from top management of these contractors. The drop-off and collect strategy was adopted to increase response rates, as was used by Agumba (2013).

3.2 Sample and sampling procedures

All contractors in CIDB grade 7-9 in Gauteng had an equal chance to be drawn and participate in the study. Out of 50 questionnaires sent out, 44 were returned and used representing 88% response rate which formed the basis of this study. The study used probability-sampling procedures to get the sample for the research. Probability sampling with the process of stratified sampling was used. The probability sampling is preferable to non-probability sampling as it ensures accurate results. This technique was selected because of the various categories of contractors. This method hence assured a better representation of the population. The data presentation and analysis made use of frequency distributions and percentages of all the respondents. The study was conducted between the months of June to August 2014.

3.3 Data analysis

A five-point Likert scale was used to examine the impact of each identified risk factor. The adopted scale was as follows: 1- No impact, 2-Law impact, 3-Medium impact, 4-High impact, 5-Very high impact. Data collected were analysed statistically using the Mean Item Score (MIS). The indices were used to determine the relative impact and ranking of each item. The ranking made it possible to cross compare the relative importance of the items as perceived by the respondents. The similar approach has been used by some researchers to analyse the data gathered from questionnaire survey (Le-Hoai *et al.*, 2008).

The computation of the relative mean item score (MIS) was calculated from the total of all weighted responses and then relating it to the total responses on a particular aspect. This was based on the principle that respondents' scores on all the selected criteria, considered together, are the empirically determined indices of relative importance. The index of MIS of a particular factor is the sum of the respondents' actual scores (on the 5-point scale) given by all the respondents' as a proportion of the sum of all maximum possible scores on the 5-point scale that all the respondents could give to that criterion. Weighting was assigned to each responses ranging from one to five for the responses of 'No impact risk' to 'Very high impact'. The mean item score (MIS) was calculated for each item as follows;

$$\text{MIS} = \frac{1n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5}{\sum N} \dots \text{Equation 1.0}$$

Where: n_1 = Number of respondents for 'No impact', n_2 = Number of respondents for 'Law impact', n_3 = Number of respondents for 'Medium impact', n_4 = Number of respondents for 'High impact', n_5 =

Number of respondents for ‘Very high impact’, N = Total number of respondents. After mathematical computations, the criteria were then ranked in descending order of their mean item score. The next section presents the findings and discussion of the survey.

5. Findings and Discussion

The questionnaire consisted of four sections to accomplish the aim of this study. The first section was the contractor organization profile which was designed to show the population properties in terms of the position of the respondent, executed projects, experience of the contractor's organization and the status of the contractor in the past five years. Section two presented the risk factors identified by literature, section three covered management methods which can be used to manage risks and the last section addressed the risk analysis strategies which can be used to analyze and estimate risk factor impact. The findings from the study are presented below.

5.1 Demographic characteristics

A total of 50 questionnaires were sent out, 44 were returned and used which represent 88% the overall sample. The distribution of the respondents is shown in table 1. The majority of respondents were construction managers 15 (34.1%), 11 (25%) were quantity surveyors, 9 (20.5%) were project managers, 4 (9.1%) were named as others while 3 (6.8%) were directors, and 2 (4.5%) were architects.

Table 1: Distribution of respondents

Position	Frequency	Percentage (%)
Director	3	6.8
Project Manager	9	20.5
Construction Manager	15	34.1
Architect	2	4.5
Quantity Surveyor	11	25.0
Other	4	9.1
Total	44	100

With regard to working experience, 48% had working experience that ranged from 1-5 years, 25% had between 6-10 years working experience, 14% had working experience that ranged between 11-15 years, 5% had experience that ranged from 16-20 years and 8% had more than 20 years of working experience. Based on their function, education, work experience and professional background, it can be deemed that the respondents have sufficient knowledge of construction activities.

The results relating to the number of construction projects executed in the last five years revealed that 32% of the respondents were involved in 3-4 projects, 26% were involved in more than 8 projects, 18% were involved in 1-2 projects, 17% were involved in 5-6 projects, 5% of the respondents were involved in 7-8 projects, and 2% were not involved in any construction projects during the last five years.

5.2 Construction risk factors

Results from the study revealed that supplies of faulty materials ($MIS=4.88$, $R=1$), poor communication between involved parties ($MIS=4.82$, $R=2$) and financial failure of the contractor ($MIS=4.78$, $R=3$) were perceived as very significant risk factors in construction projects. Furthermore, contractors' respondents perceived working at dangerous areas ($MIS=3.78$, $R=4$), closure ($MIS=3.18$, $R=5$), delayed payment on contract ($MIS=3.09$, $R=6$) and undocumented change orders ($MIS=3.02$, $R=7$) as significant risks while others such as legal dispute during the construction phase ($MIS=2.91$, $R=1$) and ambiguity of work legislations ($MIS=1.98$, $R=26$) were considered to be medium and low risks respectively (Table 2).

These five risk factors are from four major categories namely physical, management, financial and political group risks. These results draw the contractor's attention to the appropriateness of materials that contribute 70% of the total value of the project (Enshassi *et al.*, 2003). Hence, any problems related to construction materials would affect the project (Enshassi *et al.*, 2003). These findings are in agreement with the studies of Abu Mousa (2005), which reported defective material as very important risks. The results further emphasize the importance of communication in early stages of the project as poor communication between involved parties results in a waste of time and thus affecting the budget. These results concord with the findings of Hoezen *et al.*, (2006), where it was found that, making adjustments in later stages of the building process, as a result of poor communication, usually cost extra money. Contractors are advised to communicate at early stages of the project, as early and or improved communication would undoubtedly lead to fewer delays and lower expenses.

Another important risk factor is the financial failure of the contractor. This can significantly affect the procurement of material, therefore, delaying the project from being delivered in due time. These results are in line with the studies of Hallaq (2003) that concluded that more than 80% of financial contract failures were caused by financial factors such as depending on banks and paying high, low margin of profit due to competition, award contract to the lowest price, lack of capital and cash flow management. Consequently, Contractors are recommended to have enough cash to lessen financial problems (Enshassi *et al.*, 2003).

Working at hot (dangerous) areas and closure in the political group came as the fourth and fifth most important risk factors. It is evident that working at dangerous areas risk is perceived as a significant risk; contractors cannot be imposed to work in such conditions. On the other hand, the closure could be the result of material unavailability and inflation due to monopoly. Table 2 shows the results of risk factors ranking in descendant order.

The current findings concord with previous studies reviewed in the literature review regarding the severity of risk factors during construction projects. However, it is remarkable to note the exclusion in the current study, the risk of information unavailability, changes in management ways, design changes and occurrence of accidents due to poor safety procedures as part of the list of most significant risk factors while reviewed literature revealed them as the most important risk factors during the life of a construction project.

Table 2: Construction risk factors

Risk Factors	Rank (R)	MIS
Supplies of faulty materials	1	4.88
Poor communication between involved parties	2	4.82
Financial failure of the contractor	3	4.78
Working at hot (dangerous) areas	4	3.78
Closure	5	3.18
Delayed payment on contract	6	3.09
Undocumented change orders	7	3.02
Legal dispute during the construction phase	8	2.91
Delayed dispute resolutions	9	2.91
Unmanaged cash flow	10	2.86
Resource management	11	2.84
Poor work quality in presence of time constraints	12	2.80
No specialized arbitrators to help settle fast	12	2.80
Unavailable labour, materials and equipment	13	2.77
Poor communication between the home and field offices	13	2.77
Gaps between the implementation and the specifications	14	2.75
Segmentation of Gauteng	15	2.73
Unstable security circumstances	15	2.73
Monopolising of materials	16	2.66
Occurrence of accidents due to poor safety procedures	16	2.66
Vague planning due to project complexity	17	2.64
Inflation	18	2.52
Exchange rate fluctuation	19	2.48
Defective design (incorrect)	20	2.45
Difficulty to access the site	21	2.41
High competition in bids	22	2.36
Changes in management ways	23	2.09
New governmental acts or legislations	24	2.07
Varied labour and equipment productivity	25	2.02
Design changes	25	2.02
Adverse weather conditions	25	2.02
Ambiguity of work legislations	26	1.98
Awarding the design to unqualified designers	27	1.95
Actual quantities differ from the contract quantities	28	1.89
Environmental factors	28	1.89
Undefined scope of working	29	1.86
Not coordinated design	30	1.82
Lack of consistency between bill of quantities, drawings and specifications	31	1.80
Information unavailability (include uncertainty)	31	1.80
Inaccurate project programme	31	1.80
Difficulty to get permit	32	1.77
Rush bidding	34	1.68
Inaccurate quantities	35	1.25
Rush design	36	1.20

Another remarkable point to note is that difficulty to access the site (MIS=2.41, R=21), lack of consistency (MIS=1.80, R=31) and inaccurate quantities (MIS=1.5, R=35) were identified by literature as high significant risks while in the current study there were considered as medium and low risk factors. Furthermore, it is clear that among the contractors' respondents there is not a general knowledge of the significant risks revealed in literature. This situation undoubtedly has an influence on the process to responding to these risks as practitioners should be conversant with these risks in order to effectively respond to them.

6. Conclusion

This study has showed that risks factors are the key elements that need to be considered in order to achieve successfully the fundamental elements of a project (time, cost and quality). Forty-four risk factors were revealed through a detailed literature review which were then categorized into nine groups namely physical, environmental, design, logistics, financial, legal, management, political, and construction. Supply of faulty materials, poor communication between involved parties and financial failure of the contractor were considered by contractors' respondents as very high significant risk factors this followed by working at dangerous areas, closure, delayed payment on contract and undocumented change orders which were perceived as high significant risks, others were considered as medium and low risks. These risk factors were from four different categories of risk, i.e., physical, management, financial and political group risk. These findings will strengthen the contractors' evaluation of the risk factors.

To reduce the probability of failure of construction projects, contractors are recommended to take into consideration the importance of handling risk factors associated with construction projects. Contractors should have an adequate project planning that would allow them to foresee these risks factors. Moreover, risk should be taken into account by adding a risk premium to quotation, time estimation and this has to be supported by organizations such as the Construction Industry Development Board (CIDB), the Association of South African Quantity Surveyors (ASAQS), the Chartered Institute of Building (CIOB), the South African Federation of Civil Engineers Contractors (SAFCEC) and other organizations involved in the construction sector. Additionally, contracting firms should provide training programs for their personnel to properly apply management principles as it is the duty of organizations to provide such training.

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ICT AND SKILLS TRANSFER IN INFRASTRUCTURE DEVELOPMENT

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Knowledge Exchange in Construction Practice: Exploring the Impact of Embedded BIM Process Standards

Energy Maradza¹

Abstract

Research on innovation in construction investigates the roles of standards. While studies examine product standards, process standards receive limited attention even though they have influence on knowledge sharing practices. The research draws on the construction innovation literature to investigate the use of Building Information Modelling (BIM) process standards in a large construction firm. BIM involves the use of digital technologies and process standards to coordinate work between interdisciplinary construction teams. The standards regulate information exchange activities. To understand the implications of the process standards on knowledge exchange, a case study is conducted with the UK construction firm. The paper focuses on the Publicly Available Specification (PAS) 1192 standard. Data is drawn from workshops, interviews and secondary publications. Thematic data analysis shows that the standard is embedded in design technologies; hence, users might be unaware of its effects to their interactive relations. Within the firm, the process standards influence interactions between engineers and site operatives. Externally, knowledge-sharing relationships with other construction firms, government agencies, universities and suppliers are changing. The research contributes by articulating how BIM process standards transform knowledge exchange relationships in construction. Further research could investigate these findings in the wider construction industry.

Keywords: BIM, process standards, construction innovation, interactive learning, innovation systems

1. Introduction

Literature on innovation in the construction underlines the importance of knowledge exchange in stimulating production and competitiveness in firms (Gann, 2000; Bossink, 2004). Knowledge is an essential element for competitive production, learning and development in firms (Dulaimi, Y.Ling, Ofori and Silva, 2002). Construction firms create, accumulate and exchange knowledge from their environments to address design and construction problems(Salter and Gann, 2003). However, there are challenges in creating and sharing both tacit and explicit knowledge, especially in project-based settings

¹ Infradev Consultants, 317 Upper Fourth Street, Milton Keynes, Buckinghamshire, MK9 1EH, United Kingdom;
nyasha040@yahoo.com

(Winch, 1998). Construction firms tend to rely on standardised processes to facilitate knowledge flow (Gann and Salter, 2000).

The roles of standards in managing multi-disciplinary interactions in temporary project based organisational teams have received some attention from innovation scholars (Gann, 2000, Slaughter, 1998). In the United Kingdom (UK) construction, there are contrasting views about the effects of standards (Morton and Ross, 2008). In the past six decades, high profile UK government-sponsored reviews have concluded that standards improve productivity and reduce construction costs (Banwell, 1964; Latham, 1994; Egan, 1998). There has since been a number of initiatives involving collaborations between academics, public and private organisations to advance the subject of standardisation (Avanti, 2006; Richards, 2010; East, 2012; Nisbet, 2012; Building Smart-UK, 2013). These efforts have culminated in the development of Building Information Modelling (BIM) process standards. The UK government recently mandated the use of BIM in public contracts from 2016 (Cabinet Office, 2011).

BIM provides a new mode of managing the digital representation of building design, construction and operation information throughout the built asset's life. BIM has been described as a tool for facilitating collaborations between professionals involved in construction practice (Nisbet, 2014). BIM provides a common structured process of managing information in construction. Some of the BIM process standards include the Industry Foundation Classes (IFC), Publicly Available Specification 1192, Uniclass and the Construction Operation Building information exchange (COBie) standard. The standards regularise information creation, storage, exchange and communication processes (Richards, 2010; Nisbet, 2014). The use of BIM process standards promises improved productivity, efficiency, reduce risk and the fostering of long term collaborations (Nisbet, 2012). However, the implications of using the BIM process standards are less understood, hence this study.

This research involves an in-depth investigation into the use of the PAS 1192 process standard. As BIM increasingly gets integrated into UK construction (NBS, 2012; NBS, 2013), this research is useful to inform the strategic implementation of BIM standards in construction firms. The paper is structured in sections as follows: the next section provides a theoretical background of innovation in construction. The third section explains the research design chosen. The fourth section examines the empirical findings and section five discusses the implications of the findings on the literature. The conclusion presents the contributions to theory and practice, and explores opportunities for further research in this area.

2. Theoretical Background

2.1 Knowledge and innovation

The knowledge based idea of understanding economic activity has gained scholarly attention among innovation systems scholars over the past three decades (Foray and Lundvall, 1998). This idea places knowledge at the core of innovation activities in global and local economies. At the centre of the argument is that the process of innovation is systemic and influenced to some extent by the processes of knowledge production, knowledge use and the adaptation of knowledge to meet market demand (Pavitt, 2003; Fagerberg, Mowery and Nelson, 2005). As globalisation increasingly dissipates the nation state

knowledge, scholars have suggested that knowledge will become more important to competitive production in local and international markets (Neef in Foray and Lundvall, 1998). While the resource based view of the firm suggests that knowledge is a resource acquired to maximise economies of supplying goods and services to the market, a knowledge based view argues that firms exist to perpetually accumulate and disseminate knowledge (Nonaka, Toyama and Konno, 2001).

The knowledge based view of the firm suggests the firm's ability to create and disseminate knowledge is mediated by the environment the firm is embedded in(Nonaka and Takeuchi, 1995b). Knowledge is viewed as subjective, "context specific, relational, dynamic and humanistic" (Nonaka, Toyama and Nagata, 2000 p.02). Scholars of this view define knowledge as a "process that justifies personal beliefs and *truths*" (Nonaka and Takeuchi, 1995b). This view seems to espouse a belief that knowledge is shared through regularised social interactions (Kogut and Zander, 1996), however this is contrasted by Lundvall and Johnson (1994) who focus more on the use of knowledge arguing that it is a set of skills and competencies. Other scholars of a similar tradition have defined it as a meaningful set of technical skills that result from repeated interactions (Antonelli and Quere, 2002).This later view is useful in that it places more emphasis on the repetitive interactions in knowledge creation and exchange, the localised nature of practice and it's the subjective of knowledge. Lundvall and Johnson further distinguish between know-how, know-what, know-who and know-why. They argue that the type and form of knowledge has implications on how it is used and exchanged. However, scholars interested in the exchange of knowledge in social practice have noted the challenges imposed by complex interactions and interdependent relationships between practitioners (Brown and Duguid, 2001).

Scholars distinguish between tacit and explicit (codified) knowledge(Polanyi, 1969). While explicit knowledge is relational and objective, and exists in forms such as manuals, scientific formulas and data(Nonaka and Takeuchi, 1995a; Foray and Lundvall, 1998); tacit knowledge cannot be easily exchanged through documentation, instead it can only be effectively communicated through experience(Kogut and Zander, 1996).Tacit knowledge exchange is particularly complicated by the fact that it is embodied in humans. While this dichotomisation is perhaps useful in understanding knowledge generally, other scholars have argued that this is not enough. In practice they submit, focus should be more on differences in perspectives formed by humans as they interpret and consume knowledge to suit their unique but shared contexts. Brown and Duguid (2001) argued that knowledge exchange could be understood by focusing on shared practices and protocols.

2.2 Knowledge exchange in construction

Construction innovation scholars have investigated the exchange of knowledge in construction firms. While research suggests that codified knowledge is communicable, tacit knowledge is shared through observation and imitation (Gann and Salter, 2000; Antonelli and Quere, 2002; Dodgson, Gann and Salter, 2003). Studies observe that the nature of construction projects and the forms of work organisation utilised by firms affect the exchange of knowledge (Johnson, 2007). Other scholars have noted that tacit knowledge in particular resides in humans; in construction, projects are predominantly made up of temporary human teams that disband upon completion, knowledge exchange is thus an incredibly complicated process(Winch, 1998; Dodgson, Gann and Salter, 2008).

In practice, knowledge exchange is mediated by the project based nature of the environment in which firms are embedded, skills and capabilities, communication and information flows and technological mechanisms (Bresnen, Edelman, Newell, Scarbrough and Swan, 2003). Bossink (2004) suggested that knowledge exchange in construction happens through internal and external processes. Internally, knowledge is exchanged through training, interactions between employees; make use of new applications developed by consultants and lateral communication structures. Externally, he suggests that knowledge is exchanged through participation in collaborations with architects and engineers, employees accessing information from outside and stimulation of research. Salter and Gann (2003) identify face to face interactions with clients and fellow colleagues, electronic scouting on the internet and internal data bases as potential ways of exchanging knowledge in construction.

2.3 Product and process standards

Scholars interpret and ascribe different meanings to the role of product and process standards. In contrast to product standards which address interfaces between components (Farrell and Saloner, 1985), process standards are common, repeatable best practices or voluntary norms which govern human behaviour (Hawkins, Mansell, Skea and Skea, 1995). Lundvall and Johnson (1994) explain process standards as common codes for communication. Other scholars suggest that they are useful for diffusing technologies, managing market entry for new products and compatibility between different technologies (Freeman, 1995). Nelson and Nelson (2002) argue that they provide a social infrastructure technology transfer.

Construction firms interact with and acquire knowledge from various sources such as clients, material suppliers, universities and professional bodies to design, construct and maintain the built environment (Gann and Salter, 2000). These firms use sets of process standards to create, store, exchange and communicate information. Within the construction innovation literature, standards are viewed by as a form of regulation to which all firms must subscribe. This applies mostly to technical, safety and quality standards. An alternative is to view standards as tools for useful in the production of goods and services. This view explains that standards are best practices or home-grown solutions which seek to manage human behaviour. Whyte and Lobo (2010) for instance explain that standards provide a digital infrastructure for managing interactions in construction. This view shifts analysis towards the role and effects of standards to production processes. In construction practice, analysis might involve examining interactions between practitioners and a particular standard. This might also involve investigating the meanings as constructed by participants as they use a standard.

There is a distinction between product and process standards. On the one hand, scholars describe how standardised products are useful in achieving production economies, however they also argue that they limit the client's choice (Hanseth, Jacucci, Grisot and Aanestad, 2006). The availability of precast units for instance, was important in speeding up construction activities. However, demand slumped, as customers were not ready to accept reduced selection (Gann, 2000). Some scholars explain that standard processes, involve the integration, structuring, simplification and replication, of work activities to facilitate information flow, regulate interactions between diverse practices and enhance performance in the production of products and services (Davies, Brady and Hobday, 2006). This view of process standards appears to suggest that standards are a measure of best practice established over prolonged

periods. Gann and Salter (2003) have suggested such standards can support knowledge exchange and provide the building blocks for sustained process improvement. However, these scholars appear to refer to routines, rather than consensus driven national or international standards, which are external to the construction firm. As a result, of diverging views there is a simmering debate on the role of process standards in construction practice.

2.4 Building information modelling

Building Information Modelling (BIM) aims to provide common structured processes of managing information in construction. In practice, this supposedly materialises through sets of process standards which seek to regularise information creation, storage, exchange and communication processes (Richards, 2010; Nisbet, 2014). By using BIM, firms anticipate to improve productivity, efficiency, reduce risk and foster long term collaborations with other actors involved (Nisbet, 2012), however the implications of BIM remain less understood especially among engineers (Maradza, 2014). In an attempt to improve BIM uptake, the UK government recently mandated BIM use on all public projects by 2016 (Office, 2011). Findings from a few UK government sponsored trial projects indicate that BIM can improve productivity and reduce construction costs (Cabinet Office, 2012), however further investigations are necessary to validate such conclusions. Table 1 shows examples of BIM process standards used in the UK.

Table 1: BIM process standards

BIM process standard
Industry Foundation Classes (IFC) British Standard ISO 16739
Library objects: BS 854 (1-4)
BS1192: 2007, Publicly Available Specification (PAS) 1192 (1-4)
Object library standards - Uniclass2.
International framework for dictionaries of digital objects ISO 12006 -3:2007 and Digital information delivery manuals: ISO 29481:2010
BIM execution plan
Digital plan of works
Design standards
Construction Building Information Exchange (COBie)

3. Research Method

This interpretive study uses a case study design to provide an in-depth account of the complexities about the use of BIM in a large multinational construction firm headquartered in France. The firm has been involved in the design and construction of award winning landmark projects across the UK. The firm is selected because of its size (above £1 billion turnover), experience in supporting standards development and participation in government BIM trial projects. In the UK, the firm has five divisions and civil engineering division is the largest by turnover. Due to time and access limitations, this study focuses only on the Civil engineering division. The aim is to provide a holistic account of using BIM process standards on knowledge exchange, focusing knowledge exchange practices from the perspective of those involved.

Therefore, the account provided is that of the multiple meanings and mental constructions made by practitioners as they interact and use the standard. By examining interactions between professionals involved in the use of the PAS 1192 standard, the study seeks to explore the issues that arise in project-based environments.

The case study design is selected because it is useful in studying the “particularity and complexity of a single case, coming to understanding its activity within important circumstances” (Stake, 1995 p.xi). Baxter and Jack (2008 p.544) explain that case studies “... ensure that the issue is explored through ... a variety of lenses which allows for multiple facets of the phenomenon to be revealed and understood”. However, the case study design only captures the views of a limited group of individuals hence generalisation is to an individual’s context (Stake, 1978). Despite this, case studies are known to provide rich data that account for contextual issues and permits interpretation at multiple analysis levels. Wider generalisations are not the priority; instead, the focus is on theoretical generalisation. A decision was taken by the researcher to interview the engineering professional pool. Data collection lasted seven months and it involved interviews, observations and secondary documents. Data collection involved, a) three hour long workshops involving the case study firm, IT suppliers and a wider industry groups on three occasions, b) observations of the BIM core team and in three projects, c) 12 semi-structured interviews; and d) secondary publications from the firm. Participant selection was based on the role on the project. Through examining the daily use of PAS 1192, it was possible to understand interactive patterns. Interviews were conducted with design engineers, site engineers, site operatives, BIM managers and consultants. Data was analysed through an iterative process of identifying emergent themes, coding and continuous reviewing of the data to identify aggregate themes and central meanings. Although this study is inductive, concepts established in literature were used to develop an analytical framework for data coding. To improve the research’s validity, method triangulation and interview participants were accorded an opportunity to review and revise the transcriptions and subsequent publications(Silverman, 2009).

4. Findings

4.1 The construction firm and its contextual environment

The case firm employs just over 6,000 employees in the UK alone. The civil engineering division employs 3500 employees. The Civils division has over 90 years of experience in designing and constructing large-scale infrastructure projects across the world. The case firm’s UK turnover was just over £1 billion in 2012. The civil engineering division is currently involved in some of the largest infrastructure projects in southeast England. Generally, the division is involved in airports, education, nuclear, residential and commercial building, rail, hospitals roads, tunnelling and utilities. To strengthen its position in the use of innovative design technologies, the division is involved in collaborations with IT suppliers. One of the widely used information technologies in the UK was developed with the support of the civil engineering division. The BIM manager is heavily involved in the development of the national PAS 1192 standard. The civil division has also been involved in the government-sponsored trial projects aimed at improving the use of BIM standards.

4.2 Interactions using the PAS 1192 standard

Research findings suggest a general level of BIM awareness. However, a detailed understanding of specific standards is limited especially among site engineers. When participants were asked to explain the purpose of the PAS 1192 standard, most of them were unable to, especially those involved on site. When asked if they had used the PAS 1192 standard, again some of the participants were not sure. However, participants were quite happy to discuss their use of the collaboration technology (TX, not real name). TX is embedded with the PAS 1192 standard.

Table 2: Interactions using PAS 1192 standard

Source of interaction	Knowledge exchanged	Form of interaction
Government, Professional bodies and local authorities	Codified	Participation through attending conferences and workshops organised by national bodies and professional organisations such as the ICE, RICS and the BIMtask group
Standards Development Organisations	Tacit and Codified	The contractor's BIM manager is involved in and participates in SDOs such as BuildingSmart. This allows the firm to access information on latest COBie developments.
Universities and other research organisations	Codified	Participation in the COBie trial project. Workshops organised to address COBie implementation issues.
Other project based firms	Tacit and Codified	Collective action in participating in the COBie trial project. Workshops organised to address COBie implementation issues.
IT suppliers	Tacit and Codified	Participation in the COBie trial project and providing feedbacks for solving day to day problems in integrating COBie with other digital design tools. Contributing to the national BIM library of digital objects.
Clients	Tacit and Codified	Participation in the COBie trial project and providing feedbacks at seminars and conferences

5. Knowledge Exchange Practices

The theoretical background outlines the context specificity and subjective nature of knowledge. Its exchange is shaped by social interaction. The firm's environment, skills and capabilities, communication and information flows and technological mechanisms influence knowledge exchange. A community based approach is also viewed as one of the means of exchanging knowledge (Bresnen *et al.*, 2003) Findings suggest that the firm used this approach to exchange knowledge by participating in trial projects. However, findings reveal a deeper problem, which stems from a limited understanding of standards. Despite the fact the firm contributed to the development of the standard, there is significant resistance to its use by some project managers. In addition, users did not quite associate themselves with the standard. This could be the result of its embedded nature as users unconsciously interact with it without being aware of its effects. Moreover, this could also be a reflection of wider issues concerning their perception of the standard. It appears that project managers are not confident with the standard hence their resistance to its implementation. Literature suggests that standards are viewed as best practices, which emerge over,

prolonged use. Resistance could explain that the standard is not yet viewed as best practice and its nationalistic nature could be viewed as negatively, i.e. it does not address context specific issues.

The findings suggest that in practice, users interact with standard unconsciously due to its embeddedness. Findings suggest that during the use standards knowledge exchange occurs internally. These include the use of training, interactions between employees; make use of new applications developed by consultants and lateral communication structures as suggested by Bossink (2004). Knowledge exchange externally is characterised by interactions with other firms, face-to-face interactions with clients, electronic scouting on the internet and internet databases. These findings suggest that BIM process standards support knowledge exchange and thus the process of innovation in construction. Previous research suggests that face to face interactions are important for sharing knowledge (Salter and Gann, 2003), however using BIM process standards is influencing the firm's interactions. New networks are emerging and existing interactions are being reshaped in construction (Maradza, Whyte and Larsen, 2012.). Interactions with the government, other firms, standards developers and IT suppliers are considered important for accessing new knowledge and keeping ahead of competitors. This explains a strategy to engage in pilot projects and the trial project. While standards were found to be simplifying practice since they are invisibly incorporated into practice, challenges observed were that users are not aware they are complying with a standard and thus they are unable to provide suitable feedback to perfect the standard and subsequently the coordination technology. This could also limit the extent to which the standard is used to facilitate knowledge exchange activities within the firm.

6. Conclusion

The research has examined the use of BIM process standards in construction practice with an aim of understanding its effects on knowledge exchange. In the context of evolving and dynamic construction practice, the research has shown the challenges of using a new standard. However, findings suggest that standards facilitate knowledge exchange, particularly when users acquaint themselves with the standard's requirements. Standards stimulate changes in interactive relations with in particular IT suppliers that are now taking a more influential role. Further research could examine the wider implications on innovation in construction. As interdependent teams execute work in construction, research of this nature is important to show some of the issues that arise as firms implement new national standards.

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Challenges faced by Construction Companies in Retention of Workers in South Africa: A Literature Review

Morena William Nkomo¹, Wellington Didibhuku Thwala²

Abstract

There is a high rate of employee turnover and retention within construction companies, which leads to increase in expenditure, this as a result lead to lower productivity which affects production at various projects. The aim of this study is to look at the challenges contributing to retention of employees within construction companies. In alleviating employee turnover problem mostly in other international countries construction companies through the methods used to retain construction workers. The paper will investigate the causes of employee leaving or turnover, determines the current retention strategies and the cost of it to the employer. The article then describes the problems that have been encountered in South African construction companies to retain construction workers in their respective companies and in South Africa. The study was mainly a literature review, with a special focus on the human resource management and leadership. The study indicated that there are a number of factors that contribute to each and every employee leaving their companies for instance organizations implement and respond to performance reviews poorly, companies fail to invest sufficiently in skills development due to this recruitment tends to happen outside the organization rather than developing and promoting employees internally this also tend to lead to job satisfaction within the organization to employees. Men earn more than women and the wage gap widens with age and business, management expertise is the most sought after skills across most Industries, there are causes to employee turnover and there are cost implications to it. The article challenges the South African construction sector, construction companies and including the different stakeholders to value their construction workers and do more to retain them, by developing retention strategies that are more practical to employees to comprehend within the construction industry.

Keywords: employee turnover, human capital, labour mobility

1. Introduction

Employee retention is becoming a major issue with most employers. Many organizations have not kept up with the changing needs of the workforce causing many good people to leave. Combined with the growing skilled worker shortage, they are unable to fill jobs with qualified people. Graduate employee retention is the most critical issue facing corporate leaders as a result of the shortage of skilled labor,

¹PhD Candidate; Construction Management and Quantity Surveying; University of Johannesburg; Doornfontein South Africa; mnkomo@uj.ac.za.

²Professor; Construction Management and Quantity Surveying; University of Johannesburg; Doornfontein; S.A; didibhukut@uj.ac.za.

economic growth and employee turnover (Nkomo and Thwala, 2009). Many graduate construction workers regardless whether they are skilled or unskilled workers, they move from one company to the next, especially now whereby no graduate employee will stay with an employer for the rest of his or her life, people are being exposed to opportunities that they have never knew that they existed for them in various companies. The number of years an employee stays with the employer, reflect a sea change in people's attitudes about their careers and changing jobs. The days are gone when many graduates employee could expect to spend 40 years at a single company, moving steadily up the ladder and retiring with a fat pension and gold watch. Due to this there is national and global impact for shortfall in talent and retaining graduate employees within their various respective companies (Nkomo and Thwala, 2009).

Organizations today face a dilemma regarding the retention of key knowledge workers. Turnover is a critical human resource issue in all sectors of the economy. Turnover affects productivity, product and service quality, and profitability. The cost of replacing workers is high, finding skilled employees can be difficult, and investments in training are less secure. Unexpected workforce attrition may place employers at a serious disadvantage. And this turnover could occur when slimmed-down companies have little redundancy in job roles, exposing them to greater risk of losing important organizational knowledge. Regardless of economic conditions, employee turnover happens (Nkomo and Thwala, 2009).

The financial impact of workforce mobility is well documented. The Society for Human Resource Management found that direct replacement costs can reach as high as 50% to 60% of an employee's annual salary. The total costs of replacement, including training and the loss of productivity, can range from 90% to 200% of an employee's annual salary (Society for Human Resource Management, 2008).

Turnover-related costs examined by the Saratoga Institute represented more than 12% of pre-tax income for the average company. As the rate of turnover increases, so does the cost per employee. For companies with greater than average voluntary attrition, turnover costs were equivalent to nearly 40% of company earnings (The Saratoga Review, 2007). While these figures include the costs to train a new employee, they overlook the value of the organizational knowledge lost when employees leave. That value is difficult to quantify, yet organizational knowledge is fundamental to every company. When employees leave, they take a major competitive advantage with them. Companies may not have a solid understanding of the reasons employees leave. Saratoga Institute research cited by Leigh Branham indicates another conflict between the employer and employee perspectives: 89% of managers believe employees leave for money; 80-90% of employees leave for reasons other than money. Turnover is tied to employees 'unmet needs for trust, hope for the future, a sense of worth and a feeling of competence (Leigh, 2007). Employers cannot address a high turnover rate if they do not understand its root causes. As employees exit, those left behind may not be capable or willing to take on the additional responsibilities. They may already be overworked, or lack the confidence for a new role. When the only employee who knows how to run a legacy system leaves, coworkers may not want involvement with a technology or role they perceive will soon be obsolete. Companies can lose much more than full-time employees through attrition.

Job mobility has increased in past decades because similarities in processes and technology mean that knowledge is less idiosyncratic to a particular organization and thus is more transferable (Rousseau & Shperling, 2004). To be effective, organizations must establish processes that promote knowledge

transfer while simultaneously fostering a commitment to the organization that supports retention (Rousseau & Shperling, 2004).

1.1 Purpose of the study

The study will contribute to knowledge by coming with recent information which can assist construction companies in understanding the problem of not retaining staff and its cost implications. Furthermore it will challenge the construction sector including the different stakeholders to value its construction employees and do more to retain them by developing retention strategies that are more practical to employees to comprehend within the construction industry; it is through the workforce that the industry can see productivity and it is through the industry that the retention problem can be curbed, especially now that the sector is booming with new developments throughout the country. It is through the human resource management and leadership that the companies can grow thus the study will also contribute to the country's economy by developing the construction workers and retaining them in their company's and within South Africa, so that employers cannot outsource the skills they have, in order to increase cost savings associated with outsourcing.

1.2 Objectives of the study

- To investigate the causes of employee turnover.
- To determine current retention strategies.

1.3 Methodology

The study was mainly a literature review, with a special focus on the human resource management and leadership, qualitative with a special focus on the challenges faced by construction companies in retention of employees within organizations. The data used in the report was, based on the content analysis, and historical data.

2. Literature Review Findings

The number one issue for South Africans is finding good, strong graduate employees with the right education and training, and being able to retain them. The challenge for employers then lies in being the top choice of top talent, if you want your business to thrive and maintain competitive advantage, positioning your employer brand to be the top choice of top talent, has become a critical business task, the cost of talent attrition is on the increase as the employers realize it is about much more than recruitment costs. The retention of key employees within construction companies is probably the biggest challenge in human capital management today (Sokoro, 2012). One of the key features in the new world of work is the increasing mobility of graduates, who are the knowledge workers, within the organizations. The financial impact of this turnover is under-appreciated by organizations as the cost of the loss of factors such as organizational memory, lowered morale amongst remaining staff, loss of knowledge, customer dissatisfaction and reduced organizational momentum are often concealed and difficult to quantify.

Mentoring programs in organizations can be helpful in improving performance and transferring knowledge, and lead to higher job satisfaction and retention of employees, resulting in higher business

productivity. One type of relationship that can be very beneficial in the workplace, even advancing an individual's career, is the mentoring relationship. The mentoring relationship between a mentor - a more experienced employee - and mentee can provide both parties benefits offering support and knowledge in performing a job, increased admiration in the office, and navigating the politics of an organization. The benefits usually relate to an increase in performance. This relationship, although usually positive, is not without some pitfalls and risks. A mentoring relationship can sometimes develop into a negative situation with a mentor possibly sabotaging a mentee or not providing the necessary career support (Piasecki, 2011).

Company leaders around the world have for years been speaking about future skills shortages. We now live in this future, and have entered an era in history when the world will cry out for talent, where specialist skill demand outstrips supply many times over. Where human capital possessing the required experience, knowledge and application ability will have high value, and will be needed to provide leadership to guide decisions that affect the world's development today and into the future. This critical need applies to all disciplines such as construction, business management, agriculture, politics, science, information technology, medicine, etc. The challenge for business owners and leaders is to identify, attract and retain talent in their companies, especially among the graduate's employees (White, 2016).

When a business loses employees, it loses skills, experience and "corporate memory". The magnitude and nature of these losses is a critical management issue, affecting productivity, profitability, and product and service quality. For employees, high turnover can negatively affect employment relationships, morale and workplace safety. The cost of replacing workers can be high, the problems associated with finding and training new employees can be considerable, and the specific workplace-acquired skills and knowledge people walk away with can take years to replace. The problem of turnover can be addressed through a variety of pro-active retention strategies: workplace policies and practices which increase employee commitment and loyalty. Employee retention is an element of a more general concern that might be best termed 'skills management, i.e., everything that has to do with recruiting, maintaining and developing *the necessary mix and levels of skill required* to achieve organizational and business objectives (Lochhead & Stephens, 2004).

Retention is of interest in this study because of its importance to organizational performance. For decades, management researchers have emphasized the importance of retaining talented employees through research on turnover. If organizations invest in talented employees through increases in their knowledge, the knowledge transferred to these employees is lost if they leave the organization, and the investment made to them. While recognizing that there will always be some voluntary turnover in an organization, retention rates should be somewhat high so that experienced workers are available to share their organizational knowledge with newcomers in the organization and to use their expertise to directly benefit their organization. Thus, in the knowledge economy, it is important to look at issues of retention (Mitchell *et al.*, 2001).

Organizations face significant challenges in retaining valued employees because of the changes in the employment relationship that promote greater job mobility. Traditional research has focused on the influence of job satisfaction on voluntary turnover (Mitchell & Lee, 2001), to develop alternative theoretical understandings of voluntary turnover and retention, researchers have expanded upon the initial

research to explore other constructs. Recognizing that “... less turnover research has focused specifically on how an employee decides to remain with an organization and what determines this attachment” (Mitchell *et al.*, 2001), researchers are beginning to recognize the importance of relationships in retaining workers (Mitchell *et al.*, 2001).

Only a decade ago, job hopping was a foreign concept in South Africa. It was not unusual for graduate's employees to spend 25 years at the same company, at the same job even. But times have changed. The onset of information technology has changed the face and the pace of the workplace. An interesting outcome of this phenomenon is what is called job hoppers, people or graduates employees who frequently jump from one job to another in a short period of time. If this practice sounds familiar, then chances are that you may have come across some negative perception about job hoppers. This include construction employers who often think job hoppers do not have what it takes to follow through and complete lengthy projects, as they feel that such a pattern of behaviour represents a lack of commitment and accountability. And also companies are often wary to employ known job hoppers as they think of job hoppers as unpredictable, liable to up and leave at any minute.

2.1 Causes of job mobility

Employers struggle to retain, attract and develop talent, according to a recent national survey of the South African workforce. Local employers are failing to attract, retain and develop their employees. The research findings are based on more than 21,000 responses to a 70 question survey conducted among a broad spectrum of industries and employees at various job levels (Blue River Stone Research, 2008). South Africa's fastest growing jobs portal the second annual Careers 24 Salary Survey was conducted between October and November 9, 2008. Some of the key findings of the study include organizations implement and respond to performance reviews poorly, despite having proud and willing graduate employees as a result employees move from one company to the next, companies fail to invest sufficiently in skills development due to this recruitment tends to happen outside the organization rather than developing and promoting this employees internally this also tend to lead to job satisfaction within the organization to employees. Men earn more than women and the wage gap widens with age and business, management expertise is the most sought after skills across most Industries (Career 24, 2008).

Examining everything from employee salaries, benefits to organizational leadership and trade union membership, the survey results include unique insights in South Africa's human capital landscape. Through a series of qualitative questions, the six elements of human capital practice (HCP) were measured on a scale of one (strongly disagree) to four (strongly agree) in order to determine organizations' effectiveness. The six HCP elements include leadership, performance reviews, employee acquisition, development, retention and engagement. From the data, some interesting employment issues and trends relating to gender, age, geography and race were revealed. Overall, every element of HCP showed lackluster performance, indicating underdeveloped systems with organizations unable or unwilling to fully tap into employees' enthusiasm and aid their career development. With an average industry wide HCP score of 2.84, employee engagement rated moderately well 2.84, with acquisition 2.47 and retention (2.40) of employees as the biggest problem areas. In terms of attracting talent, the banking, food and beverage, manufacturing and insurance sectors are outperforming others, while construction

sector and government related sectors are struggling to attract talent (Blue River Stone, 2008). Government is not setting good example, in a country with high unemployment, among the graduates and a widespread skills shortage, it is disappointing to see government one of South Africa's largest employers failing across the board to be an effective employer (Bisaro, 2008).

Within construction companies what really happens is that, some employees rate their managers as least competent to communicate, provide feedback, develop a strong culture of learning, mentor and engage them. As a result, employees will be dissatisfied and they will move from current employer to the next. For instance, performance reviews have a greatest impact on human capital practice, ideally including transparent feedback, mentoring, active listening, and transference of skills from managers to employees, have the greatest impact on an organization's ability to retain, attract and foster staff. Despite employees being willing to go the extra mile for their employers and relatively good communication between managers and their direct reports, graduates employees indicated a lack of time spend by managers on talented related issues, as well as irregular and inadequate feedback on their performance. Among South Africa's employers, the banking and insurance industries were some of the best with well managed performance review practices in place. The weakest performance review practices were found among government related departments including construction companies, primary agriculture and the NGO sectors (Career 24, 2008).

Graduates change jobs for a variety of reasons, sometimes for economic reasons or for growth and challenge, sometimes because his company was taken over by another firm. Most of the moves increased the employees pay by 10 to 40 percent. One move even doubled their salary. Managers today complain that their graduate's employees are no longer motivated to work. Their attitudes toward their employer and work are negative. However, it is often the managers and organizational practices that are the problem, not the employees. When an employee wants to leave their current employer to work for the next organization, the problem usually lies in one of the following areas: poor selection; unclear goals; an inadequate performance appraisal system; unsatisfactory reward systems and also the manager's inability to communicate the appraisal and reward systems to the employees properly (Robbins, 2003).

There are generally two reasons why people do things: either because they want to or because they have to (Gray, 2004). Most people would agree that the reason they work is to obtain money; however, this is not always the only reason. Money is not really what people want; they want the things that money can buy. Also, whereas in the past employees were considered as just one of the inputs into the production process, most employees today want to feel that their work makes a difference (Anon, 2004), especially the new entry employees to the organization. Money can thus be a very important factor but it does not solve all the problems (Drafke & Kossen, 2002). Job hopping occurs when the, graduates employees see a weakness in one of three relationships. The first of this is the relationship between the employees' effort and their performance. Managers must make sure that the employees believe that if they exert maximum effort in performing their jobs, it will be recognized in their performance appraisal. However, in most cases, the employees do not believe that their efforts will be recognized. If this is the case, it could lead to job hopping of employees (Robbins, 2003). Secondly, the relationship between the employees' or graduates' performance and organizational rewards is important. Managers must make sure that employees believe that if they get a performance appraisal, it will lead to organizational rewards. Many

employees see this relationship as weak because the organization does not give rewards just on their performance, so there is a lack of motivation to stay within the organization (Robbins, 2003).

The third important relationship is the one between the rewards received and the rewards desired by the graduates. The company human resource personnel must know whether the rewards the employees receive are the ones they desire. Some employees might want a promotion but instead get a pay rise, or vice versa. Sometimes the managers assume that all employees want the same reward and so fail to notice the motivational effects of individualizing rewards of graduates. If this is the case, employees' motivation is likely to suffer and cause that particular employee to leave the organization to work for another (Robbins, 2003).

2.2 Labour turnover

The analysis of the numbers of people leaving the organization (labour turnover or wastage) provides data for use in supply forecasting, so that calculations can be made on the number of people lost who may have to be replaced. More importantly in most companies the analysis of the numbers of leavers and the reasons why they leave provides information that will indicate whether any action is required to improve retention rates. It can prompt further investigations to establish underlying causes and identify remedies. Consideration will be given to the following aspects of labour turnover: its significance, the reasons for turnover, what it cost, its incidence, how to benchmark rates of turnover.

2.2.1 Significance of labour turnover among graduates workers

The rates of labour turnover provide an illustration of the turbulence within an organization (Armstrong, 2006). High rates of attrition can destabilize a business and demotivate those who attempt to maintain levels of service and output against a background of vacant post, inexperienced staff and general discontent. Obviously recruitment, induction and training cost all rise with an increase in labour turnover. Turnover may be a function of negative job attitude, low job satisfaction, combined with an ability to secure employment elsewhere, for example the state of labour market (Armstrong, 2006). On the other hand, turnover is a normal part of organizational functioning, and while excessively high turnover may be dysfunctional, which most companies internationally are experiencing currently, but a certain level of turnover is to be expected and can be beneficial to an organization. When assembling and analysing labour turnover figures, it is important to obtain information on the incidence for different categories of employee, especially those who are most difficult to attract and retain such as knowledge or highly skilled workers.

2.3 Retention of employees

The turnover of key employees can have a disproportionate impact on the business and the people which organizations wish to retain are probably the ones most likely to leave (Armstrong, 2006). Every worker is five minutes away from walking out of the door to a better offer. Concerted action is required to retain talented graduates' employees, but there are limits to what any organization can do. It is also necessary to encourage the greatest contribution from existing talent and to value them accordingly.

Retention strategies should be based on an understanding of the factors that affect them. For early career employees (30 years and under) career advancement is significant. For mid-career employees (age 31 -50) the ability to manage their careers and satisfaction from their work are important. Late career employees (over 50) will be interested in security. It is also the case that a younger workforce, especially the graduate employees, will change jobs and employers more often than an older workforce, and a workforce with a lot of part timers are less stable than those with predominately full-time staff. The specific factors that affect retention are: company image; recruitment, selection and deployment; leadership-employees join companies and leave managers; learning opportunities, and performance recognition and rewards.

A retention strategy takes into account the particular retention issues the organization is facing and sets out ways in which these issues can be dealt with. This may mean accepting the reality, that the market, not the company will ultimately determine the movement of graduates employees, it can be difficult to counter the pull of the market you can't shield your people from attractive opportunities and aggressive recruiters (Cappelli, 2000). The old goal HR management is to minimize overall employee turnover needs to be replaced by a new goal, to influence who leaves and when. This, as proposed, could be based on risk analysis to quantify the seriousness of losing key people, or of key posts becoming vacant (Bevan *et al*, 1997).

The overall strategy of most companies is to become an employer of choice. The recruitment of key individuals who will contribute significantly to the value- creating capacity of the firm is crucial to success. The aim are to establish the brand image of the organization how others perceive it employee branding , to become an employer of choice, and to target recruitment and selection to obtain the sort of people the organization needs (Sokro, 2012). Employer branding is the creation of a brand image of the organization for prospective employees. It will be influenced by the reputation of the organization as a business or provider of service as well as its reputation as an employer. Employer branding is a concept of applying to the recruitment process the same marketing coherence used in the management of customers (Reed, 2001). The approaches required to develop an employer brand are:

- Analyse what ideal candidates need and want and take this into account in deciding what should be offered and how it should be offered;
- Establish how far the core values of the organization support the creation of an attractive brand and ensure that these are incorporated in the presentation of the brand as long as they are values in use (lived by members of the organization) rather than simply embraced;
- Define the features of the brand on the basis of an examination and review of each of the areas that affect the perceptions of people about the organization as a great place to work the way people are treated, the provision of a fair deal, opportunities for growth, work life balance, leadership, the quality of management, involvement with colleagues and how and why the organization is successful;
- Benchmark the approaches of other organizations(the Sunday times list of the 100 best companies to work for is useful) to obtain ideas about what can be done to enhance the brand;
- Be honest and realistic.

Sign bonuses may disappear due to market volatility. Previous years almost every senior management professional placed in the financial services sector received a sign on bonus. And hand in hand with that came a significant increase in recruitment expenditure last year. Figures show that certain candidates received sign on bonuses from between 30% and 100% of their annual package (Hammer, 2008). However, it must be remembered that sign on bonuses are often paid in lieu of a forfeited bonus that a candidate would lose when leaving their current job to join a new organization. It can also be used to compensate candidates for the loss of share options. In the past, it was certainly not taken as a given that top professionals would be offered a sign on bonus as an incentive to accept a job offer. However, in late 2006 we began to see the increasing use of joining bonuses as construction companies began to feel the pressure of skills shortages in certain sectors.

3. Conclusion

A period of two to three years usually raised a red flag when an employee stays with the employer. At present, depending on the industry, it is one to 1.5 years. But what employers are really looking at is whether the employee completes projects or commitments that they have made. Retaining good employees is critical to a firm's long term success. And in the engineering and construction markets, employee retention is especially serious since the job market is tight and competition is fierce for top graduate employees. When you add the costs of recruiting employees, the financial impact alone is shocking. Some studies estimate that losing an employee costs a company 100% of that employee's salary. When reduced efficiency, lower effectiveness, workforce instability and lost productivity are added to the cost to find and train a new employee, the stakes become high. Companies simply cannot afford to ignore employee retention.

There are a number of things that construction companies can do to keep good graduate employees from leaving which are not done in this decade:

- Companies need to show employees that they care, for instance, taking personal interest in developing their staff, mentor and coach the high performers.
- Fight turnover with good, rational training targeted to specific and individual needs of graduates; weed out poor managers, dissatisfied workers dislike poor management. Companies need to act quickly to preserve their credibility in the workforce.
- Address issues of poor performance and provide inspirational vision and strong values, other workers resent having to carry someone who cannot or will not pull their own weight.
- They can create meaningful, challenging work, an environment that enables employees to do their best and offer career development and promotional opportunities by offering tangible rewards in both monetary and non-monetary ways.
- Ensure work-life balance and support its importance. Attracting and retaining the right employees does not happen as a result of strategy but implementation. Attracting and keeping the right people translates into construction companies' bottom line.

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Equipping 21st Century Construction Graduates: A Review of Key Skills in Fostering Infrastructural Development

John Aliu¹, Clinton Aigbavboa²

Abstract

The construction industry continues to be a significant part of the global economy and shapes the built environment and quality of life for people around the world. It is an industry which is regarded as uncertain and continuously changing, requiring the services of competent professionals such as engineers, architects, surveyors amongst others, in the execution of construction activities to achieve timely results. This inherent complexity that characterizes the construction industry requires, not only graduates possessing a strong academic foundation, but also the right skills to meet up with the challenges. However, the construction industry has been plagued with a shortage of skilled graduates in proffering solutions to emerging problems. This paper aims to identify relevant skills that construction graduates need to possess in order to contribute meaningfully to the future of the building construction industry. A review of relevant literatures was conducted from journals and conference articles from databases including Taylor and Francis online, Springer, Emerald, ASCE and Scopus. Various skills were identified in the literature which further helped pinpoint the most important ones after a random study across further literatures were conducted. Notable findings from this study revealed that communication, teamwork, technology skills, problem solving skills, individual values, technical skills, leadership, numeracy and adaptability are all essential to construction graduates ahead of the construction industry. The study further makes recommendations to HEI's emphasizing the need to revise their curricula to better prepare construction students for success in the industry. In order to ease the transition from the world of the Higher Education Institutions (HEI) to the world of employment, it is of crucial importance for HEI's to provide university students with on-the-job skills to enable them cope and meet the ever increasing, changing and challenging needs of the construction industry in this 21st century and beyond.

Keywords: construction industry, education, employability, graduates, higher education

1. Introduction

The construction industry plays a key role in every economy globally. Its range of activities including construction of highways, bridges, buildings, dams amongst others are all key in meeting of socio-economic goals and helps in the provision of local amenities, employment and infrastructural development (Anaman and Osei-Amponsah, 2007; Idoro, 2011). In the achievement of economic and

¹Postgraduate student; Department of Construction Management and Quantity Surveying, University of Johannesburg, ajseries77@gmail.com,

²Associate Professor; Department of Construction Management and Quantity Surveying, University of Johannesburg, caigbavboa@uj.ac.za

infrastructural development, there is undoubtedly a serious demand for construction professionals with the right skills to manage construction projects (Haselbach and Maher, 2008; (Maclean and Wilson 2009). As a driver in the development of any economy, the construction industry is faced with challenges (Ahn, Pearce and Koon, 2012) which arise as a result of the influx of construction graduates not fully equipped with the right skills (Ayarkwa, Adinyira and Osei-Asibey, 2012).

According to Ahn *et al.* (2012), the construction industry is practical in nature which increases its dynamics in approach and participation. Clients in the construction industry in recent times are in search of consistent and improved results in construction project outputs within the budget, which has resulted in technical complexity and increase in scope. In the quest for these improved products, there exists the creation of significant upgrades in project activities required to meet objectives such as cost, schedule, quality and safety (Ahn *et al.*, 2012). This upgrade of skills will promptly increase the demands for specialists to handle the various areas of design and construction that require more than basic skills of project management. Hence, the various technical professionals involved in those activities including project managers, project engineers, and construction engineers and supervisors are required to be thoroughly skilled to meet up with these expectations (Tatum, 2010). This further increases the need for graduates to possess problem solving and organizing skills in order to resolve the challenges for the successful implementation of construction projects (Farooqui and Ahmed, 2009 ; Ahn *et al.*, 2012; Bhattacharjee *et al.*, 2013) which fosters the infrastructural development of any economy.

In further improving the infrastructural development of any economy, inventions and technological ideas are constantly on the rise, which has in turn caused the construction industry to evolve in a bid to increase project performance and output. In achieving this output, there is the need for construction graduates to be fully in- tune with this rapid advancement which further increases the need for the right industry skills. For instance, Kunz and Fischer (2009) informed that the development of tools for construction process modelling which improves output requires a sound technical base from its users; hence the need for construction graduates to possess a strong background in construction education and corresponding technological skills (Arain 2010). Also, with the increase in mechanization and automation of equipment in carrying out construction site activities, there is the utmost need for construction graduates to have basic technical skills in understanding their various modes of operation. In addition, there is the need for graduates to understand the manufacturing and assembly operations on construction site which further increases the need for sound technical knowledge (Tatum, 2010). Apart from graduates possessing technological skills, they must possess creativity, effective team working ability, show independence and problem solving skills and adapt to new technological innovations (Tatum, 2010). Furthermore, several factors including financial and government legislative requirements have caused the construction industry to effect changes in their administrative operations. Some of these legislative requirements can be as a result of union affiliations or government laws as regards quality assurance, taxes, legal proceedings and certificates of payments (Tatum, 2010). These factors arising requires graduates to possess a good foundation of problem solving skills, planning and organizing skills as well as arithmetic skills (Curtis and McKenzie, 2001; Durrani and Tariq, 2012).

In reference to the extent of key skills in construction graduates, this paper argues the importance of revisiting the key skills in the curricula of universities. Considering the fact that construction graduates are engaged in various capacities in design and supervisory roles, it is paramount that HEI educators in various construction programs design activities to provide top quality education that encompasses the necessary skills and competencies the industry require in the 21st century. This paper reviews literature from various sources including conference papers, journals and government reports to highlight the importance of such skills that are highly needed to be possessed by construction graduates. With the aid of search engines such as Google Scholar, as well as databases including Taylor and Francis online, Springer, Emerald, Scopus and ASCE, related literatures were key in the achievement of the paper objective. Therefore, the paper examined key skills required for equipping 21st century construction graduates in order to foster better infrastructural development in sub-Saharan Africa states.

2. Literature Review

2.1 The need for skills

Factors such as sharp increase in technological advancements, increased global competition, environmental factors, construction projects sophistication and varying regulation by authorities constantly give the construction industry a complex look, hence the need for the influx of highly equipped construction graduates to meet up with this significant changes (Kunz and Fischer, 2009; Tatum, 2010; Ahn *et al.*, 2012). As a matter of fact, this significant change requires not only graduates with a sound academic background and degrees but also with certain skills and competencies such as management and leadership skills. The benefits of skilled construction graduates cannot be over-emphasized as the society needs are met because they fully understand the rudiments and complexities of industry-based projects that improve the sustainability of the built environment (Batra, 2010). It is therefore paramount that universities provide the students with top notch education that comprises both the technical skills and the industry required skills. This was asserted by Russel *et al.*, (2007); Storen and Aamodt (2010); Munap, Badrillah and Mokhtar (2015), who stated that the foremost aim of the HEIs is to prepare and equip construction students for the rigors of the construction industry. In recent times, the construction industry has been faced with skills shortage with construction graduates failing to meet the various needs of the industry at various levels (Ayarkwa *et al.*, 2012). This was reiterated by Rawlins and Marasini (2011) who hinted that the construction industry graduate recruitment needs are not being met because the construction graduates are lacking in key areas. Similarly, Mukhtar *et al.* (2009) states that the 21st century graduates entering the construction industry today are ultimately posed with exceeding pressure and expectations to perform because of the challenging and ever changing needs of the industry.

2.2 Keys skills necessary for construction graduates

Various researches have highlighted the various skills that construction graduates should possess to be able to thrive in the construction industry. The Council for Industry and Higher Education (CIHE), in the UK report by Archer and Davison (2008), highlighted ten important skills graduates should possess upon graduation. These skills are: Communicative skills, team-work, integrity, intellectual ability, confidence, individual values, Planning and organization skills, literacy, numeracy and decision making skills. Also, Arain (2010) used questionnaires to determine the top five desirable skills that Canadian construction

graduates needs to possess including construction knowledge and practices, leadership qualities, business intelligence, ethical professionalism and communication skills. A total of eighty skills were identified by Farooqui and Ahmed (2009), which was peculiar to both undergraduate and graduate construction students in certain regions in the United States of America to possess ahead of the construction industry. Among the skills ranked important were communication, problem solving, technology, leadership, team work, time management and technical skills. In addition, Wickramasinghe and Perera, (2010) conducted an exploratory study in Sri Lanka which identified sixteen key skills from the view of the graduates, university lecturers and the employer's perceptions. The skills were ranked as communicative, numeracy, problem solving, innovative, self-confidence, independence, adaptability, teamwork, decision making and learning skills. Most significantly, all three groups of respondents ranked team work, problem solving and self-confidence as the most important. Similarly, various research in South Africa highlights the importance of key skills for construction graduates. There is the need for them to possess the right knowledge (CIDB 2007) to be able to fill the skill shortage in the industry. Nicholas, Theo and Ferdinand (2007) in their quantitative research determined communication and computer literacy as key skills which the construction industry requires from building graduates. These key skills alongside leadership and problem solving are also reflected in the report on construction management and civil engineering education at universities of technology by (Nicholas *et al.*, 2007).

These above researches identify several key skills construction which graduates need to possess to function effectively in various capacities in the construction industry. Though research on the subject has been conducted extensively, previous studies were either peculiar to developed countries (Archer and Davison, 2008; Farooqui and Ahmed (2009); Arain, (2010) which all grouped the various skills into categories; or were not conducted in the construction industry, Wickramasinghe and Perera (2010) and scarcely streamlined to any specific aspect of the construction industry (Farooqui and Ahmed, 2009).

From literature, the following skills have been highlighted as key skills construction graduates should possess ahead of the construction industry.

2.2.1 Communication skills

The construction industry is one which is built on relating with team members and professionals alike (Farooqui and Ahmed, 2009). It involves the ability to interact orally, analyse and communicate clearly, Love, Haynes and Irani (2001); Gardner *et al.*, (2005), Washer (2007), Gray (2010); (Archer and Davidson, 2008), who can write effectively Gardner *et al.*, (2005); Graham *et al.*, (2010); Ariana (2010), who can also listen to ideas carefully Goby and Lewis (2000) as well as remembering and analysing what is heard (Ahn *et al.*, 2012; Samavedham and Ragupathi 2008). It further means that ability to expand one's own communicative skill (MOHE, 2006; Ma and Sun, 2013).

2.2.2 Teamwork / collaborative skills

This skill is important as it enables graduates to be ready and willing to contribute meaningfully to set up groups, committees and various arms of the industry in achieving a common goal (MOHE 2006). This skill becomes relevant as a result of high influx of students into universities which results in minimal connections with educators (Washer, 2007). It further highlights ability to synergize with a group in achieving results to project based problems (Badger *et al.*, 2005; Samavedham and Ragupathi 2008). This

skill also assists graduates in understanding the orientations of other people through group activities (MOHE).

2.2.3 Technology skills

This skill is key as a result of the technological trends presently in the construction industry (Tatum, 2010). Construction graduates are needed to possess computer skills, familiarize themselves with various software and applications and be willing to upgrade these knowledge as time goes on (Archer and Davidson, 2008; Ahn *et al.*, 2012). With the ever changing technologies in the industry, possession of this skill makes them stay competitive (Barr *et al.*, 2009; Jabr, 2011). This skill therefore gives them an edge in the industry (Christodoulou, 2004; Russell *et al.* 2007; Arain 2010; Ahn *et al.*, 2012).

2.2.4 Interpretation of construction documents / technical skills

This ability is pivotal for construction graduates as it enhances their knowledge of construction operations, and enhances their ability to interpret drawings (both architectural and structural) as well as provide the necessary knowledge of construction concepts, materials and equipment (Arain, 2010; Ayarkwa *et al.*, 2012). Similarly, the interpretation of various contract documents (contract administration skills and bidding procedures) is key for construction graduates (Farooqui and Ahmed, 2009; Jackson and Chapman, 2012).

2.2.5 Problem solving skills

This skill is important for construction graduates to exhibit during complex problems that requires proffered solutions by showing creativity and practicality (Washer 2007; Kilgour and Koslow 2009; Finch *et al.*, 2012). It highlights the ability to think critically and analyse problems Ahn *et al.*, (2012); Reid and Anderson (2012) as well as using logical reasoning to design conclusions (Jackson and Chapman, 2012). It is also the ability to find ideas and alternative solutions (Wickramasinghe and Perera, 2010; Finch *et al.*, 2012).

2.2.6 Leadership skills

This skill is important for graduates to display elements of leadership like exhibiting confidence, taking responsibilities and working effectively in a team (Komives *et al.*, 2007; Kouzes and Posner 2008; Cox *et al.*, 2009; Graham *et al.*, 2009). It further involves the ability to be responsible for other team members and guiding them to success (Muller and Turner, 2010; Conrad and Newberry, 2012). It also involves possessing the knowledge of basic theories on leadership (MOHE, 2006).

2.2.7 Numeracy skills

This skill highlights the ability to carry out number functions like measuring, numeric problem solving, estimating and costing (Durrani and Tariq, 2012). It also involves the ability to use data accurately and manipulate into the much needed information (Jackson & Chapman, 2012) as well as possessing knowledge of using spreadsheet software and understanding basic mathematical calculations (Taylor, Liu and Hein, 2008).

2.2.8 Planning and organizing skills

This skill highlights the graduates' ability to think critically and work effectively by sequential analysis various tasks (Rawlins and Marasini, 2011; Jackson and Chapman, 2012). It further helps graduates to set and maintain goals, plans and realistic schedules (Jackson and Chapman, 2012).

2.2.9 Critical thinking / creative thinking skills

These set of skills involves the ability for graduates to propose well thought ideas to achieve results (Reid and Anderson, 2012). It involves the ability to recognize solution patterns in complex solutions to proffering solutions (Samavedham and Ragupathi, 2008; Kilgour and Koslow, 2009; Jackson and Chapman, 2012) and the ability of graduates to think outside the box (MOHE, 2006).

2.2.10 Ethical professionalism

These skills focuses on upholding the various building codes and regulations Shafer *et al.*, 2002; Mat and Zabidi, 2010) as well as be in conformity with the organizational policies (Jackson and Chapman, 2012). It also involves possessing a sense of responsibility to the society (MOHE, 2006), and always accepting the responsibilities for actions and project outcomes (Jackson and Chapman, 2012).

2.2.11 Individual values

This is important to be possessed by all construction graduates, whether experienced or not, as they are essential to enhancing productivity in the industry. Apart from having a good rapport with other professionals, these values help to promote harmony and excellent working conditions. They include: honesty, hard work, enthusiasm, commitment and positive feelings (MOHE 2006; Ayarkwa *et al.*, 2012; Finch *et al.*, 2012). It further highlights ability to show commitment in acquiring and developing new skills like independence, working under pressure, paying attention to details; Simon (2016), possessing enterprise skills, Matlay and Rae (2007); Farooqui and Ahmed (2009) and time management, (Rawlins and Marasini, 2011). It further embraces the ability to build relationship and possessing social sensitivity (Lievens and Sackett, 2012).

2.2.12 Soft skills

These sets of skills involve communication and professionalism as dominant characteristics to be possessed (Lievens and Sackett, 2012). Its importance cannot be over-emphasized (Gardner *et al.*, 2005; MOHE 2006; Andrews and Higson, 2008; Chamorro-Premuzic *et al.*, 2010; Nickson *et al.*, 2012). Other examples of soft skills include reliability, self-confidence, creativity and professionalism (Andrews and Higson, 2008).

2.2.13 Adaptability

This highlights the ability of graduates to fit into the changing work environment with the minimal of fuss (Love *et al.*, 2001; Rawlins and Marasini, 2011; Ahn *et al.*, 2012). It is also the ability of construction graduates to self-adjust to situations in the industry (Samavedham and Ragupathi 2008).

2.2.14 Work experience

This provides the graduates first-hand experience of what to expect in the industry. It focuses on the graduate's previous experience in the industry (Callanan and Benzing, 2004; Gault *et al.*, 2010; Hopkins *et al.*, 2011). This industry experience help graduates develop key skills such as communication, problem solving skills, management skills and self-confidence which are all key requirements by the industry (Gill and Lashine, 2003).

3. Research Methodology

This paper reviews literature from various sources including conference papers, journals and government reports to highlight the importance of such skills that are highly needed to be possessed by construction graduates. With the aid of search engines such as Google Scholar, as well as databases including Taylor and Francis online, Springer, Emerald, Scopus and ASCE, related literatures were key in the achievement of the paper objective. It is key to note that a large number of researchers in various studies have identified numerous skills construction graduates are to possess, but a total of ten were reviewed in this paper because they highlighted in details the importance and implications of possessing such skills. The skills also identified by different researchers vary considerably in the way they are organised which provided a large number of skills to be examined (Love *et al.*, 2001; Archer and Davidson, 2008; Samavedham and Ragupathi, 2008; Farooqui and Ahmed, 2009; Arain, 2010; Wickramasinghe and Parera, 2010; Rawlins and Marasini, 2011; Ahn *et al.*, 2012; Jackson and Chapman, 2012; Bhattacharjee *et al.*, 2013). From the review of these literatures in this study, a total of 17 skills were identified as important skills to be possessed by construction graduates who are poised for the construction industry. The skills obtained were used in the formulation of a ranking table to illustrate the order of importance of such skills to be possessed by construction graduates in meeting the 21st century needs. Each individual skill in table 1 had a total score which reflected its frequency of importance and relevance from the considered literature. Thus, the accumulated numerical scores of each identified skill factor were used to rank the skills according to its importance from the literature considered.

4. Findings

As presented in table 1, from the review of extant literature, communication (R=1) and teamwork (R=1) were jointly ranked as the most important skills construction graduates should possess in order to thrive in the 21st century construction industry. Communication skill is key for construction graduates to possess as it helps in interaction amongst themselves as well as with industry professionals. Specifically, communication skills (oral and written) are important for graduates because they help them to inquire why and how certain industry decisions are taken, which fosters their learning process and boosts their confidence. Communication skill is important as shown by the highest ranking across the literature examined.

Teamwork (R=1) as seen from (Table 1) just like communication skill was ranked the highest as graduates who are introduced into the working world are most times expected to work in groups with or without supervision to complete tasks within a specified time. The skill also assists communication

between members which further increases work output and quality as well as effectiveness, as supported in Samavedham and Ragupathi (2008).

Further findings from Table 1, revealed that the next ranked skills were technology (R=2), problem solving (R=2) and certain individual values (R=2). From literature, technology (R=2) include the possession of computer skills related to building construction such as computer aided design (CAD) including two-dimensional (2D) and three dimensional (3D), and the use of various softwares in design and detailing. With the challenging needs of the construction industry in the 21st century, employers are constantly seeking graduates who show creativity and practicality in solving complex problems. Hence, problem solving skill (R=2) is very important and as seen from the (Table 1), the skill is ranked highly. The Table 1 results further showed that industry employers value graduates with individual values such as listening ability, confidence, trust, honesty as well as risk taking abilities. It can also be deduced from Table 1 that the industry value graduates who possess technical skill (R=3) as this skill involves the graduates possessing adequate knowledge of health and safety regulations in the construction of buildings, interpretation of contract documents, possessing ample knowledge of building codes and regulations and a vast knowledge of various construction operations.

Leadership skill (R=3) was also ranked highly as the industry requires graduates who are people-oriented as well as have the ability to build good relationships, providing guidance and vision and be able to take up leading positions to lead to employee satisfaction (Conrad and Newberry, 2012).

The table also ranked numeracy (R=3) which involves graduates ability to be good with the use of numbers and its application as well as the ability for them to adjust in a challenging and dynamic environment with regards to adaptability (R=3).

4.1 Implications of the findings for construction graduates, universities and industry employers

From the findings of the paper, it can be concluded that the possession of key skills by construction graduates is key in meeting the needs of the industry as well as foster better infrastructural development in sub-Saharan Africa states. There are however, skills that were not ranked highly, for example, soft skills, work ethics, work experience, time management, and decision making. As seen from extant literature, these skills are also important for construction graduates and can be acquired through construction work experience and experiential learning. Industry managers and professionals need to recognise the fact that fresh graduates barely have the needed experience before they are integrated into the industry workforce after graduation and therefore they need to be forbearing of their relative inexperience.

It is therefore important that industry firms provides mentorship programs to help new industry recruits acquire and develop the necessary skills needed to succeed in the industry. The industry employers can further improve the skill sets for graduates by providing platforms and opportunities for them to carry out their internships. Apart from skills creation, this opportunity provides first-hand experience to students to understand the intricacies of the world of work as well as its challenges.

Table 1: Summary of literature showing various key skills necessary for 21st century construction graduates

S/ No	Skills/Authors	Love <i>et al</i> (2001)	Archer and Davidson (2008)	Farooqui and Ahmed (2009)	Arain (2010)	Wickramasing he and Parera (2010)	Rawlins and Marasin i (2011)	Ahn <i>et al</i> (2012)	Jackson and Chapman (2012)	Bhattacharj ee <i>et al</i> (2013)	Samavedha m and Ragupathi (2008)	Total	Rank
1	Communication	X	X	X	X	X	X	X	X	X	X	10	1
2	Teamwork/ Collaborative	X	X	X	X	X	X	X	X	X	X	10	1
3	Technology	X	X	X	X	-	X	X	-	X	X	8	2
4	Problem Solving	X	X	X	-	X	-	X	X	X	X	8	2
5	Individual Values	X	X	X	-	X	X	-	X	X	X	8	2
6	Leadership	X	-	X	X	-	X	X	X	X	-	7	3
7	Numeracy	X	X	X	-	X	-	X	X	X	-	7	3
8	Adaptability	X	-	X	-	X	X	X	X	X	-	7	3
9	Technical	X	X	X	X	-	X	X	-	X	-	7	3
10	Soft Skills	X	-	X	-	X	X	-	X	-	X	6	4
11	Work Ethics	-	-	X	X	-	X	X	X	-	X	6	4
12	Work Experience	X	-	X	-	X	X	-	X	-	-	5	5
13	Planning/ Organising	-	X	X	-	-	X	-	X	-	-	4	6
14	Creative Thinking	-	-	X	-	X	-	-	X	-	X	4	6
15	Time Management	X	-	X	-	-	X	-	X	-	-	4	6
16	Decision Making	-	X	X	-	X	-	-	X	-	-	4	6
17	Critical Thinking	-	-	X	-	-	-	-	X	X	X	4	6

As seen from this study, for fresh graduates entering the 21st century industry, it is key that they are furnished with the right skills, ideas, innovations and concepts as these are important ahead of the rigors of the industry. This further implies that construction graduates as entry-level professionals are a source of industry renaissance to improve its effectiveness. They must further show patience, hard work and competency if they are to be effective in the workplace, as the transition from the classroom to the world of work is a challenge that requires willingness, consistency and commitment. Furthermore, in order to be more productive in the industry today, construction graduates must be able to do more than just possess technical skills. They must be willing to work in teams, possess personal attributes to work efficiently, comply with industry policies and effectively make intelligent decisions.

With the complexities and challenges of the construction industry, it is no longer enough for an academic course to focus solely on the professional aspect and principles of the construction profession. The construction industry needs the HEI's programs to not only churn out an adequate number of graduates to take up industry positions, but also to properly equip its future leaders with the right skills in order to meet their needs. An all-inclusive academic program which covers both the technical aspects of construction and other areas like facilities and environment management is also necessary which further prepares the students for a variety of roles in the construction industry. Hence, higher education institutions need to revise their curriculum to increase its scope, if they are to exceed the expectations of the 21st century industry employers.

5. Conclusions and Lessons Learnt

This paper studied the relevant skills that construction graduates should necessarily possess in order to solve contemporary 21st century construction industry problems. A review of extant literatures were done and a compilation presented of the key skills and competencies required to be possessed by construction graduates to succeed in the construction industry. Findings from the literature revealed that communication, teamwork, technology skills, problem solving skills, individual values, technical skills, leadership, numeracy and adaptability are all essential to construction graduates to enable them function effectively in the construction industry. Also, findings from the literature revealed various factors that necessitates the need for the influx of highly equipped construction graduates into the 21st century construction industry. These factors which gives the industry a complex look includes sharp increase in technological advancements, increased global competition, environmental factors, construction projects sophistication and varying regulation by authorities. Considering the complex and challenging factors affecting the construction industry today, it is therefore paramount the 21st century construction graduates should possess adequate knowledge of their field, as well as a range of key skills to function effectively. It is therefore key that undergraduate programs in construction related courses should aim at providing its graduates with the necessary skills to make them attractive to the industry. The construction programs of HEI's further needs the industry to be supportive and make quality inputs to improve the education of the future construction professionals before entry into the industry workforce. Considering the construction industry have many opportunities opened to construction graduates, it is difficult to limit education to certain areas. Therefore, HEI educators must strive to ensure their various construction programs align with the varying requirements set by the industry by providing their graduates with the opportunity to enhance the right skills. Hence, a university-industry collaboration to effectively examine and improve the undergraduate construction curriculums is highly recommended. Therefore, construction programs should be aimed at equipping graduates with the right skills to enable them fit into the industry that await them. The findings from this study would be valuable to industry professionals, researchers as well as educators who are

involved in construction education and its improvement. With the changing needs of the construction industry, future studies could be conducted to determine the various actions taken by HEI's to impart skills in students to meet industry needs.

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Sustenance of Construction Skills: A Case for Zambia

Christopher Mulenga Nondo¹

Abstract

In Zambia, skills resource issues are challenging because the genesis is three pronged: the individual, corporate, and work site commonly referred to, as the employee, employer and the works. From 2000, the Zambian construction industry has been on a path of reawakening, growth, and capacity building for skills lost during the seventies and eighties. This paper set out to explore these problem origins in order to re-establish current skills and employment prospects and to propose possible solutions to this deficit. A review of literature was undertaken. This paper identified that, it is important to participate and initiate innovation in the training programmes to suit immediate and future requirements thereby sustaining the construction industry. In terms of sustenance and development, corporate bodies are expected to absorb the individual workers on various projects. The challenge is that this is a balancing act that can be affected by external pressure from a global economic standpoint. Interestingly, there has been an influx of skilled people within the region and their view is that, there are too few skilled people within the construction industry. This commonality reinforces the observation on labour mobility that agreements across economies, especially within regions, must elicit the positive involvement of parties on both sides – exposure through labour mobility, and where this is possible, can enhance acquisition of industry-recognized credentials. As a further resolve, there must be an impetus of participation from corporate bodies coupled with responsive training programmes that effectively impart hands-on tutelage to students, who in turn, should positively apply themselves when they are offered a job or indeed when an apprenticeship opportunity is availed to them. Zambia stands to benefit from this insight because she has embarked on an enthusiastic infrastructure development programme that demands these credentials like the Pave Zambia 2000 and Link Zambia 8000 Road Projects. Technical training institutions at all levels should not only respond to labour market needs, but their input should stimulate the small and medium scale construction firms to drive employability of this group. This should sustain the labour market enabling the industry to grow. From this basis of technology transfer, as and when an opportunity arises out of subcontract work, the small and medium enterprise should compete favorably within the industry.

Keywords: apprenticeship, innovation, skills, sustenance, training

1. Introduction

In Zambia, skills resource issues are challenging because the genesis is three-pronged: the individual, corporate, and work site commonly referred to, as the, employee, employer and the works; not necessarily in the same order. In exploring this genesis, the status of the individual employee was

¹Lecturer/Head of Department, Construction Economics and Management, The Copperbelt University, School of Built Environment, P.O. Box 21692, Kitwe, Zambia

established to be anchored and enforced by the skills training programmes that they receive in their careers. Once the basic training programme was fulfilled, what followed was apprenticeship within the employing construction firms. The construction industry in Zambia and indeed elsewhere experiences high labour mobility. It is for this reason why this exposure must be beneficial to the employee and to the employer. Consequently, the employee's career prospects broaden and they would be empowered to innovate their day to day challenges; building up on their responsibilities and reliability that, the employer would grant them employment security. This recognition by the employer for their skilled personnel is what should bring about sustenance of skilled manpower in the construction industry.

For the last fifteen years, 2000 to 2015, the Zambian Construction industry has been on a path of reawakening, growth and capacity building for skills lost during the seventies and early eighties when the Zambian construction industry was at its peak. The decline started from 1980 through to 1990 when there was no significant economic activity due to the collapse of the world price of copper (Obidegwu, 1980). From 1990 to 2000, Zambia's construction industry was at its lowest ebb. It was not until the privatization of the mines (Lungu, 2009), and by the year 2000, that, capital investment into this sector stimulated the re-awakening, growth and capacity building particularly in construction activities. Construction indeed, provides the investment that underpins development; providing houses to live in, buildings to work in and infrastructure to support communication and transport (Myers, 2013). Effectively, the industry is trying to recreate the skills abundance of forty-five years ago – that crop is but a handful; meaning that, today's skills trainer may not be as thorough as yesteryear's exacerbated by student's low zeal and a country's economic state. This knowledge gap should not be deferred into the future of our graduates but through participation and innovation of training programmes, sustain immediate and future requirement.

1.1 Aim and objectives

The aim of this study was to establish if there was a commonality in the deficiency of construction skills in Zambia in comparison with the southern Africa region. One of the reasons for focusing on the region was because the labour requirement for infrastructural investment especially in Zambia, has attracted participation from the sub region and indeed globally. As a result, the following three objectives were outlined in order to understand the study:

1. To explore existing literature on construction skill deficit and its effect in the selected countries of the Southern region.
2. To compare the skills deficit in Zambia and some of the countries in the sub region.
3. To identify possible solutions of counteracting the skills deficit in Zambia and some of the countries in the sub region.

1.2 Research methodology

In exploring this area of interest, some literature from the selected countries particularly from Labour Ministries, local and international organisations with keen interest on construction skills deficits and sustenance of the same was accessed and compared in order to find out if there were commonalities to the problem. The internet was used to collect data from the year 2000 to date. This time period of sixteen years, has seen Zambia chart out a new path of infrastructural development programmes coupled with foreign direct investment and regional collaboration. The selected countries have played

a role in these development strategies for Zambia in that, projects like recapitalization of the mines and others that require multi skilling have attracted construction labour and equipment from these countries. It is of interest that, these same countries have also been vigorously tackling the problem of skills deficit in the construction industry. This is the paradox that the exploration was focused on except for one country whose local population need not look else where for employment on a scale as has been happening in other countries within the sub region.

2. Literature Review

Governments through their organs and in collaboration with other stakeholders on labour and skills issues constantly monitor the trends in skills that they can manage and link this information to available projects for execution. Lack of skills demands strategies that should bring about technology transfer to equip personnel in these areas to be ready to tackle developmental issues effectively. Training therefore becomes an important factor and this comes from both public and private sectors. Creation of these skills however, does not culminate into a ready reckoner for employment. Skills must be improved upon, new ones learned, and through interaction and exposure at local and or international levels, managed to impact on the local availability and participation by micro, small and medium enterprises. Institutions like the World Bank, International Labour Organisation (ILO), individual governments and their organs, scholars and employers have made efforts in trying to establish reasons for skills flight, and lack of the same with due cognizance of the fact that, training institutions churn out new entrants annually. The fact that, projects require specific skills for execution is what sifts through the available skills literally making some of them obsolete. The proponents of multiskilling in construction like Lill (2009), and Kashiwagi and Massner (2002), intimate that, if this is lacking, it may result into a labour market reliant upon a casual workforce with low quality skills. This was and still remains the objective of the Department of Labour in the Republic of South Africa in the Skills Development Act of 1998, that, the needs be identified for each sector for policy formulation. It is important to note that, this is the basis of the creation of ‘employable’ skills.

2.1 Republic of South Africa

In the 1997 Green paper on Skills Development Strategy for Economic and Employment Growth in South Africa, the Department of Labour, defined skills as comprising practical competence, foundational competence and reflexive competence. Respectively, this requires an individual to have the ability to perform tasks, understand why and what they are doing, and have the ability to integrate that performance with others creating a learning curve where adaptability to changes and unforeseen circumstances is possible. The South African Government resolved to implement the following;

- Facilitating the placement of new entrants in the labour market through learnerships and Internships
- Facilitating the recruitment of skilled foreign workers in areas of critical skills shortages, while ensuring the concurrent development of South Africans in those fields.
- Providing career guidance and counselling to school leavers to assist them to pursue further studies in fields that are relevant to the needs of the economy.
- Fast tracking the implementation of the HRD Strategy by all government departments.

The survey also undertook to identify scarce skills from a multi-sectoral array that would be helpful to invest in the operationalization of economic growth strategies. This would effectively supplement the skills transfer to the locals in areas where foreign employees were holding positions.

2.2 Zimbabwe

Research was undertaken in Zimbabwe by Chigara. and Moyo (2014), on Factors Affecting Labour Productivity on Building Projects. The results indicated that, lack of manpower skills besides unavailability of materials, late payment of salaries and wages, suitability/adequacy of plant / equipment, and supervisory incompetence was one of the top five most important factors impinging on labour productivity. It was recommended that continuous professional development for workers should be regarded as an intervention strategy to improve on-site labour productivity. From an earlier research, Chigara and Mangore (2012) stated that ‘lack of manpower skills and labour inexperience negatively affects labour productivity and that the Zimbabwean building industry suffered from mass exodus of skilled personnel to greener pastures in neighbouring countries and across continents during the year 2000 through to 2008’. Coincidentally, Zambia started recapitalising the mines from the year 2000 and it is true that, there was an influx of construction workers who had the employable skills.

2.3 Botswana

It is of interest that Ssegawa-Kagwa *et al* (2013) in their situation analysis to identify the construction industry deficiencies concluded that, respondents complained that most contractors, especially at lower levels, lack management skills that include an inability or unwillingness to employ sufficient and/or skilled personnel. In previous decades, the construction industry in Botswana recorded high growth rates, ranging from 5% to 8%, surpassing most industries in sub-Saharan Africa (Ssegawa, 2008). Performance in recent years has shown a decline due to the downturn of the global economy, the impact of reduced diamond sales and the inefficiencies of the construction industry itself. What comes to mind is not the lack of skills but management of the available skills. As a consequence of steady economic growth, there has been considerable technology transfer on development projects without the construction sector population being attracted to migrate to other countries for employment.

2.4 Namibia

A survey was conducted in Namibia by Frederico Links (2010), on skills deficits and the results indicated that, strategies needed to be instituted as quickly as possible to arrest the situation. It was recommended that, Government needed to prop up the tertiary education sector, and that, collaboration was required with the private sector and industry. Government was going to carry out a skills audit out of which interventions were to be instituted within two years. In addition, Government was going to offer incentives to encourage the private sector to develop increasing their training commitment and speed up work permit processes for specialized skills for three to five years to enable constructive transfer of skills. The Deputy Minister of Works and Transport, James Sankwasa stated that, the ministry has no choice but to make use of junior expatriate engineers to manage capital projects (Namibian Sun, June, 2016). He added that the ministry was unable to fill many vacancies because of the skills shortage.

2.5 Global report

The report by Aring, (2012) on skills gaps in the background paper prepared for the Education for All Global Monitoring Report alluded to the fact that skills gaps were severe – and countries in the SADC region were covered. It was noted that, some countries were planning to relax their immigration laws to substitute foreign skilled labour as a strategy to ease the pressure. The focus would be the need to link education to a training system that was in tandem with current and future market needs.

3. The Case for Zambia

3.1 Challenges of the entrant

For sustenance and development of construction skills, the individual entrant in this industry must be resolved that their energies will be sapped on a daily basis because of the nature of work. For many others who are not resolved and are ill-prepared for the hard work ahead, this ‘presumed future discomfort’, has had a negative impact on them as a potentially employable population. Many youth when asked about what they would like to do for a career answered that, they were willing to do anything. This is a desperate signal with potential to frustrate the future skills of the same population. They would have gotten into it half heartedly. On a macro aspect, it is also important to note that if the economy cannot absorb the entrant or does not offer alternatives of personal growth, it is difficult to identify a role where an entrant can build up and enforce a career prospect. In other cases, it is a matter of not only lack of skills, but also skills mismatch where the entrant is still not qualified to take up certain positions. This was highlighted by Aring, (2012) in the report on skills gaps in the world.

3.2 Training

Construction skills are imparted to the student for on and off site application to exhibit knowledge, expertise, competence and involvement on any project. They are expected to gain experience as a consequence of their continued exposure to work practices. This in effect, fills up the knowledge gap which is short term. Construction training institutions should develop responsive training programmes that impart hands-on tutelage to students who in turn should positively apply themselves to the task and apprenticeship opportunity availed to them. Training programmes should respond to the labour market by targeting Small and Medium Scale Enterprises availing to them ‘apprenticed graduates’ whose potential to learn should enable growth, technology transfer and favourable competition. This is especially so when subcontracting with foreign firms. This is the ‘new apprenticeship ‘training programme that must be established and driven in order to reach the desired levels of growth and quality output. This is a risk worth taking as echoed by United Kingdom’s Rt, Hon. John Healey, MP (2014, USA), that, ‘our companies need nothing less, our young people deserve nothing less, our countries should settle for nothing less’. The fact that we need human resource in the quest to sustain construction skills means that, they should earn and deserve that attention. It is also expected that, Government should reciprocate through policies that support such development.

The benefit that accrues to construction workers and students alike out of the privilege of exposure whether locally or externally is unparalleled when you look at the capacity of training institutions. Sustenance of construction skills therefore, requires multiskilling to enable a wider choice of participation in the construction industry (Lill, 2009). However, if this is not complemented with training programmes that ‘apprentice’ the student, one may find a mismatch between graduate competencies and market skills (Witt and Lill 2010). The deserving graduate must be multi skilled in

order to continue being useful to the industry – this requires effecting training programmes that expose the student to a wider net of facets that comprise the constructed environment. Pertinent and regular revision of curricular should be the norm and for the students at Certificate level, an initial preparatory multi faceted programme that enables the entrant to have a choice of career close to their heart. This long lasting reminder (of that choice) from the entrant, reinforces their resilience within that path opening up potential avenues where they can build on, acquire further qualification and continue contributing to the industry for a considerable time. As a precaution, training packages should not delimit the student's potential to think outside the box. The diversity so created, and within the realm of construction, should underscore the possibility of filling the skills gap that is prevalent today.

3.3 The employer

The Zambian Construction Industry (ZCI) is composed mostly of small and medium scale enterprises (SME's), now reaching almost 4,500 in number registered with National Construction Commission (NCC, 2014). Currently, both the new entrant and employer are weak in terms of capacity and experience coupled with a general lack of jobs that they can tender for, expect to win and execute successfully. Growth and sustainability of these SME's cannot only be assured by Government's intervention like the 20% policy on subcontracting by local contractors as an incentive (CEE, 2011), particularly on road construction. Paradoxically, there has been an influx of skilled people from countries within the region whose cry is similar to the Zambian situation that, 'there are too few skilled people around', (CIDB, 2007. The Zambian construction industry has also experienced a high level of labour mobility. This commonality reinforces the observation that, employees have the right and can move within and between different economies with a resultant impact on production where they are coming from.

However, mobility can be made beneficial through Preferential Trade Agreements (PTA), to enable and elicit the positive involvement of parties on both sides through a further modification by creating Temporary Worker Programmes (TWP's), Stephenson and Hufbauer, (2010). The position of the construction SME is that, they do not have capacity to further train their employee because of the fear of labour mobility despite the need for the skills. On the other hand, the TWP would expose the employee to various skills and because they would be time-barred, upon return, they would be expected to infuse that competence into the industry. This is possible if the economies where these employees are coming from are stable and growing to create a pull effect. If this is not prevailing, and as a consequence of the scramble for the same resources, rejection in host countries can be expected but the need and objective of the PTA should bring about concerted effort to stamp out this human weakness. What is eluded to herein, be that, exposure through labour mobility can enhance acquisition of industry-recognized credentials.

Employment and continued employment assurance can only be achieved through employee loyalty and commitment and if backed by gratitude and trust from the employer, may result into mutual understanding beyond the labour and wage. It must be mentioned that, apprenticeship does offer skills transfer. The apprentice avails themselves to this opportunity, while the trainer exhibits what one may not find in textbooks. In addition, there is need for Consultants, Contractors, skilled workers and indeed all participants on building projects to acknowledge what has been done and achieved by them no matter the extent. This revisit, anytime after completion, if possible, should provide lessons on skills that were engaged and which can be used as a yardstick in the skills innovation process. Kazi,

(2005), postulated that, “without the willingness to acquire and share knowledge, even if the knowledge exists, few will know where it resides and even fewer will be able to use it”.

3.4 The works

This is always an interesting decision afforded to any entrant in the construction industry. The choice, if any, to want to join a construction firm may bring about several considerations such as the size of the firm; extent of ongoing works; proximity; pay packages; including hearsay from colleagues best described as the ‘fear of the unknown’; what small and large sites offer; ; what is an employment opportunity?; why do employers want the skilled person and vice versa; Can they learn from each other?; Can the job teach both employer and employee something not before experienced?; Who loses by not advertising or getting employed?, *and so on.*

The role of Government is to enact and drive a policy for growth of SME’s because this is the potential ‘future employer and consumer’ of all those skills that may be created as a result of this support. In Zambia, the Citizens Economic Empowerment Act No. 9 of 2006 is a positive indication of that objective. One of the key components of this Act is to ‘Transform society in order to ensure sustainable development of human resource by recruiting, training and promoting local people into leadership roles in enterprises and thereby building on the full potential facets of the economy’.

4. Conclusions

The value and extent of knowledge that the apprentice gets is an important addition to what can be found in a library. The graduate must be given the chance to refine their hands-on training with a new apprenticeship programme. Training programmes must offer practical tutelage to stimulate the attitude of the learner as a first level of apprenticeship. Thereafter, this will require continuous collaboration between training institutions and industry on curricula reviews, practical exchange of information with trainers and students alike, and Government impetus to support the new dispensation. Should the objective be to leap-frog into the future? Yes, that could be the way forward – the sub region shares a common problem and it will not be beneficial to localize the solution. The sub region would do well to ease regulated movement of construction experts and personnel particularly as a strategy for skills transfer. If the Temporary Work Permit (TWP), enables an emerging construction SME to grow within the available local incentive programmes – and each country has got this framework, the construction industry can only grow because construction SME’s who reach a level where they can tender for works of substantial volume will be attracted to do so within the individual country. And for those who have had the opportunity and privilege to acquire construction skills and are able to share this tenet of development, the onus is on them. There is an urgent need to infuse skills training at various levels including tertiary in order to sustain the future. As and when students have the privilege to join industry should not be told that, ‘they do not know what they saw!’. Technology can only enhance their ability in sharpening their minds as experts. Construction skills sustenance and success of entrants through training, participation and growth in the industry, can only be tackled from within the individual countries because therein lies their potential. It is important to integrate Education systems with potential employers because if this is not cohesive the resultant misalignment may engender identification, acceleration and sustenance of much needed scarce skills in the construction sector.

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Establishing the Relationship of Cost Changes to Construction Work Groups and the Estimated Construction Cost to improve Overall Project Control

David Oliphant¹, Abimbola Windapo², Alireza Moghayedi³

Abstract

This research paper examines cost changes of construction work groups and the resultant relationship to the construction cost. By establishing this relationship, the main drivers can be determined and modelled in a standard form to assist construction managers in the aims of cost estimation and thereby improve project control. The preliminary investigation indicated that the majority of construction work groups are significantly related to changes in the construction cost. Understanding and modelling the resulting relationship shows the main drivers for change in construction cost to be reinforcement, electrical, formwork, plumbing and concrete work and thus appropriate techniques of project control for these work groups would assist in accurately estimating and managing changes to the construction cost and identifying particular work groups which require focussed management to ensure improved overall project control. It can be concluded that an increased project control can be achieved by understanding the relationship that cost changes of work groups have on the estimated construction cost. This process allows construction management professionals, both contractors and client agents, to better mitigate or even negate unanticipated future events within construction based on a good understanding of the estimated construction cost and thereby improve project control. It is proposed to undertake continuous research using a case study approach to examine the changes of the real cost of construction work groups of completed public sector projects in the Western Cape region of South Africa. This will aim to test the validity of the findings and thus provide a basis for the derivation and implementation of the necessary techniques to improve the project control and scheduling ability of construction management professionals through establishing and modelling the relationship between changes in cost of work groups and the resulting estimation and management of the construction cost of public sector projects.

Keywords: construction work groups, construction cost, public sector projects, project control

¹ Postgraduate Student; Department of Construction Economics and Management; University of Cape Town; Rondebosch 7701, Cape Town, david.oliphant@uct.ac.za

² Associate Professor; Department of Construction Economics and Management; University of Cape Town; Rondebosch 7701, Cape Town, South Africa; abimbola.windapo@uct.ac.za.

³ Postgraduate Student; Department of Construction Economics and Management; University of Cape Town; Rondebosch 7701, Cape Town, South Africa; MGHALI001@myuct.ac.za

1. Introduction

This research paper examines the changes in the cost of construction project work groups and its effect on the estimated construction cost. The drivers of construction costs are largely unexamined in the South African construction industry (Odediran & Windapo, 2014). It therefore presents an opportunity to determine which of those construction constituents that are related to construction costs and model the relationship for the purposes of cost estimation and management.

Previous studies by Odediran and Windapo (2014) and Lowe *et al.* (2006) identified construction work groups as factors to construction project cost. Through the examination of historical data of construction work groups (and the trends thereof) in the South African construction industry, commonly used as legislated mechanisms for contractual adjustments on construction projects, are represented by two sources (Snyman, 2010). First, Contract Price Adjustment Provision (CPAP) compiled by Statistics South Africa. This weighted index provides for a definition of construction project work groups as a group of 38 representative activities of the construction process in terms of the input costs of labour, plant, material and fuel and therefore seen as input index of construction cost. Secondly, BER Building Cost Index compiled by the Bureau of Economic Research, which is price index for a collection of 22 common construction activities of the construction process. This measure of cost trends however takes into account the profit and productivity expectations of the builder as it is based on accepted tender prices and therefore seen as an output index of construction cost. Only Input costs will be used for this study as it allows insight into those construction work groups which are direct inputs to the construction and therefore unavoidable by the builder and stakeholders to the process (Fapohunda & Chileshe, 2014). By investigating these costs it aims to bring measures of control to the unavoidable construction activities with the appropriate project control procedures (Olawele & Sun, 2010).

The need for project control for the purposes of accurate cost estimation is due to its important role in proactive construction management (cost/schedule controls task force, 2010). This therefore lends itself to use in all work planning and becomes primary to cost budgeting and scheduling and must be involved in circumstances involving either. Adequate project control therefore requires a good understanding for cost relationships of a construction project and thereby becomes the basis for improved ability to assess of the real changes in construction costs over time (Shane, Molenaar, & Anderson, 2009). This has directed the understanding of cost relationships and the resulting trends to be used in a number of applications, most commonly, guaranteed value clauses in rental, leasing and other contracts, adjustment of sales contracts in buildings under construction, indexation for insurance purposes, deflating national accounts and, for the purposes of this study, estimating the cost of construction (Statistics Directorate, 2013). The increased use is due to the anticipative nature required during construction which necessitates an understanding of cost relationships and therefore, if a problem arises, it can be mitigated or even corrected, to bring the project back to schedule and thereby forecasting or minimising the effect of unwanted events during the construction process (Chester & Hendrickson, 2005).

2. Research Methodology

The study follows a longitudinal examination based on a cross sectional quantitative research design. Following the literature review, a desktop survey on the construction work items and their cost trends in the South African construction industry was employed to obtain historical data from institutional

sources. The trends of construction work groups were then statistically analysed to develop a model to establish which work groups most significantly affect the cost of commercial/industrial construction projects. To test these findings, the generic work groups from five public sector projects were identified to simulate a construction project. The identified work groups and their trends were then analysed using a time series of the CPAP indices to determine the statistical relationship of changes in cost of work groups to the estimation of the construction cost by making use of appropriate predictive modelling techniques.

2.1 Primary desktop analysis

A desktop survey of the historical data concerning construction work groups was completed based on the available indices, those being the Contract Price Adjustment Provision of Statistics South Africa and another by the Bureau of Economic Research. The work groups for which indices are released by the respective organisations are listed in table 1.

2.2 Simulation of a commercial/industrial construction project

A project simulation was employed to find the most generic construction work groups related to commercial/industrial construction by examining the Bills of Quantities of five representative public sector projects from the Western Cape region of South Africa for which only those work groups that occurred in each project were perceived as generic.

Based on the indexation from 2006 to 2016 of the work groups identified, gradients and intercepts for these were calculated and their resulting mean derived. These linear models for work groups represented the independent variables and the construction cost for commercial/industrial buildings was used as the dependent variable for the multi-linear regression to determine the drivers of construction cost under generic project conditions for commercial/industrial construction projects.

The method for regression analysis follows the Model Development Plan for predictive variables for construction cost modelling (Hollar, Arocho, Hummer, Liu, & Rasdorf , 2010). The model follows a four stage process:

1. Seek descriptive project data to populate predictive variables.
2. Apply statistical analyses to filter predictive variables.
3. Develop a multiple linear regression model using significant predictor variables.
4. Test and validate the model for predictive purposes.

Construction cost modelling is the determination of the mathematical relationship between construction work groups and the estimated construction cost using statistical analysis (Dysert, 2008). For this study, statistical significance, achieved through multi-linear regression, is defined by “a mathematical representation of cost relationships that provide a logical and predictable correlation between the physical or functional characteristics of a project (plant, process system, etc.) and its resultant cost.” Advantages of regression modelling for estimating purposes is the provision of efficiency in terms of developing estimates in a shorter time period, linking quantitative inputs to algorithms to provide quantitative outputs, often allows two estimators to come to the same conclusion in terms of cost and is flexible as it allows for a range of independent input variables that have been derived from historical data (Black, 1984).

Table 3: Construction work groups by StatsSA and BER

NO	Type of index	CPAP	BER
1	Work group indices	Alterations	Excavation for footings
2	Work group indices	Earthworks	Concrete in footings
3	Work group indices	Piling	Concrete in slabs
4	Work group indices	Concrete	Centring to slabs
5	Work group indices	Formwork	Reinforcement
6	Work group indices	Precast Concrete	Vinyl or block flooring
7	Work group indices	Post tensioning	Half brick wall
8	Work group indices	Reinforcement	One brick wall
9	Work group indices	Brick and blockwork	280mm hollow wall
10	Work group indices	Masonry	Facings
11	Work group indices	Waterproofing	Asbestos or gal roofing
12	Work group indices	Non-metal roofing	Sawn softwood trusses
13	Work group indices	Metal roofing (steel)	Gypsum-asbestos ceiling
14	Work group indices	Metal roofing (aluminium)	Semi-solid core door
15	Work group indices	Carpentry and joinery	4 lever mortice lock
16	Work group indices	Ceilings	Steel door frame (HB)
17	Work group indices	Resilient wall and floor coverings	Stock steel window
18	Work group indices	Ironmongery	25mm cement screed
19	Work group indices	Structural steelwork in buildings	Internal plaster
20	Work group indices	Metalwork	White glazed tiles
21	Work group indices	Partitioning systems	3 coats PVA on plaster
22	Work group indices	Aluminium work	3mm glass in steel frame
23	Work group indices	Stainless steel work	
24	Work group indices	In situ finishes	
25	Work group indices	Tiling	
26	Work group indices	Drainage	
27	Work group indices	Plumbing	
28	Work group indices	Aluminium shopfronts	
29	Work group indices	Glazing	
30	Work group indices	Painting	
31	Work group indices	Roadwork	
32	Work group indices	Electrical installations	
33	Work group indices	Electrical reticulation	
34	Work group indices	Mechanical services	
35	Work group indices	Ductwork installations	
36	Work group indices	Refrigeration systems	
37	Work group indices	Steel water pipe installations	
38	Work group indices	Lump sum domestic building	
39	Work group indices	Commercial or industrial building	
40	Work group indices	Lump sum preliminaries	

4. Data Presentation and Discussion

The data collected and analysed are presented in the following sections:

4.1 Cost increases for project simulation from 2006 to 2016

The gradients are shown in table 2. Each increase positively while 52.94% of constituents increased faster (those in yellow) than the mean increase of 6.59%. The mean increase shows a common trend to the domestic building and commercial/industrial construction indices which increase at 6.30% and 6.24% respectively. This trend was experienced over the period of May 2006 to May 2016.

Table 2: Linear models for generic work groups

Work groups for virtual construction project simulation					
No	Most commonly observed work groups	Change in cost index	Equation	Gradient	Intercept
1	Roof Coverings	9.20%	$y=-3229.73+0.0920x$	0.0920	-3229.73
2	Floor Coverings, Wall Linings	8.74%	$y=-3123.41+0.0874x$	0.0874	-3123.41
3	Mechanical Installation	8.35%	$y=-2905.15+0.0835x$	0.0835	-2905.15
4	Concrete	8.02%	$y=-2762.98+0.0802x$	0.0802	-2762.98
5	Reinforcement	7.97%	$y=-2691.42+0.0797x$	0.0797	-2691.42
6	Waterproofing	7.32%	$y=-2548.30+0.0732x$	0.0732	-2584.30
7	CEILINGS (Partitions Included)	6.90%	$y=-2413.95+0.0690x$	0.0690	-2413.95
8	Paintwork	6.63%	$y=-2293.47+0.0663x$	0.0663	-2293.47
9	Electrical Installation	6.59%	$y=-2200.26+0.0659x$	0.0659	-2200.26
10	Glazing	5.69%	$y=-1922.27+0.0569x$	0.0569	-1922.27
11	Earthworks	5.22%	$y=-1755.02+0.0522x$	0.0522	-1755.02
12	Ironmongery	5.16%	$y=-1745.27+0.0516x$	0.0516	-1745.27
13	PRELIMINARIES (Removed)	5.13%	$y=-1688.79+0.0513x$	0.0513	-1688.79
14	Formwork	5.10%	$y=-1676.92+0.0510x$	0.0510	-1676.92
15	Masonry	4.63%	$y=-1559.87+0.0463x$	0.0463	-1559.87
16	Carpentry And Joinery	4.32%	$y=-1399.93+0.0432x$	0.0432	-1399.93
17	Plumbing	3.88%	$y=-1210.02+0.0388x$	0.0388	-1210.02
18	Fire Detection	NOT INCLUDED IN CPAP			
	Mean of construction constituent gradients	6.59%			

Fire detection, one of the generic work groups based on the examination of five representative government projects, was however not an indexed cost the CPAP indexation and therefore could not form part of the regression analysis. Considering that this cost has no historical data, no relationship could be traced and thus the significance of its effects on the construction cost cannot be understood within framework the model.

4.2 First and second regression analyses to determine cost drivers

4.2.1 First level regression to establish significance

The time series for the regression was based on the CPAP indexation (from period May 2006 – May 2016) for the identified generic construction work groups and the construction cost index of

commercial/industrial buildings. The index of commercial/industrial buildings is the dependent variable and the generic construction work groups for the project simulation represent the independent variables.

For the statistical analysis, a 95% confidence level was chosen for the study. Table 3 shows the statistical relationship of the work groups to the commercial/industrial construction in terms of the respective P-values, showing relational significance to the construction cost, as well as the coefficients which indicates the value by which the construction cost will change when one unit of cost of work group changes.

The first level of regression was used to determine which work groups were significant to the changes in the construction cost of commercial/industrial buildings. This resulted in masonry and ironmongery being insignificant to cost changes of the commercial/industrial construction projects. Considering the elements which constitute commercial/industrial construction, it satisfies that the structure is generally concrete with internal divisions being mainly drywall partitioning. Masonry is generally used in small scope construction and therefore does not lend itself to the major work required of commercial/industrial applications. The investigated building type is also typified by office blocks and administration buildings that do not generally have very high value finishes and thus ironmongery becomes an insignificant cost element.

Table 3: Regression of virtual simulation

	Coefficients	P-value
Electrical Installations	0.11106	1.09E-35
Reinforcement	0.05398	2.51E-31
Formwork	0.16936	5.16E-22
Concrete (excluding formwork)	0.08398	3.32E-18
Plumbing	0.11688	6.91E-18
Water proofing	0.05145	7.38E-16
Mechanical services	0.07013	1.34E-14
Painting	0.10468	4.63E-06
Resilient Floor and wall coverings	0.04876	1.34E-05
Carpentry and Joinery	0.05295	2.21E-05
Glazing	0.01567	2.24E-05
Metal Roofing (Steel)	0.01448	0.000947
Earthworks	0.05901	0.010371
Ceilings	0.03392	0.010548
Intercept	-0.76656	0.730667
Masonry	0.00348	0.884433
Ironmongery	-0.00008	0.994014

Considering the low coefficient derived from the regression for insignificant work groups, the effect of cost changes to these will not result in major changes to the overall construction cost. Employing sophisticated cost budgeting and cost scheduling techniques to these will therefore not result in an improved ability to estimate and manage the construction cost and thus major improvements to project control will not be observed.

4.2.2 Second level of regression to determine the standard form of commercial/industrial construction

The second level of regression was employed, as shown in table 4 above, on only those variables that were significant based on the first analysis. This was completed to derive the standard form of cost of commercial/industrial buildings in relation to the cost of significant work groups which are generic to its construction. A 95% confidence level was maintained. The statistical relationship is represented as:

Commercial/industrial construction cost = -0.658 + (reinforcement cost x 0.0539) + (electrical installations cost x 0.1110) + (formwork cost x 0.1693) + (plumbing cost x 0.1168) + (concrete cost x 0.0839) + (waterproofing cost x 0.0514) + (mechanical services cost x 0.0701) + (painting cost x 0.1046) + (glazing cost x 0.0156) + (resilient wall and floor coverings cost x 0.0487) + (carpentry and joinery cost x 0.0529) + (earthworks cost x 0.0590) + (steel roof covering cost x 0.0144) + (ceilings and partitions cost x 0.0339)

The five work groups most significant to changes in the construction cost of commercial/industrial buildings, those shaded in green, are reinforcement, electrical installations, formwork, plumbing and concrete. Electrical installations, formwork and plumbing also show to have the largest coefficients and therefore have the biggest effect on the construction cost when scope or specification changes regarding these are made during the construction process. The resulting relationship therefore satisfies that of commercial/industrial construction as the majority of the building cost is focused on the structure for which reinforcement, concrete and formwork are major elements. Understanding this relationship thus assists the construction management team to estimate and manage the construction cost more accurately.

Table 4: Regression of significant work groups

Work groups	Coefficients	P-value
Reinforcement	0.053843889	1.43E-37
Electrical Installations	0.111076811	8.37E-37
Formwork	0.169213519	7.29E-28
Plumbing	0.116109411	3.68E-23
Concrete (excluding formwork)	0.083772372	6.72E-21
Water proofing	0.05139404	1.99E-16
Mechanical services	0.070139796	6.03E-15
Painting	0.105963584	3.9E-07
Glazing	0.015567439	5.77E-07
Resilient floor and wall coverings	0.048465086	1.58E-06
Carpentry and joinery	0.053584523	3.47E-06
Earthworks	0.061225687	5.85E-05
Metal roofing (steel)	0.014763396	0.00016
Ceilings	0.033952229	0.006361
Intercept	-0.685279265	0.686843

A better knowledge of the relationship of cost changes of work groups to construction cost then enables and justifies, contractors and client agents, allocating expenditure to employ more sophisticated strategies of cost budgeting and cost scheduling which assist to mitigate or negate unwanted future events during the construction process and thereby enabling improved project control and a better management of the overall cost and related variations.

These findings are in line with historical literature on relationship modelling of construction cost by the Construction Industry Institute of the University of Texas that propose that project control can be implemented through a good knowledge of the relationship between construction works groups and their significance to the estimated construction cost. Preliminary findings have established the relationship of work groups to the construction cost based on trend analysis and therefore the drivers of cost were isolated to assist in the development of construction management techniques.

5. Conclusion

The primary objective of determining the relationship between construction work groups and the resultant construction cost is to assist in the estimation and management of the construction cost and therefore aid informed decision making in the efforts of achieving necessary project control requirements. This study has aimed to establish the relationship between cost changes to work groups and the resultant effect these changes have on the commercial/industrial construction cost to assist in construction cost estimation and thereby improving project control for construction management professionals.

Looking at fire detection, which is not an indexed cost of the CPAP, the research has observed that relationship modeling is halted if no historical data is listed for a specific work group and therefore its effect on the construction cost cannot be quantified within the model – it therefore becomes important to update indexation requirements based on the current construction work groups that constitute modern construction output. Further to this, by having a representative work groups as a basis for trend analysis, it provides the tools and the framework within which cost effects can be monitored and acted upon.

It has also emerged that electrical installations, reinforcement, concrete, formwork and plumbing are drivers of commercial/industrial construction. It serves purpose therefore to understand those core drivers of construction cost so as to focus appropriate project control techniques based on the significance these work groups have to changes in the construction cost. It then becomes primary that construction management professionals understand these relationships and employ the necessary cost budgeting and cost scheduling techniques appropriate to its significance to the estimated cost so the desired benefit can be derived from the techniques that are employed. Once these relationships are understood and indexed over time, it is then possible to quantify the significance and anticipated effect of cost changes to work groups and the resulting construction cost which better allows construction managers to institute appropriate project control techniques based on the anticipated relationship. It then improves efficiency and accuracy to the estimation, monitoring and management of the construction cost which brings benefit to project stakeholders and the industry as a whole.

6. Continuing Research

Continuing research will aim to test and validate the model. Five government projects in the Western Cape region of South Africa have been selected for examination so as to reduce the effect of price irregularities due to locational differences. The limitation of public sector projects assists in standardising the type of contractor and client that can be expected from the analysis and therefore practical and implementable solutions to construction management techniques can be derived.

With respect to the independent variables, continuing research will aim to determine whether current records of construction work groups and their resulting trends are representative of the modern construction environment through the analysis of a broader range of building applications such as domestic projects and health-care facilities (dependent variables). These findings will speak to the ability of construction management professionals to estimate and manage construction costs in the modern construction industry with respect to specific building applications and thereby improve the ability of project stakeholders to effect the required project control necessary of contemporary projects.

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Impact of involvement of Chinese Construction companies on Zimbabwe's public sector projects

Mernard Mukawa¹, Ringisai Mawondo-Dhliwayo²

Abstract

Due to limited liquidity to support its construction and infrastructural development, Zimbabwe has pledged through Zimbabwe Agenda for Sustainable Social and Economic Transformation (ZIMASSET) blue print, to facilitate the injection of foreign direct investment (FDI) from other countries in return for exploitation of the country's natural resources. The arrangement which once attracted trading partners from the West has now been dominated by China through the Look East Policy. A number of Chinese companies have won a large share of public sector projects due to their ability to offer competitive prices and use of modern construction technology thus making it difficult for local firms to benefit from the country's indigenisation and empowerment strategies. This study seeks to analyse the impact of involvement of foreign companies in the development of the construction industry and Zimbabwe as a whole. Six structured interviews were conducted with the government officials responsible for public works, architects, engineers, consulting quantity surveyors and contractors to obtain information on engagement of foreign companies in construction of projects. The results show that all the projects directly financed by China are tied to the use of Chinese companies. Findings also show that there is a slow uptake by Chinese companies to utilise locally available resources to a large extent to enhance economic growth. The study concludes that foreign companies' involvement on construction projects has done little progress in development of the construction industry of Zimbabwe. It is recommended that Zimbabwe should spearhead the process of ensuring partnership models conducive to both Chinese and indigenous construction firms through creating appropriate investment laws and joint-venture (JV) options. The study could have focused on all the construction firms of Zimbabwe as this would have resulted in a more informative study, but the few selected companies are representative of the construction companies in Zimbabwe.

Keywords: foreign companies, construction projects, public sector

1. Introduction

Foreign Direct Investment (FDI) is defined by the International Monetary Fund as investment undertaken in businesses which are operated outside the country from where the investment is coming from (Davletshin, Kotenkova, and Vladimir, 2015). The involvement of foreign companies on public sector infrastructure projects goes a long way in alleviating funding problems for construction projects which require a lot of financial injection. As such the need for financial injection is more significant for developing economies which are in dire need of rehabilitating worn out infrastructure together

¹ Lecturer; Department of Quantity Surveying, National University of Science and Technology; P. O. Box AC939, Ascot, Bulawayo, Zimbabwe; mernardmukawa@gmail.com

² PhD Student; Quantity Surveying and Construction Management; University of Free State; PO. Box 339 (IB47), Bloemfontein, 9301, South Africa; ringimawo7@yahoo.com

with meeting new infrastructure needs. Developing countries were noted for heavy reliance on FDI inflows than developed countries because of high growth rates and of resource abundance existing in these countries (Davletshin, Kotenkova, and Vladimir, 2015). However, various negative debates have been put forward concerning how some of the foreign companies undertake their businesses in developing countries (Mapaure, 2014). The governing regulations of the Foreign Direct Investments are not usually properly enforced (Mapaure, 2014).

Foreign construction companies can get involved in developing countries through formally undertaking competitive complex large projects or they can provide loans to developing countries which would be paid back at an agreed date in form of natural resources that are abound in those countries. For example, oil rich countries in the Middle East have satisfied their demand for infrastructure through exchanging crude oil with construction services (Drewer, 2001). The involvement of China on construction activities in Africa has been beneficial in terms of political and financial support in exchange of natural resources (Corkin and Burke, 2006; Burke, 2007; Davies, Edinger, Tay and Naida, 2008).

Developed countries used to dominate in global construction activities due to high economic magnitude and improved technologies prevailing in those countries (Drewer, 2001). These are considered to be the important ingredients in construction projects' success. However Chinese firms are currently dominating in the provision of infrastructure in developing countries particularly in the African continent (Corkin and Burke, 2006; Burke, 2007; Sauvant and Zitian, 2014) due to their highly competitive bids resulting from access to low cost capital, cheap labour forces and low cost building materials (Corkin and Burke, 2006). As such, China fulfils two objectives through provision of FDI; that is to cultivate competitive Chinese companies on a worldwide basis and achievement of the Chinese's country development (Sauvant and Zitian, 2014). Consequently, foreign companies would not be interested in undertaking investment where the gains are low (Joo Jung and Rich, 2016). Accordingly, China is influential in the infrastructure development of many African States (Gu, Chuanhang, Vaz and Mukwereza, 2016), because of the resource abundance which can be used to pay up loans and other developments.

China is also one of the major countries investing in Zimbabwe thereby assisting in the alleviation of economic challenges that have hampered the progress of Zimbabwe's development (Hogwe, 2013). For instance, about US\$545 million investments were injected into Zimbabwe in 2014 (Kachembere, 2015). Some of the notable examples of construction projects undertaken through FDI from China include the National Sports Stadium, Long Cheng Plaza and the Zimbabwe Defence College (The Standard, 2013). Besides assisting in the development, the emergence of Chinese construction companies in Zimbabwe have resulted in a number of problems on the way construction business is undertaken. Stiff competition is currently being experienced on government tenders thus many indigenous Zimbabwean construction companies were forced out of construction business (The Standard, 2013). It has also been reported that the presence of Chinese construction companies has increased the chances for occurrence of corruption and power abuses in the way construction tenders are awarded (Hogwe, 2013; Mapaure, 2014). The indigenous firms have also faced funding challenges due to incapacity to secure capital from banks thus leaving the construction business to Chinese construction companies. Subsequently, one of the macroeconomic objectives of any country to achieve equality will not be achieved.

In addition, workers employed on construction sites operated by Chinese firms also face various challenges inter alia, are low wages, poor working conditions and restrictions in undertaking legally

organised industrial action (Hogwe, 2013). About 75 % of the Chinese companies do not pay gazetted wage rates for labours and virtually all the companies do not abide by the Indigenisation and Empowerment Act (Chapter 14:33) (Mapaure, 2014). In a notable example, about 1500 were dismissed after undertaking a legal strike concerning the poor working conditions and lower wages (Mapaure, 2014). Whilst all countries may strive for higher development levels, the rights of both labourers and citizens at large should be prioritised on projects undertaken by the Chinese construction companies through various monitoring tools. Thus this paper addresses two objectives that is determination of the level of involvement by Chinese firms on construction projects and the assessment of the impact of foreign companies' involvement in infrastructure provision in developing countries through analysing public sector projects in Zimbabwe.

The following section will discuss the related literature of benefits and associated challenges in the involvement of foreign companies in construction business. Later the paper will detail the methodology, results, discussion and the conclusions.

2. Literature Review

There are several benefits that can be derived from the involvement of foreign companies in the construction companies in developing countries. For instance developing countries can possibly access funding for construction projects (Burke, 2007). Other paybacks that may be derived from involvement of foreign companies on construction projects are provision for financial resources for infrastructural development, technology transfer to indigenous companies and reduced prices for infrastructure projects (Ofori, 2000). Consequently, in the African context, Chinese construction companies have contributed greatly to the development of infrastructure in developed countries (Corkin and Burke, 2006; Hogwe, 2013).

Shortcomings of the involvement of foreign companies on infrastructure projects are unpreparedness by indigenous firms to embrace new skills and disinterest in foreign companies to transfer technology to the indigenous construction companies (Ofori, 2000), usually incited by *inter alia*; communication barriers, inexperience amongst local management personnel and the lack of repetitive construction undertakings (Carrillo, 1996). In addition to the shortfalls cited above, the quality of Chinese produced buildings is only high where building codes and proper enforcement mechanisms are in place (Corkin and Burke, 2006). Other shortcomings cited were limited interest of Chinese companies in engaging indigenous companies in joint ventures since the indigenous companies lacked technical, managerial and financial capability to undertake major infrastructural projects (Corkin & Burke, 2006; Osabutey, Williams and Debrah, 2014). This negated the main essence of engaging foreign companies in developing countries.

2.1 Involvement of Chinese construction companies in Angola and Namibia

The Chinese government usually selects construction companies for selected developmental aid projects through a competitive tendering that will be undertaken in China (Burke, 2007). This will enable the company that would have won the tender to access funding at reduced interests rates from the central bank of China for the purposes of site establishment, thus construction companies from China have full back up support from their government (Corkin and Burke, 2006; Hogwe, 2013). Subsequently, the Chinese construction companies will outperform the indigenous construction companies during the tendering procedure. The Chinese construction companies also sub-contracted

different specialist areas to Chinese firms, and these will be taken to the host developing country (Burke, 2007).

In Angola, Chinese construction companies were involved on a number of construction investment projects such as the repairs of the Benguela railway line and the construction of 371km linking Luanda and the Uige(Lucy and Burke, 2006). Although some of the Angolan construction projects were competitively won by Chinesecompanies there are a number of problems associated with the way the Chinese construction firms undertook their work in Angola For instance, some of the work positions supposed to be executed by Angolan were filled by Chineselabourers and the firms paid wages that were sometimes lower than the state determined wages for the host country. The payment of reduced wages for construction labourers made Chinese construction companies complete projects within cost limits.Lucy and Burke (2007), also claimed that Chinese construction companies import most of their materials and equipment from China where a bag of cement costs a lower price of US\$4 whilst in Angola a bag of cement was costing US\$10 per bag. This results in reduced price of for the cost/m² for construction which is their major strength contributing to success in tendering.

Chinese construction firms were found to be dominant in the Namibian construction industry (Buys and Hallick, 2010). Consequently, the involvement of Chinese construction companies in Namibia has been beneficial in a number of ways; provision of inexpensive housing and pumping stations amongst other projects (Buys and Hallick, 2010). Initially, Chinese companies penetrated the Namibian construction industry as foreign players who were backed up by the Chinese government(Jauch and Sakaria, 2009). Further, they have now been absorbed by the private sector thus causing stiff competition for available construction contracts.Interestingly, about 70% of the Namibian construction tenders were won by Chinese companies, leaving only 30% for other construction players(Jauch and Sakaria, 2009; Buys and Hallick, 2010). Examples of projects executed by one of the Chinese construction companies, are the Supreme Court in Windhoek and the New Police Station and Prison Training College (Jauch and Sakaria, 2009).

Amidst the successes recorded for Chinese construction companies, the study carried by (Buys and Hallick, 2010) shows that there are a number of Namibian regulations that were not being complied with by these companies. For instance labour regulations such as working hours, understudy regulations, tender requirements, minimum wages regulations and social security requirements (Odada and Kakujaha-Matundu, 2008; Buys and Hallick, 2010; Mapaure, 2014) and other construction industry regulations such as proof of registration as tax payer, valid affirmative action certificate were also being flouted in the engagement of Chinese companies on construction projects.Consequently, the Chinese construction companies were being handled in a special manner (Odada and Kakujaha-Matundu, 2008). However, this special treatment is usually regarded as a right for Namibian citizens, escpecially where the government's major challenge is that of eradicating poverty and inequality (Buys and Hallick, 2010).Although the Chinese construction company employ a large number of unemployed Namibians, (Buys and Hallick, 2010) claim that Chinese companies were not subcontracting works to SMEs with much of the sub-contarct works being performed by Chinese Labourers.

From the various examples that have been detailed out it seems common that in all the African countries wre Chinese firms are operating construction business, a number of infrastructural projects have been developed although there is an infringement on the rights of workers. This then needed an empirical study to be undertaken on whether the engagement of Chinese firms has been beneficial to

Zimbabwe and provide recommendations on the best way to allow development to take place without contradicting country jurisdictions on workers.

3. Methodology

The study was centralised in Harare, the capital city of Zimbabwe, where most of the construction activities are undertaken. Moreover Harare is also the administrative capital of most construction consultant's firms. Due to the various interactive issues surrounding the involvement of Chinese construction companies in Zimbabwe, the study adopted a descriptive design where quantitative and qualitative methodologies were used. Whilst the qualitative research enabled for the discussion of the phenomena in detail, quantitative study enabled for the measurement of the trends regarding the phenomena being studied. A qualitative study involving a study on the impact of Chinese investments in Africa was also undertaken by Mapaure (2014).

Six structured interviews were held with government officials, consultant quantity surveyors, architects, engineers and contractors involved on construction project since year 2009. In addition, twenty questionnaires were administered respectively to a group of construction consultants (quantity surveyors, architects and engineers) as they are mostly involved in the awarding of tenders to construction contractors. In an attempt to ascertain the level of participation, data was collected on Chinese companies' bidding response to tenders. Qualitative data was analysed through carrying out a content analysis where the data was cross-examined together with the literature to obtain the meanings of the trends depicted in the study whilst quantitative data was analysed through descriptive statistics.

4. Results and Discussion

The interview carried with a government official revealed that most of public sector projects in Zimbabwe were funded through grants acquired from the World Bank, International Monetary Fund (IMF) and African Development Bank (AfDB) that require bidders to provide bid bonds though Zimbabwe is currently relying most on FDI from China in the execution of priority construction projects. This requirement has forced local contractors not to partake in construction projects funded by the above mentioned institutions since they do not have the capacity to secure the finance that is required to obtain bid securities. The interviewee mentioned that some of the projects undertaken by Chinese construction firms Zimbabwe were procured through competitive tendering.

4.1 Involvement of Chinese construction companies

One of the government official interviewed cited that Chinese construction companies took a lead against other foreign players in the execution of construction projects in Zimbabwe. The questionnaire respondents indicated that Chinese construction companies are frequently involved on construction projects (43.75%) whilst 37.5 % of the respondents cited that the Chinese construction companies are most frequently involved on construction projects. This could be a result of the China-Zimbabwe bilateral agreements which require participation of Chinese firms on China government funded construction projects thus supporting the arguments of Corkin and Burke (2006). The participants also claimed that Chinese companies come under government underwriting. This increase the opportunities for the Chinese companies to participate in the tendering of construction projects in Zimbabwe.

The interview with one of the consultants revealed that 30% of the public sector projects underway were won by Chinese companies whilst 70% of the projects were won by local companies. However, the interviewees indicated that Chinese companies won projects of higher value up to around US\$15 million whilst their Zimbabwean competitors won projects of about US\$1.5 million. The Chinese contractors proved to be more competitive than Zimbabwean construction companies as pointed by 68.75 % of the questionnaire respondents whilst a quantity surveying firm manager interviewed mentioned that the bids of two Chinese firms were leading by 10% and 1.5% respectively against the lowest local construction company's bid. This could be as a result of the fact that Chinese companies usually secure low interest capital which will reduce the overheads on the project cost thus lowering the total construction costs and bids. Other interviewees mentioned that most Chinese firms failed to meet pre-qualification criteria (e.g. registration with recognised local construction regulatory bodies such as). Surprisingly the interviews revealed that the authorities persistently engaged the same Chinese firms which fail to satisfy the registration requirements. About 83% of the questionnaire respondents also pointed that the laws governing the construction activities in Zimbabwe were not equally enforced between Zimbabwean and Chinese construction companies. The results support the findings of Buys and Hallick (2010) and Hogwe (2013). Chinese construction companies' special treatment than the counterparts of the host country signifies contravention of the rights of the indigenous companies in Zimbabwe.

4.2 Effects of involvement of foreign companies on Zimbabwe's economy

Empirical results indicate that the expected mutual gains from the involvement of Chinese contractors on the Zimbabwean construction may not have been realised. The following section details the various effects of the involvement of Chinese firms on construction sites in Zimbabwe by focusing on how these firms procure their materials and labour and assessing the performance of projects in which they were working on.

4.2.1 Procurement of materials and labour

From the questionnaire that was administered, 100% of the respondents indicated that the Chinese construction companies procure cheap materials from China. The interviewees had the same sentiments concerning material procurement. Consequently, these findings confirm the arguments of Corkin and Burke (2006). The procurement of building materials from China leads to the achievement of savings on projects. Consequently the actual economic growth that was supposed to be realised in Zimbabwe through the local procurement of building materials is not being realised. All the interview participants alluded that Chinese construction companies employ local labour on projects in Zimbabwe though senior positions such as foreman, general foreman and site agent were reserved for Chinese citizens. This supports the report put forward by Corkin and Burke (2006). Response from interviews revealed that "lack of expertise" and "knowledge" in local personnel could be a possible reason why Zimbabweans were not employed on senior positions on construction projects undertaken by the Chinese construction companies (Osabutey, Williams and Debrah, 2014). However 43.75% of the respondents rated Chinese construction management team as hardworking whilst 25% of the respondents did not view them as hardworking and 11% of the respondents were indifferent. This could explain the failure by Chinese firms to employ Zimbabweans on senior positions. Empirical findings confirm the findings of Osabutey, Williams and Debrah (2014). In addition, 68.75% of the questionnaire respondents were of the view that the wages which were being given to Zimbabwean construction workers on Chinese led projects were lower than the statutory gazetted rates and as such

maybe causing them to attain targeted cost of construction. These findings point to the infringement of the rights of workers in Zimbabwe on construction sites manned by the Chinese.

4.2.2 Performance of projects undertaken by Chinese

Interviewees cited that projects undertaken by Chinese construction companies are completed in much lesser time than expected. Similarly 56.75% of the survey respondents also echoed that the projects executed by Chinese firms are achieved within the stipulated time limits whilst 25% of the respondents were indifferent. Use of efficient modern and advanced plant by the Chinese firms compared to use of aging and obsolete equipment by local contractors (Corkin and Burke, 2006) could be a possible explanation of the high rate of productivity by Chinese firms. Findings confirm the view that Chinese companies contribute positively towards the economic resuscitation of Zimbabwe (Hogwe, 2013), by making it possible to execute construction projects which seemed impossible to be constructed through higher construction costs and prolonged delivery periods proposed by Zimbabwean builders.

The government officials and quantity surveyors interviewed also concurred that project undertaken by Chinese rarely encountered price variations. Nonetheless, some of the interviewees criticised the good budgetary control skills of the Chinese construction companies which they claimed to be a result of local labour exploitation. Hogwe (2013) points out that the Chinese construction companies involved in Zimbabwe were noted for underpaying indigenous labourers. This seems to be common habit for Chinese construction in most of African countries where they are operating (Jauch and Sakaria, 2009; Buys and Hallick, 2010). As such, the common understanding that could be reached concerning the way Chinese firms operate on construction projects is that there exist evidence for contravention of the rights of workers that should not be overlooked when seemingly beneficial projects are being incepted.

The interviewees also cited that the quality standards for the projects constructed by Chinese construction companies met the specifications required on most of the projects and this was also supported by 43.75% of the questionnaire respondents who rated the construction projects executed by the Chinese as of high quality. Moreover, the findings match those of (Corkin and Burke, 2006) who reiterated that performance on construction projects were high on projects that had strict monitoring mechanisms. However, interviewees also stated that “zhing - zhong (sub-standard) materials are normally used on projects if proper monitoring mechanisms are not established”. This leads to maintenance and repair of construction works being required at a much earlier time than envisaged. In order to improve the national economy of Zimbabwe, the government should make it mandatory for building materialsto be sourced from local companies.

Participants from government as well as contractors alluded that local companies face the dilemma of failing to secure partners to undertake projects of reasonable magnitude as almost all local companies lacked the capacity to raise security bonds. Interviewees further pointed that the Chinese companies are reluctant to partner with local companies except for nominated subcontractors who are selected by the client. As such the local companies are not benefitting much from the involvement of Chinese construction companies. These findings then support the findings of (Corkin and Burke, 2006; Buys and Hallick, 2010, The Standard, 2013) and it seems all African developing countries face this dilemma. Thus, African countries will not benefit from the technology transfer and will continue importing construction services from foreign companies.

5. Conclusion and Recommendations

From the research findings the study concludes that although involvement of foreign companies' on construction projects has assisted a long way in provision of finances required for construction projects, there exist little progress in development of the construction industry of Zimbabwe through technology transfer, beneficiation of construction labourers and business improvement in construction materials supply firms. The time, cost and quality specifications for projects undertaken by Chinese construction firms performed better than those undertaken by Zimbabweans (where monitoring mechanisms are in place) due to use of obsolete equipment, failure to achieve higher productivity levels and use of expensive construction materials amidst expensive capital from financial institutions in Zimbabwe.

The study also concludes that the employment of local labour by Chinese construction companies operating in Zimbabwe is remarkable. Nevertheless there is likelihood of exploitation of indigenous labourers by under paying them. Local materials are not utilised on Chinese construction projects, but the sentiments of this study would be that it may lead to sub-standard work on construction projects as some of the materials might not have been tested for suitability of their use in Zimbabwe. This practice of buying materials from China has a negative impact on economic growth as construction material supplying companies fail to get support from the consumers leading in company closures and reductions in extent of operations.

It would be prudent for Zimbabwe to establish appropriate investment laws which provide a win-win basis for the two governments entering into an investment agreement involving construction projects. Quality monitoring systems should be put in place and properly enforced to enhance the achievement of sustainable products.

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6

INFRASTRUCTURE LEADERSHIP AND GOVERNANCE

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Types and Sources of Micro-Political Risks Affecting International Construction Projects: A Case Study

Abimbola Windapo¹, Isaac Muchenga²

Abstract

This research examines the micro-political risks affecting international construction projects in Namibia and whether these arise from host government or society. The rationale for the study stems from the fact that Namibia is currently implementing a multi-billion dollar infrastructural investment drive and it is expected that a growing number of projects undertaken will be in the international construction sector. The study employed a qualitative research approach using a case study research design with data collected using semi structured questions and from an array of documents and observations. The population of the study was made up of the top most project team members who constituted a sample that was likely to generate useful data for the research. The data was analysed using descriptive and thematic analysis. It emerged that the key threat risks in this context are repudiation; contract problems; labour unrest; hostile press; and delay in permit approvals; while local ownership requirements and expatriate labour restrictions are both threats and opportunity risks. A significant number of the micro political risks identified arise from the host government, while the balance arises from the host society. These findings are likely to apply to other international construction projects in the nation and therefore have serious implications on the role of the government in ensuring the success or failure of infrastructural projects that are required for national development. Therefore, the Namibian government can positively contribute to risk mitigation on construction projects through the introduction of policies that enhance opportunities, minimize downside risk and thereby, improve the cost performance of international projects in the country.

Keywords: government, international construction project, Namibia, performance, micro-political risk, society

1. Introduction

This research examines political risk management in international construction projects. For a construction company, as with any other business, risk is an inherent part of the business (Frynas and Mellahi, 2003; Zhao and Duan, 2008; Garrido *et al.*, 2011). In the home country a company, deals with market-related and project-specific risks only. However, in cross-border projects, a foreign construction company has to contend with more complex risks with political risk being the most prominent (Robock, 1971; Kobrin, 1979; Mortanges and Allers, 1996; Hastak and Shaked, 2000; Alon and Herbert, 2009; Zhang and Wei, 2012; Loo *et al.*, 2013). Apart from a lack of consensus on what political risk is, it has been argued that political risks are difficult to assess and manage owing to

¹Associate Professor; Department of Construction Economics and Management; University of Cape Town; Rm 5.20 Snape Building, Rondebosch, 7701, South Africa; Abimbola.windapo@uct.ac.za

²Masters Student; Department of Construction Economics and Management; University of Cape Town; Rm 5.20 Snape Building, Rondebosch, 7701, South Africa; mchisa007@myuct.ac.za

their subjective and qualitative nature (Smith and Gannon, 2008). International construction projects are exposed to financial loss, schedule overruns and other negative outcomes as consequences of these political risk (Abdul-Rahman *et al.*, 2012).

Those construction projects undertaken in another country by a foreign company are called international construction projects (Ngowi *et al.*, 2005). The removal of trade barriers between nations or world regions through the signing of bilateral or multilateral agreements, such as the protocols of the World Trade Organisation (WTO), has resulted in the phenomenon of globalisation. For construction companies it means bidding for and engaging in construction work in markets outside the political borders of the domicile of the company (Ngowi *et al.*, 2005).

Construction risks can be grouped in several ways as there is not a universally agreed method of risk categorization (Bing and Tiong, 1999; Hastak and Shaked, 2000; Al Khattab *et al.*, 2007). Han and Diekmann (2001) classify international construction risks into five categories namely, political, economic, cultural/legal, technical and other special risks, while Shen *et al.* (2001) classified risks as financial, managerial, legal, market, policy and political and technical risks. These risks are further divided according to source into internal and external risks. External risks arise from sources outside the organisation's operations while internal risks emanate from within the organisation. External and internal risks are further broken into controllable and uncontrollable subcategories. Controllable risks in both subcategories if identified early enough in the project can be eliminated by applying the correct techniques but uncontrollable risks cannot be controlled and will require close and continuous monitoring and mitigation measures (Lam *et al.*, 2007; Sharma, 2013).

Political risks are classified as external risk factors as they are driven by activities outside the company or project (Loo *et al.*, 2013; Sharma, 2013). They are further divided into macro and micro level risks (Robock, 1971; Simon, 1982; Hastak and Shaked, 2000). The construct of political risk is broad and influenced by a variety of environmental factors and thus does not only arise from government action but also from the actions of society (Al Khattab *et al.*, 2007; Alon and Herbert, 2009; Crăciun, 2011; Howell, 2014). In the past political risk was viewed as emanating from an adversarial attitude of the host government but of late the source of these risks is considered environmental rather than emanating only from government actions (Fitzpatrick, 1983; Alon and Herbert, 2009). Naturally, countries can be subjected to innumerable internal and external pressures, any combination of which could result in actions being taken that could impact on the business environment (Simon, 1984; Alon and Herbert, 2009; Howell, 2014). To that end, political risks arise from changes or discontinuities in the business arena due to political activities and/or societal events and these risks are imposed upon an international project (Howell, 2001; as cited by Al Khattab *et al.*, 2007).

Studies in the risk management process in international construction are necessary to provide empirical evidence on the matter. On that basis, one can argue that a country-based study on micro-political risks could add to the overall knowledge on risk management in international construction. As Namibia is implementing a multi-billion Namibian dollar infrastructural investment drive as espoused in the 4th National Development Plan (NDP4) which forms part of Vision 2030 (NPC, 2012) it is expected that a growing number of projects will be undertaken and that some of these will be in the international construction sector making Namibia a good candidate for such a study.

2. Political Risk Overview

Research into country risk or political risk started in the 1950s and became popular with researchers in the following two decades, motivated by high profile expropriations and nationalisations of foreign interests: in the Suez Canal (1956), Cuba (1959), Chile (1972), Texaco and Chevron petroleum assets held in Nigeria in 1975, and then in the late 1970s; in Nicaragua, El Salvador and then in particular the Iranian revolution with the potential loss of US\$ 1 billion in assets by multi-national enterprises (Micallef, 1982; Simon, 1984; Prakash and Luther, 1986; Agarwal and Feils, 2007; Jarvis and Griffiths, 2007; Yackee, 2014). These events in particular left businesses with a clear and unsavoury understanding of the link between political and societal processes and the business environment (Torre and Neckar, 1988).

Robock (1971) divides political risks into macro and micro risks, where macro-political risks affect the whole country or region, and micro-political risks affect selected industries, firms or projects. For example, revolutions, civil wars, nationwide strikes, protests, riots, and mass expropriations are macro political risks. Political risks are classified as external risk factors because they are driven by activities outside the company or project (Loo *et al.*, 2013; Sharma, 2013). Targeted expropriations, discriminatory taxes, and import restrictions applied to specific firms, are micro-political risks (Hastak and Shaked, 2000; Han and Diekmann, 2001; Wang *et al.*, 2004; Pheng *et al.*, 2009; Ling and Hoang, 2010; Sharma, 2013).

There are also other perspectives on political risk, with Alon and Herbert (2009) identifying two broad ways of defining political risk. The first being that in the past political risk was viewed as emanating from an adversarial attitude of the host government interfering with the business of the multi-national enterprise (Shou *et al.*, 1999; Gao, 1983). The second, and new approach, considers the construct of political risk as being broad and influenced by a variety of environmental factors and thus it does not only arise from the actions of government, but also from the actions of society, as well as the actions of other countries (Kobrin, 1979; Simon, 1982; Fitzpatrick, 1983; Gao, 1983; Rice and Mahmoud, 1986; Al Khattab *et al.*, 2007; Alon and Herbert, 2009; Ekpenyong and Umoren, 2010; Ling and Hoang, 2010; Crăciun, 2011; Howell, 2014). In line with the definition of political risk adopted for this study, the definition of political risk according to Ling and Hoang (2010) which embraces both downside and upside consequences of risk is considered appropriate.

2.1 Political risk classification

Al Khattab *et al.* (2007) used the event–source approach to classify political risks. Three sources of threats are identified namely; host government, host society and the possible risks, which could result from each of these sources, are shown in Table 1. The framework presented by Al Khattab *et al.* (2007) is limited as sources of political risks are much broader than what they assumed (Simon, 1984; Torre and Neckar, 1988). Another shortcoming is lack of distinction between macro and micro-political risk (Kobrin, 1979; Simon, 1982). Simon (1982) used a classification based on two dimensions of event source and relationship to project, to develop a framework for political risk as shown in Table 3. In this framework risks are split into those arising from the actions of governments and those arising from the actions of society, both with external and internal components. However, the framework by Simon, (1984), leaves out some important sources of political risk, exemplified by the press, public opinion and delays in the approval of permits.

2.2 Stakeholder identification

Stakeholders are any individuals, groups, or organisations, who may have actual or perceived stake, or interest in the performance of a project (Chinyio and Akintoye, 2008; Ward and Chapman, 2008; Jepsen and Eskerod, 2009; PMI, 2013; Windapo and Qamata, 2015). There are internal and external stakeholders for every project (Wang and Huang, 2006; Rowlinson and Cheung, 2008; Ward and Chapman, 2008). Apart from being a big source of uncertainty, stakeholders bring different and sometimes conflicting objectives to the project (Ward and Chapman, 2008; Tang and Shen, 2013; Davis, 2014). Different stakeholders also have unique risk profiles, risk appetites and risk attitudes (Cano and Pilar de la Cruz, 2002; Hillson and Murray-Webster, 2011). The worldview of a public housing project could be to provide infrastructure and decent accommodation for vulnerable people, and to raise their standard of living (Checkland, 2000). The identified stakeholders in this study have interests in the project objectives and include the customers-those affected (environmentalists, residents, surrounding communities, business, media); actors-the doers (contractors, suppliers, subcontractors, consultants); and the owners-decision makers (local council, regional government, national government, government agency).

Table 1: Classification of political risk

Source of threat	Threats (source of harm)
Host Government	Expropriation and or confiscation
	Contract repudiation
	Currency inconvertibility
	Ownership and or personnel restrictions
	Taxation restrictions
	Import or export restrictions
Host Society	Terrorism
	Demonstrations, riots and insurrection
	Revolutions, coups d'état and civil wars
Interstate	Wars
	Economic sanctions

Source: Al Khattab et al.(2007)

3. Research Methodology

The study adopted a qualitative research approach involving interviews with professionals such as engineers, quantity surveyors, project managers, accountants, and human resource practitioners involved in an international construction project handled by a South African Construction Company in Namibia. A non-probability, but purposive sampling technique was employed for this study. The involvement of different professions in the sample enabled the study to capture different perspectives on micro-political risks impacting the project. Ten top-most project team members of whom 75% had more than 20 years of experience in the construction industry were interviewed. The case study strategy and research protocol involving semi-structured interviews, follow up interviews and obtaining evidence from project documents such as status reports, minutes of meetings, financial reports, correspondences, court orders, and media reports enabled corroboration and triangulation thereby impacting positively on internal and external validity. The main interview questions were divided into sections: questions 1–3, about the respondent's background profile; questions 4–7, about

the organisation; questions 8–10 about the project; and questions 11–25, about micro-political risk. The data collected was analysed using descriptive and thematic analysis.

The relative impact values in the International Project Risk Analysis (IPRA) tool, which uses a semi-quantitative technique was used for risk analysis in the study. The relative impact rankings of risks in the IPRA model are given letter designations ranging from A to E starting with A = ‘negligible’ and ending with E = ‘extreme’. The relative impact of a risk is its ranking based on its overall impact on project objectives (CII, 2003b). The probability of occurrence using a Likert scale starting with 1 = ‘very low chance’ and ending with 5 = ‘very high chance’. Using the IPRA tool, the relative importance of a risk on a project is determined by combining the relative impact and probability of the risk occurring, yielding a risk classification of ‘negligible’, ‘moderate’, ‘severe’, or ‘extreme’. Thus the probability of occurrence and relative impact of the risk are plotted on the probability-impact matrix shown in Figure 1.

Likelihood/Probability	Threats						Opportunities					
	5	Severe risk	Severe risk	Extreme risk	Extreme risk	Extreme risk	Extreme risk	Extreme risk	Extreme risk	Severe risk	Severe risk	
	4	Moderate risk	Severe risk	Severe risk	Extreme risk	Extreme risk	Extreme risk	Extreme risk	Severe risk	Severe risk	Moderate risk	
	3	Low risk	Moderate risk	Severe risk	Extreme risk	Extreme risk	Extreme risk	Extreme risk	Severe risk	Moderate risk	Low risk	
	2	Negligible	Low risk	Moderate risk	Severe risk	Extreme risk	Extreme risk	Severe risk	Moderate risk	Low risk	Negligible	
	1	Negligible	Low risk	Moderate risk	Severe risk	Severe risk	Severe risk	Severe risk	Moderate risk	Low risk	Negligible	
		A	B	C	D	E	E	D	C	B	A	
Impact (on project objectives e.g. cost, time, scope or quality)												
Notes												
Extreme risk (E) – occurrence would prevent achievement of objectives, causing cost overruns, schedule slippage etc.												
Severe risk (S) – could substantially delay the project schedule or significantly affect technical performance or costs												
Moderate risk (M) – requires identification and control of all contributing factors by monitoring conditions and reassessment at project milestones.												
Low risk (L) – normal control and monitoring measures are sufficient.												
Negligible Risk (N) – Controls adequate, risk level reduced to as low as reasonably practical (ALARP)												
Not Applicable (NA) – this element does not apply to this participant or this project.												

Figure 1: Probability Impact Matrix (adapted from Walewski, 2005)

Every research design that is adopted for a study has inherent limitations (Bhattacherjee, 2012). Generalisability of findings poses a challenge for a case study, as the interpretations are limited, especially if it is a single case study as is the situation with this study (Rowley, 2002; Choy, 2014). Additionally, a single case study research method without a proper protocol may fail to meet generalisability requirements (Rowley, 2002; Bhattacherjee, 2012). Another limitation is the fact that since micro-political risks are specific to a project it may make generalisability of the findings difficult (Robock, 1971; Alon and Herbert, 2009).

4. Data Presentation and Discussion

The background profile revealed that the majority of respondents had more than ten years of experience in construction and 75% had more than 20 years of experience. The study also found that the key micro-political risks impacting on the international construction project studied based on the respondents perceptions on its likelihood of occurrence includes repudiation, corruption, bribery permit delays, hostile press and labour unrest (See Figure 2). It emerged that 62% of the listed risks were considered as likely to occur by all respondents. The micro-political risks of expropriation and local ownership requirements got the least response at 60%.

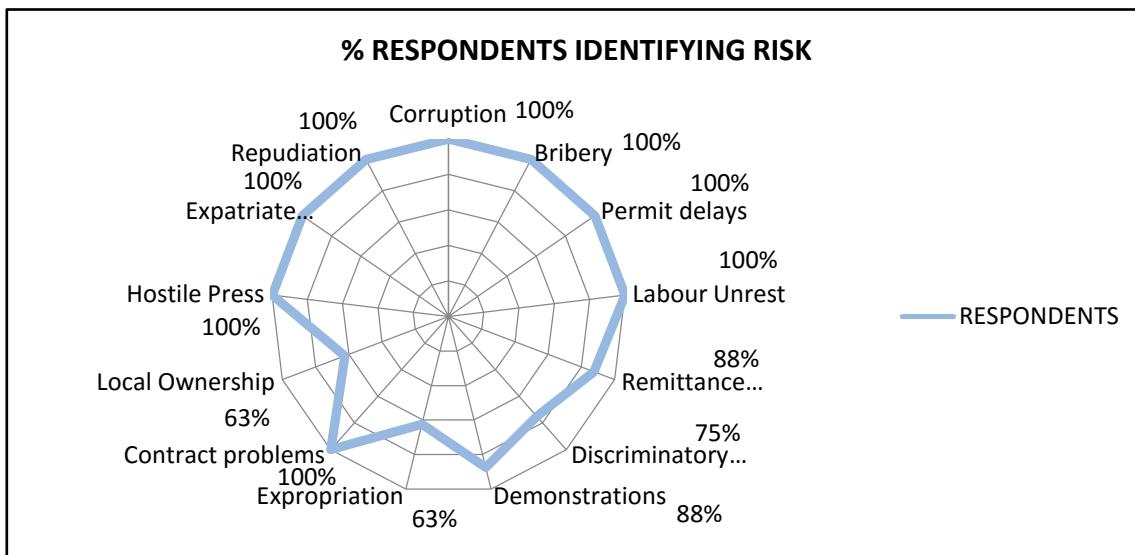


Figure 2: Percentage of respondents selecting a micro-political risk

Table 2 shows the equivalent international project risk assessment (IPRA) elements, micro-political risk variables and source. Since the median is the most suitable measure of central tendency, it was used for assessing the probability of occurrence of the risks. It can be seen from Table 2 that the source of ten of the Micro-political risk is attributed to the government, while only three is attributed to the society.

All seven interviewees attested to the presence of the repudiation risk. The source of the risk, according to the Government, was the mishandling of the International Construction Project by the implementing agency. Further documentary evidence of the risk came from actions of the Attorney General who were representing the Namibian Government in a written speech on 25 August 2015. Documentary evidence shows that the repudiation risk resulted in serious financial implications for the project; with a massive negative impact on the project revenue which ignoring variation orders, reduces the contract price from N\$ 796 million (54.3 million USD) to an estimated–N\$ 360 million (24.5 million USD) – a 55% reduction. Interviewee C indicated that some corporate social responsibility (CSR) projects, such as building a boundary wall for one of the schools in Swakopmund, were abandoned due to reduced revenues affecting empowerment efforts.

Table 2: Micro-political risks IPRA equivalents and source

Item	Micro-political Risk	IPRA Element	Level of Risk	Multiple source Evidence	Source
1	Contract Problems	II.D4	Extreme	Yes	Government
2	Hostile Press	II.C2	Extreme	Yes	Society
3	Labour Unrest	II.B3 ₁	Extreme	Yes	Society
4	Anti-project Demonstrations	II.B3 ₂	Severe	No	Society
5	Local Ownership Requirements	II.A3	Severe	Yes	Government
6	Restrictions on Expatriate Employees	III.D1	Severe	Yes	Government
7	Bribery	II.D6 ₁	Moderate	No	Government
8	Corruption	II.D6 ₂	Moderate	No	Government
9	Delay in approval of permits	II.A7	Moderate	Yes	Government
10	Discriminatory Taxation	II.A7	Moderate	No	Government
11	Expropriation	II.B1	Moderate	No	Government
12	Repudiation	II.B4	Moderate	Yes	Government
13	Profit remittance and exchange controls	II.A8	Negligible	Yes	Government

Three follow-up interviews conducted with respondents A, B, and C, confirmed contractual problems arising from breach of contract and non-payment. The effects of the risk were insufficient materials on site and reputational damage attracting punitive action as indicated in a letter from a supplier, dated 13 January 2015: "We have received numerous orders for phase 2 of the project as well as a request for immediate manufacture and supply of trusses. Although we understand the situation in which you current (sic) find yourself due to non-payment by...we regrettable (sic) cannot at this stage continue with the supply of materials to you until payment has been received."

Interviewee A provided evidence of the impact of risk on cost, revealing that by the end of June 2015 the project had incurred substantially increased costs due to contract problems. The effect on time was contained in a letter to the implementing agency dated 30 June 2015 reading in part: "...We do, however wish to note that the current extension of time at this stage is in the order of 6 working months..."

In addition, domestic subcontractors' workers engaged in industrial action nearly every month end because of either late or non-payment. In a newspaper article quoting the MD of the JV company executing the project, the workers' dilemma was captured as follows: "Recent work stoppages that delayed the work for one or two days were due mainly to late payments from the Side." In terms of the Hostile Press, Interviewee C, referring to the press, said: "There was no good publicity at all." Interviewee B also expressed the same sentiments that the bad press was fuelled by jealousy and rumours. Some subcontractors, and their skilled workers, were also seen leaving the site because the image of the project was not good.

Delay in permit approvals was meant to cover all project-related approvals by the central or local government, including the ones that were cancelled after approval. Approval delays at government level were to do with township establishment approvals by the Township Board, for the new areas allocated to the JV for construction. The CEO of the local authority, one year after applications were made to the Township Board, had this to say in the national press: "Until the statutory processes are finalized we will not be able to service these houses." Evidence at local authority level indicates that the approval of building plans and permits were often delayed. Documentary evidence of approval delays was also found in minutes of progress Meeting number 08 held on 16 April 2015, item 8.2 in which the engineer's representative stated that the local authority personnel claimed that no plans

were submitted for a batch of houses completed, yet payment records showed that the approval fees for those house plans were paid.

5. Conclusion

The research examines the micro-political risks affecting international construction projects in Namibia and whether the host government or the host society causes these risks. The research findings suggest that the key threat micro-political risks affecting international construction projects in Namibia were repudiation, contract problems, labour unrest, a hostile press, and delays in permit approvals, while local ownership requirements and expatriate labour restrictions were not only threat risks, but opportunity risks as well. Of the micro-political risks identified, a significant number came from the host government and lesser number were from the host society. Evidence gathered, indicated that international construction contractors were equally concerned about the host society- and host government-related key risks on international construction projects in Namibia.

These findings are likely to apply to other international construction projects in Namibia and will have implications on the role of government in ensuring the development of infrastructural projects required for national development. Based on these findings, the study recommends that the Namibian government can positively contribute to the mitigation of risks on construction projects through the introduction of laws that enhance opportunities, minimise downside risk, and thus improve the cost and time performance of international construction projects in the country.

This study, in addition to contributing to an understanding of the management of micro-political risk on international construction projects in Namibia, has also created a need for further research. To validate the findings of this study, it is recommended that multiple case studies on micro-political risk involving, a number of international construction projects in Namibia, be conducted. In addition, research on the micro-political risks in each phase of the project life cycles of international construction projects, with only the participants in each phase as respondents, is necessary to build on the findings of this study. The results for each phase can then be aggregated to produce a single micro-political risk profile for the entire project life cycle. Another research area is that of developing a micro-political risk-path model by establishing the interaction of micro-political risk sources, events, and effects, on project objectives. A study to compare the effectiveness of qualitative and quantitative methods in risk assessment of micro-political risks in international construction projects, is likely to give an insight into micro-politicalrisk management on international construction projects.

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Compliance by Public Sector CDPs to the CIDB Guidelines for Contractor Development

Abdulrauf Adediran¹, Abimbola Windapo²

Abstract

This paper examines the contractor development programmes (CDPs) of public sector clients in South Africa to determine the level and areas of compliance or alignment to the Construction Industry Development Board (CIDB) guidelines for contractor development. The rationale for this study stems from the premise that despite efforts to implement a consistent and co-ordinated approach to contractor development through the National Contractor Development Programme (NCDP) framework, lack of commonality and varying levels of compliance among CDPs remains a major challenge to achieving the core objectives of the NCDP. There is a need for further research to first determine the level and areas of compliance, and later the contributing factors to the level of compliance. The research adopts a qualitative research approach, mainly through a desktop survey. The CIDB guidelines for implementing contractor development are first reviewed to establish the checklist for implementing a CDP, against which the CDPs was assessed for alignment/compliance. A review of existing literature was also carried out to identify some of the contributing factors to the level of compliance. Archival data of public sector client's relevant policy documents is the main source of primary data for this study. Preliminary findings reveal that most contractor development programmes assessed meet the basic elements of the NCDP framework (borderline or minor non-conformity), and with commitment and the proper guidance, have the potential for successful implementation. However, major challenges to budget and project allocation, as well as monitoring and evaluation of contractors within CDPs and the CDPs themselves need urgent attention. The study concluded that there are low, but rising compliance levels among the CDPs, with contributing factors ranging from internal technical and administrative factors to external political influences.

Keywords: compliance, construction industry, contractor development

1. Introduction and Background to the Study

Compliance is generally understood as conformity (or acting in accordance) to regulations and legislation (Snell, 2004). However, some authors (Dunphy *et al.*, 2007, Parker, 2012; Pfeffer and Salanick, 2003) construe organizational compliance as organizational behaviour that meets or aligns with external stakeholder expectations because stakeholder and community scrutiny also requires that organizations operate in line with expected values and norms (cited in Interligi, 2010).

¹PhD Candidate; Department of Construction Economics and Management; University of Cape Town; Rondebosch 7701, Cape Town, Western Cape, South Africa; addabd001@myuct.ac.za.

²Associate Professor; Department of Construction Economics and Management; University of Cape Town; Rondebosch 7701, Cape Town, Western Cape, South Africa; Abimbola.Windapo@uct.ac.za.

Contractor development is a deliberate and managed process to achieve targeted developmental outcomes that improves contractor grading status, performance and quality, equity and targeted ownership (CIDB, 2011). Depending on the geographical location, Contractor development programmes (CDPs) aim to develop skills and promote business sustainability for emerging, minority and historically disadvantaged contractors in the construction industry.

In South Africa, the Construction Industry Development Board (CIDB) launched the National Contractor Development Programme (NCDP) to address certain growth constraints and develop sustainable contracting capacity in the construction industry (SA DPW and CIDB, 2011). Although there were other programmes that pre-existed the NCDP, the impetus for introducing the NCDP was due to the lack of a co-ordinated and consistent approach to contractor development. Lessons and progress learnt from some of these pre-existent programmes were also incorporated into the NCDP framework. The NCDP framework also established the parameters for implementation of CDPs, known as ‘guidelines’ for implementing contractor development.

According to the CIDB, it is estimated that 80% of government infrastructure spend is concentrated at CIDB Grades 7 to 9 contractors who represent only 11% of the total number of CIDB registered contractors. The increasing complexity of projects and concentration of capacity in the higher grades provides a compelling need for targeted contractor development which aims to increase the delivery capacity and capability, as well as sustainability of emerging contractors who constitute an estimated 80% of CIDB registered contractors. Sustainability includes promoting the participation of these contractors on government infrastructure projects. Hence public procurement represents a significant instrument of contractor development programmes.

In South Africa, one of the key principles which underpins the NCDP stipulates that government entities may use procurement of infrastructure as a means to achieve contractor development. The combined achievement of infrastructure project delivery objectives and incorporation of social development opportunities (e.g. contractor development) during the process of design, procurement, implementation and operation has the potential to increase the contribution of investment in infrastructure towards economic growth, poverty reduction and attaining the UN Sustainable Development Goals (SDGs) (Hawkins, 2012).

The need for regulatory compliance is increasingly gaining attention in developing countries due to the rapid structural changes and reforms to standardise procurement laws and systems (Jibrin *et al.*, 2014). The problem of non-compliance is prone to both developed and developing economies; however, most of the studies on compliance has been conducted in the developed world (Gelderman *et al.*, 2006). In Nigeria, despite the wave of procurement reforms that begun in 1999, many government entities are yet to adopt prescribed practices (Agaba and Shipman, 2006; Jibrin *et al.*, 2014). Furthermore, the high levels of non-compliance constantly reported by the CIDB Register of Projects Compliance Monitor is an indication of the compliance challenges in the South African construction industry (CIDB, 2013). This paper therefore examines the contractor development programmes of public sector clients in South Africa to determine the level and areas of compliance or alignment to the CIDB guidelines for contractor development.

2. CIDB Guidelines for Contractor Development

The CIDB Guidelines for Contractor Development has its roots in the NCDP framework which provides the three main components of contractor development, namely: Contractor Learnerships,

Enterprise Development, and Performance Improvement (SA DPW and CIDB, 2011). The Contractor Learnerships component targets CIDB Grade 1 to 3 contractors, incorporating the development of new emerging contractors predominantly through mentorships where developing contractors learn the basics of construction contracting business, and provision of sustainable work within CDPs. Enterprise Development targets CIDB Grade 2 to 6 contractors, incorporating the development of contractors who exhibit potential to grow either through a structured developmental support provided within CDPs or through a structured relationship with an established contractor. Performance Improvement targets CIDB Grade 4 to 7 contractors, incorporating the development of established contractors who exhibit potential to develop further to improve their performance by introducing best practice systems for health and safety, quality management, environmental management, etc.

According to the NCDP framework, various instruments may be used to support the contractor development process, the two main instruments include: Contractor Development Programmes (CDPs) and procurement-driven models. CDPs operate based on a direct targeting model that provides structured developmental support and direct contracting opportunities to contractors which is targeted to achieve predetermined developmental objectives. Further key instruments used for contractor development are procurement models that provide developmental support by indirect targeting through a main contractor to a developing JV partner or sub-contractor. Various strategies may be adopted to achieve predetermined developmental objectives called targeted procurement strategies (Adediran and Windapo, 2016). Typically, CDPs will generally address supply side constraints while targeted procurement addresses demand side constraints.

The guidelines for implementing contractor development has been developed by the CIDB in accordance to the NCDP framework, incorporating the components and instruments as well as best practice elements for contractor development therein. The purpose of the guidelines is to assist clients to design and implement compliant CDPs through direct targeting of contractors. It addresses the following aspects of implementing CDPs: targeting of budgets, projects and contractors; evaluation of contractors when entering a programme; training and mentoring; sharing the cost of contractor development; risk and cost sharing in contracts; payment dispute resolution; exiting from the programme; and monitoring and evaluating the programme. The guidelines further establish the key requirements for implementing a successful CDP that aims to exit and graduate contractors from the programme with measurable improvements (e.g. NQF level or improvement in contractor grading) and incorporates commitment of financial and human resources by both the client and the contractor to achieve the objectives of the NCDP (CIDB, 2011). The process for implementing a CDP, as derived from the key requirements is depicted in figure 1.

The process for implementing a CDP depicted in Figure 1 form the basis for the criteria for assessing CDPs for alignment to the NCDP framework. As the contractors within CDPs need to be evaluated periodically and re-evaluated before exiting the CDP, the NCDP mandates that CDPs are also to be monitored and evaluated for alignment and compliance to the NCDP objectives. CDPs' compliance is assessed/measured against an established checklist of key performance indicators or requirements. This checklist has been developed in line with the NCDP framework and CIDB guidelines for implementing contractor development. The assessment checklist for implementing CDPs is provided in Table 1. There are 20 checklist items in 5 categories to be scored during an assessment, which if fully compliant give a score of 40 points (100%). Based on evidence gathered, the CDP may be categorized in the following score range: 0 - 70 – MAJOR nonconformity (unacceptable); 71 - 89 – MINOR nonconformity (borderline); or 90 - 100 – COMPLIANT (acceptable).

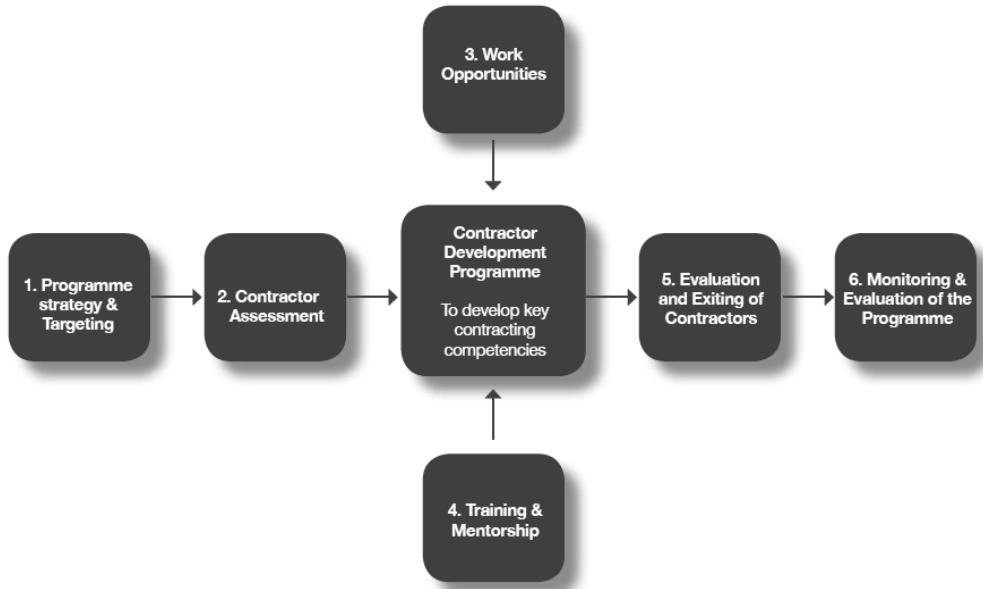


Figure 1: Process for implementing a contractor development programme (CIDB, 2011)

3. Contributing Factors to Level of Compliance

Previous studies have highlighted many elements that affect compliant behaviour. Some of these are discussed as they relate to the purpose and context of this study. According to Eyaa and Oluka (2011), lack of clarity in regulations results in low compliance levels; as compliance with a regulation is an indication of knowledge of the rule (Rossi, 2010). Gelderman *et al.* (2006) added that familiarity with the regulations could serve as an organizational incentive to comply.

Some authors contend that media exposure or publicity enhances organisational compliance, as there is a direct correlation between negative publicity about an organisation and their approach to corporate compliance (Jibrin *et al.*, 2014; Zubric and Sims, 2011). Previous studies show that enforcement of regulations also has an effect on compliance. While some scholars (Gunningham and Kagan, 2005; Imperato, 2005; Sutinen, 1999; Zubric and Sims, 2011) agree that enforcement action with increased penalties/sanctions enhances compliance levels, others argue that coercive enforcement may make violators more susceptible to hide from detection by authorities (Sparrow, 1994).

Poor record-keeping culture also undermines enforcement and reduces compliance. According to Alfresco (2009), proper records management controls is an integral part of achieving compliance. Bolton (2006) found that insecure, poor and dysfunctional records management prevents effective monitoring of targeted procurement in South Africa, and significantly promote non-compliant behaviour. Sutinen and Kuperan (1999) added that the perceived legitimacy of enforcing authorities influences the willingness and moral obligation of actors to comply with regulations; moral obligation is a significant motivation to compliance behaviour. Hui *et al.* (2011) contend that corruption threatens legitimacy which promotes non-compliant behaviour, and as such must be curbed to

enhance transparency, accountability and integrity (Hui *et al.*, 2011). On the other hand, compliance is also an effective deterrent to corruption (Obanda, 2010; OECD, 2007).

Table 1: Checklist for implementing contractor development

Requirements	Tick if completed ✓ or x
Needs, Programme Goals and Strategy	The need for contractor development has been established Evidence that budget has been allocated for a CDP exists Align CDP to Municipal/Departmental infrastructure goals Identify and allocate projects to support CDP Establish CDP goals in accordance to ‘SMART’ principle Allocate enough budget to achieve CDP goals in accordance with CIDB’s Targeting Guidelines for CDP Assign CDP implementation timelines Establish steering committee and document member roles and responsibilities
Resources planning	Develop and document CDP business case Assign organisational and institutional resources to support CDP Outline and document supervisors’ and other staff roles and expected tasks in the CDP Adopt procurement methods to support CDP in line with the CIDB Practice Note 29 Establish training programmes that lead to NQF qualifications in line with the CIDB Competence Standards Develop and document a mentorship programme
Contractor selection	Establish fair and transparent contractor selection based on predetermined criteria (Competence and Financial Upgrading Factor)
Contractor appointment	Determine contractors’ skill base, and outline and document developmental outcomes Contractors sign Contractor Development Agreement Contracts outlining performance standards and exit clauses
Monitoring and evaluation	Establish formal and documented CDP assessment programme detailing how and when to conduct assessments Document Monitoring, Evaluation and Quality Control measures to be complied with Follow-up assessment findings and take corrective measures where necessary.

Social and political influence also has a negative effect on compliance (Jibrin *et al.*, 2014). External interference from local politicians, businesspersons, and top management individuals hinders transparency and promotes non-compliant behaviours such as collusion (Coviello and Gagliarducci, 2010; Hui *et al.*, 2011).

Interligi (2010) emphasized the role of culture in the organizational compliance process and associated outcomes. Scholars (Arjoon, 2006; Lotzhof, 2006; Ramusen, 2006; Gebler, 2006) contend that employees in an organization that encourages a ‘culture of compliance’ characterized by values of openness, trust and honesty are more likely to engage in compliant behaviours (cited in Interligi, 2010). Hence top management support and dedication to ethical corporate behaviour plays a central

role in improving compliance (Krawiec, 2003), as compliance culture starts in the boardroom (Heneghan and O'Donnell, 2007). Other salient factors that impacts on compliance include organizational incentives (Gelderman *et al.*, 2006; Ntayi *et al.*, 2010) and professionalism (De-Boer and Telgen, 1998; Raymond, 2008).

4. Methodology

Two perspectives to measuring compliance was identified in literature – the formal concept where the response/behaviour/conduct of the actor/target is compared to the formal definition of the corresponding legal obligation; and the perspective that considers the scope and degree of compliance as the outcome of a negotiated process between an actor and the enforcer (Fairman and Yapp, 2005; Gelderman *et al.*, 2006; Lange, 1999). This study adopted the formal qualitative approach, comparing public sector client's CDPs to the CIDB checklist for implementing a CDP. The data reported in this study were mainly obtained through desktop study of archival data – reviews of the CIDB guidelines and public sector client's relevant policy documents.

The guidelines for implementing contractor development is first examined to identify the key requirements for a successful CDP, and establish the checklist for implementing a CDP, against which the policy documents will be assessed for alignment/compliance to the NCDP framework. A review of existing literature was also carried out to identify some of the contributing factors to the level of compliance. A sample size of 11 registered CDPs was selected for the investigation, which represents 68.75% of CDPs listed on the CIDB's Electronic Monitoring System. The unit of analysis of the study was the public sector client's CDPs.

5. Findings and Discussion

The study revealed that all programmes have established a need for contractor development. However, in most cases, they only specify socio-economic objectives instead of contractor development objectives such as access to work opportunities, addressing historical imbalances etc. Although the core focus of all the programmes assessed are aligned to the service delivery objectives of the implementing entities, programme goals are usually stated as broad statements of intent, without clearly quantifiable or measurable targets. Hence there is a problem of objective specificity and conflicting objectives, one that needs to be addressed to ensure that the objectives of the NCDP framework is achieved.

With regards to evidence of *budget allocation* and project identification to support the programme, it was found that the policy documents simply state that budget will be allocated, and projects will be identified accordingly. In other words, budgets are not allocated nor projects identified until when the programme is actually being implemented. And as a result, there have been instances where programmes have stalled due to projects not identified on time or not allocated at all. According to the CIDB's Electronic Monitoring System, it is evident that most contractors within CDPs have secured work. However, variable information is available on *budget allocations* and contracts awarded to contractors are not necessarily awarded through the CDP, and hence compliance with the guidelines cannot be determined.

Regarding institutional resource allocation, the study found that while relevant stakeholders have been identified, some coordination challenges have been experienced. Furthermore, while policy

documents indicate that training that lead to NQF qualifications will be provided to contractors, there is little or no evidence to suggest that training provided is aligned to the CIDB Competence Standard for Contractors. The CIDB affirm that funding for training and mentorship intervention remains the single biggest challenge.

The study also revealed that although monitoring, evaluation and quality control measures exist, no formal and documented CDP assessment programme detailing how and when to conduct assessments has been established. In addition, there is little or no evidence that findings from assessment are followed-up and corrective measures taken accordingly.

6. Conclusion and Further Research

Based on the aim of this study, which set out to examine the compliance of public sector client's CDPs to the CIDB guidelines for implementing contractor development, the following conclusions were made from the findings contained in the previous discussions. It can be inferred that there is low but rising compliance levels among the CDPs, with contributing factors ranging from internal technical and administrative factors to external political influences. Most contractor development programmes assessed meet the basic elements of the NCDP framework (borderline or minor non-conformity), and with commitment and the proper guidance, have the potential for successful implementation. Furthermore, it is apparent that more combined effort from stakeholders is needed in improving budget and project allocations to support contractor development if the government's objective to develop competent contractors is to be achieved.

The paper adopted a desktop study of policy documents as the main source of data. Further research may look to conduct a field study to assess the respective CDPs. In addition, other smaller CDPs across the country may be assessed to improve generalizability. Finally, further empirical research may be carried out to examine the causes of high or low compliance.

7. Acknowledgement

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Evaluating the Use of PPPs in Delivering Sustainable Building Projects in Zimbabwe

Ringisai Abigail Mawondo-Dhliwayo¹, Kahilu Kajimo-Shakantu², Fortune Chiheya³

Abstract

Due to financial challenges which governments generally face, it is becoming more difficult for many to continually use their limited resources to undertake sustainable infrastructural development. Governments increasingly now need to adopt other delivery approaches in particular, the Public Private Partnerships which make it possible for the public sector to achieve infrastructural development without incurring major costs thus supporting sustainable development efforts. Zimbabwe's gap for the provision of infrastructure especially the housing and schools provision is huge and there exist limitations in the finances required for the provision of these services. However there seem to be low extent in the use of PPPs to deliver these projects thus this study aims to investigate the reasons behind the low uptake of PPPs. The literature reviewed indicated that projects implemented through the use of PPPs are delivered within time, cost and quality specifications thereby leading to the achievement of value for money. Challenges to the effective implementation of PPPs were identified in the literature as delays and contradictory legal framework. The methodology utilised for the empirical study comprised eight interviews and sixty questionnaires which were undertaken and administered to construction consultants, financiers and government officials involved on PPPs projects. The results obtained showed that PPPs are not widely used in Zimbabwe although the need for their use exists. Political influence was found to be the main constraint to the implementation of PPPs. Despite their limitations, this study concluded that, PPPs remain the most effective and viable option in the delivery of sustainable government projects. The study recommends that a policy framework and an independent PPP unit (responsible for the governance of PPPs) be established. More useful information could have been obtained if the study was carried on a large scale.

Keywords: procurement, public private partnerships, public sector, sustainable building projects

1. Introduction

Globally, governments are increasingly constrained in mobilizing the required finances to cope with the rising demand in infrastructure (Akintoye, 2009), and this is exacerbated by rapid economic

¹PhD Student; Quantity Surveying and Construction Management; University of Free State; PO. Box 339 (IB47), Bloemfontein, 9301, South Africa; ringimawo7@yahoo.com

²Adjunct Professor; Quantity Surveying and Construction Management; University of Free State; PO. Box 339 (IB47), Bloemfontein, 9301, South Africa; kajimoshakantuk@ufs.ac.za.

³Student; Quantity Surveying; National University of Science and Technology, PO Box Ac 939, Ascot, Bulawayo, Zimbabwe;fortuechiheya@gmail.com

growth, population growth and increasing rural–urban migration which are causing more deterioration to the existing infrastructure (Bhattacharya, Romani and Stern, 2012). While the infrastructure gap is rising, resources have become more constrained in provision. For instance, the annual financial requirement for infrastructure in Sub- Saharan Africa is about USD 93 billion a year whilst only USD 45 billion is being mobilised (Organisation for Economic Co-operation and Development (OECD), 2012). As such, this gap in Africa's infrastructure can only be filled by private investments (OECD, 2012) through Public Private Partnerships (PPPs). In other words the high demand for infrastructure development and pressures on national budgets has made governments in most developing countries to encourage the private sector to invest in public sector infrastructure projects (Alshawi, 2009). The use of PPPs tends to contribute a long way in increasing sustainable building which is a component of the overall sustainable development concept where sustainable building is a process which encompasses reforms in usage of resources in a bid to increase rate of building construction, performance and reduction of the life cycle costs of buildings (Hakkinen and Belloni, 2011).

Although the PPP arrangement is more appropriate to mega infrastructure projects where final users are requested to pay tolls, evidence shows that they have also been used as delivery method for buildings (Walker and Hampson, 2003). Through use of PPPs whole life cycle costs of facilities are reduced (Smith, 1999as cited by Walker and Hampson, 2003), thereby resulting inthe deliveryof value-for-money in public infrastructure (Chan, Lam, Chan, ASCE, Cheung and Ke, 2010; Tang, Shen and Cheng, 2010). Thus, PPPs as a delivery method can be used as a tool to achieve sustainable development especially for developing countries. In this study, sustainable development through building processes would be mainly achieved through the objectives (environmental sustainability and economic sustainability) of reducing the resource usage, improving efficiency and competitiveness of service provision and provision of employment opportunities for a country's citizens (Williams and Dair, 2006).

The use of PPPs for sustainable infrastructure development has become common in the 21st century (Chinyere and Xu, 2012), and a number of countries have made use of this delivery method. For instance, the method has been successfully implemented though to varying degrees in countries such as United Kingdom, Japan, Spain, Portugal, Scandinavian countries, France, Canada, Australia, United States of America and the Republic of South Africa in delivering infrastructure (Ismail, Takim, Nawawi and Egbu, 2009). PPPs have also proved to be burdensome to developing countries (Tambulasi, 2010), thus negating the successes that have been experienced where they are used. For example, more than half of entire health budget (51%) is being spent on payments to a SPV that built and runs a PPP hospital in Lesotho (International Finance Corporation, 2009) (Guardian, 2014; Oxfam, 2014) whilst the Independent Power Project in Tanzania was reported to be one of the costly PPPs for a developing country (Zimbabwe National Chamber of Commerce (ZNCC), 2009). This will now contradict the principles of sustainable development where value for money issues should form the centrepiece of any project development.

Although the PPP concept has been eagerly embraced in many countries, the use of PPPs in Zimbabwe is quite low, whilst for instance, Zimbabwe is facing a gap in the provision of schools, an estimated housing backlog of 1.25 million (Zimasset, 2013). The evidence noted above shows that the need for the implementation of projects is vast, though the resources for implementing these projects are limited. This was supposed to be the major driver of the implementation of PPPs projects. This current state of affairs makes economic growth difficult, as one of the impediments of economic growth is poor infrastructure and high infrastructure costs (ADB, 2011). As such, the objective of the

study is to investigate the paybacks and shortcomings of the use of PPPs in the delivery of construction projects in Zimbabwe.

2. Public Private Partnerships

A PPP is a long term arrangement between a public authority and private sector, in which the private sector finances the design and build of new facilities and operation of the construction works when completed (Hollowell, Price and Pollock, nd). This form of project delivery was first used in autumn 1992 by the UK government (Brook, 2008; and House of Commons, 2011). For a PPP project, the government usually invites the private consortia (Special Purpose Company (SPC) or Special Purpose vehicle (SPV)) to bid by submitting a proposal (Chan and Cheung, 2014). The SPV raises capital to finance, invest, maintain and manage the project (Chinyere and Xu, 2012; Kurniawan, Mudjanarko, and Ogunlana, 2015) and this capital is paid back to the private sector over a pre-determined concession period usually between 25-30 years (Uher and Davenport, 2009). The final users of projects usually pay back this capital with some part of the payment being met by the government. This then causes people to have different sentiments concerning PPPs, as people have the notion that government should pay for everything.

The use of PPPs method of delivery has successfully been implemented on construction projects in the United States of America (US Department of Transportation, 2007), in the delivery of high-quality facilities for public services in the UK (Brook, 2008) and thus they have increasingly been used as a mode of public service delivery in various countries (OECD, 2008). Whilst PPPs have not fully been embraced in most parts of Sub-Saharan Africa, South Africa has been reported to have implemented a number of PPP projects (Ter-Minassian, Hughes and Hajdenberg, 2008). In countries where they have been used, PPPs allow the provision of major capital projects without the government having to raise the capital required (Alshawi, 2009; Dube and Chigumira, 2010). PPPs promote economic growth (ZNCC, 2009; Dube and Chigumira, 2010) and ensure timely delivery of projects (Alshawi, 2009; ZNCC, 2009). PPPs result in improvement in efficiency levels in public services provision (Greve and Hodge, 2005; OECD, 2008; Dube and Chigumira, 2010) only if a proper risk allocation (Cuttaree and Mondri-Perrott, 2011) to a party that is best able to manage it at minimum cost (Mutandwa and Zinyama, 2015) is undertaken. In addition, PPPs allow knowledge and management skills transfer, and use of new technology (ZNCC, 2009). This will ultimately culminate in overall development of a nation thus raising the living standards in a country.

Opponents of PPPs point out that PPPs projects are undertaken at low transparency levels (Greve and Hodge, 2005), thus resulting in corruption which reduces the increased uptake of PPPs (Otairu, Umor, Zawawi, Sudongi, and Hammod, 2014; Osei-Kyei and Chan, 2016). The absence of specific and less rigid legislation for PPPs (Cuttaree and Mondri-Perrott, 2011), will culminate into failure on PPPs projects. It's not so obvious for every project to be delivered through a PPP arrangement (Koppenjan, 2005; Villalba-Romeo and Roumboutsos, 2015), thus the policy makers face the challenge of appraising and evaluating the public sectors which can be delivered more appropriately with PPPs (Greve and Hodge, 2005). Consequently, this delivery method may be difficult to use on small financially viable projects. Lack of government commitment or political will (Osei-Kyei and Chan, 2016), and poor communication amongst the PPPs project team members has also been found to be challenging the performance of PPP projects (Koppenjan, 2005), by causing delays in reaching a common decision by the involved parties. Expected bidders may also redirect all their attention to

profitability thus neglecting the economic effect of such projects to a country (Cuttaree and Mondri-Perrrott, 2011). This becomes a challenge as the targeted growth of a country may fail to materialise after undertaking such huge expenditures.

3. Research Methodology

The research was undertaken in Harare, and Bulawayo where construction companies are mainly concentrated (Saungweme, 2011). In addition, most government departments involved in these PPPs deals are based in Harare and Bulawayo. The researcher targeted directors and chief personnel in government departments and financing institutions as these were considered to have access to the information required for the study. Consultants (quantity surveyors, architects and engineers) and contractors also formed part of the study participants.

Quantitative and qualitative data collection tools were utilised for the study. The questionnaire respondents were selected through stratified random sampling and snowball sampling technique was largely employed to select research participants for the interviews. Projects delivered through the PPPs method are still very few and not every construction professional or contractor has been involved on such projects. Thus a total of 60 questionnaires were administered to the above mentioned group of respondents and 8 interviews were held with financiers and government departments dealing with infrastructure projects. Quantitative data was analysed through the use of weighted means approach. The weighted mean was also used by Chan *et al* (2010) who undertook a study concerning PPPs. The formula for calculating the weighted means has been adopted (How to Statistics, n. d.).

$$x = \frac{\sum_{i=1}^n (x_i * w_i)}{\sum_{i=1}^n w_i}$$

Where: w is weight given to each factor and x is value and n is the total number of respondents

The weighted mean formula was used for analysing data on benefits and challenges of using PPPs. A ranking of 1 to 3 was used to indicate their likelihood of occurrence where, 1 = Unlikely, 2 = Likely and 3 = More likely to occur. For consideration the weighted mean likelihood of occurrence of at least 2 since a weighted mean likelihood of 2 signifies that the benefit is likely to occur.

4. Findings and Discussion

Traditional procurement method was used as a delivery method by 69% of the questionnaire respondents whilst 6% of the projects were delivered through PPPs and 25 % of the respondents used other project delivery methods. This shows that there is a low extent of use of PPPs as a delivery method on Zimbabwean construction projects thus contradicting with (OECD, 2008).

4.1 Benefits of using PPPs for building projects

From the questionnaire that was administered, 95% of the respondents cited that there are benefits associated with undertaking PPPs and 5% pointed out that there are no benefits. The respondents were later tasked to rate the likelihood of occurrence of benefits associated with the use of PPPs. Table 1 shows the benefits associated with the implementation of PPPs as a delivery method for construction projects.

The three most likely benefits of PPPs ranked by respondents were found to be increasing the rate of infrastructure growth (weighted mean, 2.68), promoting economic growth (weighted mean, 2.63) and enabling governments to provide major capital projects without having to raise the initial capital (weighted mean, 2.62). The respondents also pointed out that PPPs offer better risk allocation (weighted mean = 2.48) and ensure the timely delivery of projects (weighted mean = 2.46).

Table 4: Benefits associated with PPPs on construction projects

Benefits of using PPPs	Weighted Mean	Ranking
Increasing the rate of infrastructure growth	2.68	1
Promote economic growth	2.63	2
Enable governments to provide mega projects without raising the capital	2.62	3
Offer better risk allocation	2.48	4
Ensure timely delivery of projects	2.46	5
Attract Foreign Direct Investment (FDI)	2.43	6
Offer higher project quality	2.38	7
Allow transfer of knowledge	2.38	7
Achieve better value for money	2.22	9

The interviewees cited that implementation of PPPs results in increased rate of infrastructure growth which concurs with questionnaire findings. This finding concurs with ZNCC (2009) and Dube and Chigumira (2010). Since construction is a major contributor to a nation's Gross Domestic Product (GDP), an increase in construction activities brought by PPPs is likely to boost the country's GDP hence improved economic growth (ZNCC, 2009).

A weighted mean of 2.62 revealed that PPPs enable the government to provide major infrastructure projects without having to raise the initial capital required for construction and this concurs with interview findings. Accordingly, the interviewees regarded PPPs as the "the only way forward" in the development of infrastructure in Zimbabwe primarily because of this benefit. In spite the fact that the government is currently facing financial challenges, PPPs still allow the government to meet its development goals, thus carefully planned PPPs projects are a panacea to infrastructure development.

The achievement of better value for money through the use of PPPs (weighted mean = 2.2) was ranked slightly lower but still significant. Better value for money could not be ranked highly perhaps as respondents cited that the PPPs projects that are in existent are charging high rates, and that maintenance is not regularly being done, thus contradicting Chan *et al.* (2010). Failure to charge affordable rates and poor maintenance is attributable to poor feasibility studies thus PPP projects will prove to be burdensome to developing countries (Tambulasi, 2010). The implementation of projects under PPP arrangement will bring out value for money if there is careful consideration of the interests of final beneficiaries of projects before the projects are implemented. The findings then uphold the view of Cuttaree & Mondri-Perrott (2011) who claimed that bidders of PPPs projects should not focus on profitability alone without carefully considering the impact of a PPP project to the sustainable development of a country.

Interview participants cited that a considerable number of housing projects delivered through PPPs were completed at the specified time, budget and quality constraints. Few of the PPPs projects were delivered more than two months late. Value for money and overall sustainable development was achieved on PPPs projects that were delivered at the expected time, cost and quality parameters henceenable the achievement of efficiency in public service provision (Greve and Hodge, 2005).

Based on this, the government of Zimbabwe can fully utilise PPPs, but only after carrying out the required planning and setting up of proper mechanisms that will enable successful implementation of projects.

The PPPs models in use have been formulated in developed countries, with different environments from that of developing countries in which they are being implemented. African countries should carry out research to determine the optimum models which can be applied in their environments. PPP projects are also more capable to achieve value for money on projects if the partners of the consortium are committed to the success of the projects and if careful feasibility studies are carried out before the actual implementation of a PPP project. Achievement of value for money on PPP is best assured by the existence of a clearly structured policy framework for PPPs.

4.2 Challenges in the implementation of PPP projects

Respondents were asked to rate challenges which were hindering the extensive use of PPPs in Zimbabwe. The respondents cited that the most likely challenge were political and social obstacles (weighted mean = 2.71) followed by lack of well-established policy framework (weighted mean = 2.38) and lastly, non-conducive financial market (weighted mean = 2.19). The political regime that is presently governing Zimbabwe has adopted policies and rules, some of which are quite hostile towards foreign investments such as the indigenisation policy which favours or gives preference to indigenous investors over foreign investors. Interview findings also support the fact that PPP implementation is hampered by the challenge of “absence of proper legal framework ad contradictory laws” for the governance of the implementation of PPP projects. One of the key success factors of PPPs is the presence of clearly established policies (Cuttaree and Mondri-Perrott, 2011), and these are lacking in Zimbabwe.

The interviewees cited that the banks of Zimbabwe lacked the capacity to raise the capital investment that is needed for the implementation of PPPs projects. For the few financial institutions that offered capital for PPPs projects, the challenge faced was the higher cost of capital (interest rates) which is provided by the financial institutions in Zimbabwe. Higher cost of capital has a negative effect of pushing up the construction costs thereby frustrating prospective investor's actions and this supports ZNCC (2009). Other challenges which interviewees cited were delays by government to approve PPP proposals due to absence of proper communication channels (Koppenjan, 2005).

5. Conclusion and Further Research

Use of PPPs on construction projects is beneficial to any country. The most likely perceived benefits realised in Zimbabwe include increase in infrastructure growth by enabling the government to provide major capital projects without having to raise the capital hence promoting economic growth. Also PPPs ensure that projects are delivered to the best possible quality at a given level of cost and time limitations. Therefore, it can then be concluded that if properly structured and implemented, PPPs could be an effective procurement method for delivering sustainable Zimbabwean government building projects. Although there are benefits associated with this delivery method, the implementation of PPP projects also faces some challenges such as political and social obstacles, lack of a well-established policy framework to guide their implementation and poor financial market currently prevailing in the country. If these are not properly addressed, then PPP implementation on construction projects will remain at a low level and thus preventing sustainable development.

In order to increase the rate of PPPs uptake in Zimbabwe and also to realise the full benefits of this procurement method, it is recommended that the government should enact PPPs act and publish detailed PPPs guidelines. The country should also establish an independent PPPs monitoring agency which has the responsibility of governing the implementation of PPPs projects. More research should be carried out to determine the effective ways in which PPPs projects can be implemented on new and existing facilities such as schools, sports stadiums and housing schemes so that a holistic view of the performance of PPPs construction projects can be determined.

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Exploring Gilbert's Behavioural Engineering Model (BEM) for improving Risk Allocation in the Zambian Building Sector

Chipozya Tembo¹, Nthatisi Khatleli²

Abstract

Completion of a construction project within time and cost, without disputes, claims or tensions are the main indicators of good project delivery. However, the construction industries in developing countries seldom deliver projects within the aforementioned parameters due to risks. The allocation of risks by contracting parties affects performance negatively if improperly allocated. As a consequence, proper risk allocation is always desirable. An understanding of how risk allocation can be enriched through human performance improvement is vital for the construction industry in developing countries to improve project delivery. This research explores how risk allocation can be enhanced through identifying the human performance improvements that can be harnessed from the use of Gilberts Behavioural Engineering Model. The study used interviews and questionnaire survey to explore how Gilbert's management model can be used to improve risk allocation in the construction building sector. It was found that firms have un-formalised and un-systematic risk management practices, clients offer incentives occasionally for risk liability; and lack of knowledge and skill in quantitative risk analysis is wide spread. Additionally, risk monitoring is not done by most professionals. The study focused only on how Gilbert's Behavioural Engineering Model can be used to improve risk allocation in the construction industry from a human perspective. The identification of human performance areas for risk allocation could enable construction professionals and stakeholders appraise themselves and thereby improve the allocation of risk leading to improved project delivery.

Keywords: risk allocation, construction industry, BEM, building sector

1. Introduction

Risks are a common feature of construction projects regardless of the magnitude of the project. This makes risk management and risk allocation inevitable. The generic understanding of risk is that it is an uncertain event or occurrence leading to a loss. However, Cano and Cruz (2002) define it as "an uncertain event that, if it occurs, has a positive (opportunities) or negative (threats) effect on a project objective". Consequently, appropriate assignment of risk is essential in a project environment to ensure a project is delivered within budget, schedule, to the required quality, with minimal tensions

¹Lecturer, Department of Construction Economics and Management, Copperbelt University, chipozya@yahoo.co.uk, Tel No. +260 212 225086; PHD Student, Department of Construction Economics and Management, University of the Witwatersrand.

²Senior Lecturer, Department of Construction Economics and Management, University of the Witwatersrand, Nthatisi.Khatleli@wits.ac.za, Tel No. +27 11 717 7651.

and disputes (Alsamam & Sillars, 2013). The resultant effects of risk misallocation make the practice of equitable risk allocation fundamental to project performance. Nevertheless, risk allocation is understood differently in different industries or fields. In construction, risk allocation is the assigning of management responsibility and liability for risk(s) (Alsamam & Sillars, 2013) while in finance, it is the assignment of risk reserves from a total project or portfolio level to individual constituent elements (Smart, 2014). Notwithstanding, risk allocation practice have been described in various ways in the construction industry such as poor, unbalanced, misallocated, and inappropriate (Alsalman & Sillars, 2013; Baloi & Price, 2003; Khazaeni, *et al.*, 2012), resulting in numerous research on risk allocation. However, the current discourse in existent literature has a focus of identifying misallocated risks and seldom establishing why risk misallocation persists.

For risk allocation to be done properly; risk identification, risk analysis, response, monitoring/control, and communication should be carried out in the allocation process. Poor risk allocation refers to any instance of misallocation including incomprehensive (some risks are unallocated) allocation of risks (Meng, 2012; Mead, 2007). It is unbalanced if most of the risks are allocated to one party (Alsamam & Sillars, 2013; Bakr, Khaled, & Ayda, 2012); and balanced risk allocation identifies and distributes liability associated with risk events in order to proportionally distribute possible prospect loss or gain of project (Khazaeni, *et al.*, 2012). Inappropriate risk allocation refers to the contractual shifting of risk to the contracting party with the least amount of bargaining power, this is also misallocation (Hanna, *et al.*, 2013). Alsalman and Sillars (2013) established that when risks are generally not allocated equitably; this results in disputes, claims quality shortfalls, time and cost overruns.

The Zambian construction industry (ZCI) has shown poor performance from 2003- 2012 according to the Zambian Auditor general's report (2012), evidenced by poor quality, time and cost overruns. These challenges are mostly attributed to incomplete contracts, poor management of risk in the implementation stage, poor risk sharing (Sibanyama *et al.*, 2012) and lop-sided contracts where risk(s) is mainly shifted to the contractor (Mukumbwa & Muya, 2013). Other studies have identified various factors hindering risk management and as a resultrisk allocation, resulting from human factors such as knowledge, information, skill etc. (Chileshe & Kikwasi, 2013). This study, with the use of Gilbert's management model, endeavours to explore the interventions needed to improve risk allocation in the Zambian construction industry by using the building sector. The sector is chosen because little research has been done in this area in the Zambian context. Additionally, the majority of projects carried out are building projects and the Zambia Development Agency report (2013) shows deficits for infrastructure in this sector (housing, health facilities and education facilities). The interventions will be determined by understanding and analysing the current environmental supports and personal repertory behaviours in the Zambian building sector using a mixed method approach.

2. Risk Management Practice in the Construction Industry

Construction organisations that manage risks effectively and efficiently enjoy financial savings, greater productivity and improved success rates on new projects (Banaitiene & Benaitis, 2012). However a study done by Akintoye and Macleod (1997) revealed that risk management (RM) and risk allocation was not used due to; lack of familiarity with the techniques in RM by practitioners, inadequate time and lack of information, the sophistication of the process; and doubts resulting regarding suitability. Uher & Toakley, (1998) identify culture, lack of knowledge, negative attitude and mistrust as barriers to RM. Lyons and Skitmore (2004) point out lack of time, lack of familiarity

with techniques to use and lack of resources as hindrances; Choudhry and Iqbal (2013) through a survey revealed that RM is not utilised because; organisations lack formal risk management systems; lack joint risk management systems; shortage of knowledge on appropriate techniques; complexity of RM, and reactivity of the RM practice. Further to this, RM is centralised rather than decentralised; risk analysis is done rather than risk identification; RM periodic rather than continuous; there is usually lack of historical data for risk trend analysis and lastly consciousness of risk is simply absent (*Ibid*). Chileshe and Kikwasi (2014) discovered a lack of expertise in techniques, difficulties in seeing the benefits, lack of information, disparities in cost-effectiveness, lack of knowledge on RM process by contractors and clients, lack of familiarity with RM process concepts and methods and lack of information as barriers to risk management. Mu *et al.* (2014) argue that the application of RM is dependent on risk management capabilities. Sherry and Wilson, (1996) point out that people are agents for organisational change hence success depends on human capabilities. However, Boulay (n.d.) suggests that organisational competence is limited by individual competence hence the human asset is seen to be very valuable. In contrast, Gilbert (1988) contends that competence of an individual should be the last intervention, environmental factors such as information, incentives and instrumentation have to be in place. In affirmation Rothwell, *et al.*, (2007) conclude that most problems in organisations stem from the environment in which people work rather than the individual. In spite of this, Boulay (n.d.) suggests that individual competence and organisation competence (environment) must be aligned for an organisation to adapt its environment. More often than not, training is viewed as the only means for achieving improved performance (Rothwell, *et al.*, 2007) however; it should be the last resort. This is because most problems in a work environment stem from the environment in which work is performed rather than in the individual/organisation that is performing the work (*Ibid*). The next section discusses Gilbert's management theory.

2.1 Gilbert's management theory

The management theory of Thomas Gilbert was debited in 1978 (Chyund, 2005). Gilbert (1988) posits that there is differentiation between behaviour and an accomplishment that is an outcome of that behaviour. Gilbert explained that accomplishment and behaviour are two aspects of human performance, that is, "in performance, behaviour is a means; its consequence is the end" (Gilbert, 1988, p. 49 cited in Chyund, 2005). Gilbert business management ideas concern changing the behaviour of organizations and/or employees, in this case, it refers to the temporary organization created by the construction client. The theory is aimed at identifying deficiencies management oriented in a project organization and identify areas that need improvement (Gilbert, 1978). Gilbert's model (management theorem) will be adapted to fit the risk allocation challenge the industry is facing. Gilbert listed six areas where causes of the performance deficiencies might be found: data, instruments, incentives, knowledge, capacity, and motives (Chyund, 2005). The first three categories are environmental supports, and the last three categories are the performer's personal factors (See table 1). The theory has the following principles:

- (1) that workers/organization need to have the right information (data, information, and feedback), the right resources (environment support, resources, and tools) and the right motivation (consequences, incentives, and rewards);
- (2) It is important that incentives do not reward bad behaviour (as an example, an incentive that makes a contractor take shortcuts on the task); and
- (3) If all the conditions are in place for the organization to perform well and it does not, it becomes a matter of considering the client (consultant) or contractors' motivation. By observing the

organization's behaviour, new conditions are to be put in place to get the organization to perform well.

Table 1: Gilbert's behaviour engineering model

	Information	Instrumentation		Motivation
Environmental Support	Data	Work	Environment	Consequences
	Information	Support		Incentives
	Feedback	Resources		Rewards
		Tools		
Person's Repertory of Behaviours	Skills Knowledge		Individual Capacity	Motivation
				Expectations

Source: Tiem, Mosley & Dessinger (2012)

2.2 Environmental support

2.2.1 Data, information, and feedback

Risk allocation and the success of risk management need the necessary data, information and feedback to be provided. In a project environment, type of client, procurement route preferred, nature of the project, site data and information are important considerations for risk. Various members of the project team such as the quantity surveyor, architects, project managers, contractors and engineers need timely information to carry out their work. When it comes to risk allocation, internal and external risks should be understood so that relevant decisions are made. Feedback is also needed as it leads to improved performance (Stolovitch, 2000). It could nevertheless be acknowledged that this view is not universal, for instance Stolovitch (2000) argues that immediate feedback is more beneficial for simple tasks while complex tasks require delayed feedback. Having the relevant data, information, and feedback are not enough; project team members have to have the relevant skills and knowledge to act on the aforementioned (Mu *et al.*, 2014). Once the required data, information, and feedback are in place the project organisation needs the relevant resources, tools, supports and work environment to foster risk management and therefore risk allocation.

2.2.2 Work environment and tools- Instrumentation

Instrumentation refers basically to the right tools and resources that should be available to the project organisation to do their work. Various tools and resources have been identified as useful for carrying out risk allocation which is an iterative process requiring risk identification, analysis, risk treatment, monitoring and communication/reporting (Cagliano *et al.*, 2015). Risk identification determines which risk might affect the project and documents their characteristics, as an iterative process because new risk may become known as the project progresses (Bakr *et al.*, 2012). Tools for risk identification include checklists, brainstorming, the Delphi technique, interview/expert judgement, influence diagrams, flowcharts, and cause-and-effect diagrams (Project Management Institute (PMI), 2004). Risk analysis the second stage needed to allocate risks is a process that examines each identified risk, refines the description of the risk and assesses the associated impact qualitatively or/and quantitatively (PMI, 2004). Risk analysis tools include quantitative approaches (probability analysis, sensitivity analysis, scenario analysis) and qualitative approaches (direct judgement, ranking options, comparing options and descriptive analysis) (PMI, *ibid.*). These have been mainly developed to address the project deliverables of schedule (time), budget (cost) and quality (Imbeah & Guikema, 2009). The only technique that addresses all parameters is the advanced programmatic risk analysis and management model (APRAM) (Zeynalian *et al.*, 2013). APRAM needs a rich database for its

application hence it is seldom utilised (*Ibid*). Risk response the area in which risk allocation is done is a process that allows for developing options and determining actions to be taken to enhance opportunities and reduce threats to the project objectives (Hilson, 2002). It involves choosing alternative response strategies; implementing a contingency plan, taking corrective actions and re-planning the project (Bakr *et al.*, 2012). Response measures could be alternative procurement methods, alternative construction method/material, the use of insurance or bonds, contingency introduction (time or money), sub-contracting or even collaboration (Bakr *et al.*, 2012; PMI, 2004). While the identified tools and resources can be used to equip organisations, it is of paramount importance that these are updated to suit the current environment to ensure performance is improved. Contract practice in terms of procurement methods and contracts in use define the environment. This has to be enabling to necessitate appropriate risk allocation. The work environment needs to be enabling to enhance performance. Once all these are in place incentives need to be in place and consequences for actions need to be understood.

2.2.3 Consequences and incentives

Normally, there has to be an incentive for carrying a risk in a project (Ashworth, 2006). This will act as an enabler for the project participants to perform. These could be consequences, rewards or incentives in monetary or non-monetary terms (Gilbert, 1978). Consequences could be in the form of lost revenue e.g. liquidated and ascertained damages. Rewards in the construction industry mainly depend on the type of contract used and the efficiency in the implementation phase. For instance, in guaranteed maximum price contract there is an incentive for completing a task below the agreed maximum price (Hackett *et al.*, 2007) while in a fixed price contract savings made by being more efficient obviously without comprising the expected quality could be viewed as a reward. Once environmental supports are in place persons repertory behaviours have to be looked at.

2.3 Person's repertory of behaviours

2.3.1 Skill, knowledge, capacity and motivation

Individual factors that affect performance include skill, knowledge, capacity and motives. The most common mode of fixing knowledge, motives, and capacity shortfalls is training, while fostering the right motives could be by understanding the values and needs of individuals/organisations and later provide them (Chyund, 2005). The role of knowledge cannot be undermined even in using environmental factors such as information, data, and feedback. A knowledge-based approach has been advocated for by Serpella *et al.* (2014) in improving risk practices.

3. Methodology

Semi-structured Interviews and a questionnaire survey were conducted to investigate the risk management practices used in the Zambian building sector with a view of suggesting improvement areas. The approach taken for this research is the mixed method approach; using semi-structured interviews and questionnaire survey on industry practitioners (consultants and contractors) with sample sizes as shown in tables 2 and 3.

Table 2: Respondents' profile (questionnaire survey)

Category	Firms	Population	Responses	Response rate %
Contractors	Building Category	150	79	52.6%
Consultants	Quantity surveyor	36	32	88.9
(firms) engaged in buildings	Engineers	32	28	87.5
	Architects	54	38	70.4
	Project managers	17	14	82

Table 3: Respondents' characteristics (interview)

Respondent	1	2	3	4	5	6	7	8	9	10	11
Sector	Pub	Pub	Pub	Pub	Pri	Pri	Pub	Pri	Pri	Pri	Pri
Experience in Years	15	12	20	19	10	32	23	30	29	10	10
Role	QS	Eng.	QS	Arc	Ktor	PM	PM	Eng.	Ktor	Ktor	Arc

Pub-Public sector, Pri –Private sector, QS-quantity surveyor, Eng.-engineer, Arc- Architect, PM project manager, Ktor- Contractor

The mixed method approach was used to establish how widespread practices are and to elicit in-depth information on the practices. Only a selected number of practices are recorded here; environmental supports (work environment and tools, and incentives) and persons repertory behaviours (skill, knowledge, and motivation). For semi-structured interviews, purposive sampling was used to select industry practitioners with at least 10 years experience in the building; while the questionnaire survey (similar approach by Alsaman & Sillars, 2013; Hanna, *et al.*, 2013) used random sampling of firms to ensure that the recorded information could be generalised to the industry. Content analysis was used to analyse the semi-structured interviews and descriptive statistical analysis using SPSS version 20 was used for the analysis of questionnaire survey.

4. Findings and Discussion

4.1 Environmental supports

4.1.1 Work environment- risk management practice

Risk management practice and consequently risk allocation is generally un-formalized and unsystematic in the Zambian constructionbuilding sector, and this was pointed out in the interviews and confirmed in the questionnaire survey. The survey provided evidence that 62.2% of the firms do not have a formalised and systematic risk allocation approach while 37.8% do. However, those who have formalised and systematic approaches only use them when things go wrong. The practice of risk management and consequently, risk allocation results in the incomprehensive allocation and use of inadequate risk response mechanisms.Nevertheless,risk allocation has to be done for both contractual and non-contractual risks. The Zambia construction industry is not the only country in a developing context with un-formalized and unsystematic RM practices. For instance, Siang and Ali (2012) in Malaysia, Visser, *et al.*, (2008) in South Africa and Perera, *et al.*, (2009) in Sri-Lanka all record similar findings.

4.1.2 Tools/techniques

Various tools/techniques are available for risk allocation and management (Project Management Institute, 2004). Processes used in the Zambian construction industry are shown in Table 4.

Table 4: Risk management processes, and tools/techniques

Process	Percentage usage of Tool/technique				
Risk identification	Site visits 88%	Experience from past projects 79%	Local knowledge 72%	Brainstorming 63%	Checklists 57%
Risk analysis	Expert Judgment 59%	Brainstorming 56%			

The results on risk identification show that it is widely practiced although simplistic subjective techniques are generally utilized. Risk analysis, on the other hand, is not widely practiced. The methods used for analysis are simplistic and qualitative in nature and complex methods such as Monte Carlo simulation are uncommon (used by 4%). From the performance of the industry, there is an indication that risk allocation might be alleviated by use of more objective methods and complex approaches for relatively complex projects. Monitoring techniques are those that are indicated for identification and analysis except monitoring was indicated as adequately done by 42.6% of respondents, 13.9% are unsure of the adequacy on monitoring done while 43.6% clearly indicated that the monitoring done is inadequate. The tools and techniques used point to risk management being at novice level according to Hilson, (2002) maturity model. Implying that the need for risk management and allocation is recognised but the practice of it is un-formalised and unsystematic.

4.1.3 Incentives

Incentives are commonly construed as a positive; the negative forms of incentives are possible through penalties. In the construction industry, penalty clauses are used to achieve this. The questionnaire survey provided evidence that penalty clauses are adequate in allocating risk. Therefore, players could also be said to have incentives to perform by the presence of these clauses in the contract. Nonetheless, the interviews pointed out that clients are not normally compliant to contract provisions. This results in risks allocated in this manner being unnecessarily borne by the contractor. Notwithstanding, only 45.1% of the questionnaire respondents indicated that incentives provided on projects are adequate for risk liability. This shows that clients need to provide more incentives for risk liability for contractors and consultants. Notwithstanding, Gilbert's management model (1978) recognises the provision of incentives for the attainment of desired results in an organisation such as a project organisation which is temporary in nature.

4.2 Person's repertory behaviours

4.2.1 Skill and knowledge

Both the interviews and questionnaire survey indicate that skill and knowledge in the building sector are more in risk identification. However, the questionnaire survey further provides evidence that various players have skill in varying aspects of risk allocation. This is shown by using a mean score out of 5 where 1 is not adequate at all and 5 is exceptionally adequate as shown below.

Table 4: Risk management abilities in building sector

Respondents	Risk Identification	Risk Analysis	Risk response	Risk control	Risk communication
Consultants	3.3814	3.3021	3.1789	3.1959	*3.4124
Project Managers	3.9231	3.3692	3.7692	3.3692	*4.0769
Contractors	3.3333	3.1519	3.0385	2.9367	*3.3671

*High skill and knowledge by respondent type

Consultants have the least skill in risk response. The least skill by project managers is risk analysis. Evidently, the mean scores for risk analysis are the same for risk control. While contractors risk control is the least skill. It is saddening that respondents indicated not to have high skill where their inputs are key. In addition, risk monitoring was indicated as adequate by 42.6% of the respondents, 13.9 were unsure and 43.6% found monitoring inadequate. Given that monitoring is not adequate it implies that even though risk communication is an area of skill and knowledge; it is ineffectively done. Skill in risk monitoring should be attained as Gilbert management model (1978) motivates for skill as a contributor to performance.

4.2.2 Motivation

The questionnaire survey demonstrates that majority (73.3%) of players in the industry are motivated by financial gain. However, it is unclear if the financial benefits given are adequate. Other forms of motivation include gaining experience and gaining knowledge (prevalent among those with 1-5 years' experience), career development (prevalent among those with 1-5 and 6-10 years' experience) and Satisfaction of achievement/excellence (prevalent among those with 6-10 and over 15 years' experience). To attain required performance motivation should be adequate (Gilbert, 1978).

5. Conclusion

Using Gilbert's management theory, as a lens shows that not all conditions are in place for the construction organisations to perform well. Environmental supports and person's repertory behaviours need to be improved to achieve desirable project outcomes. It has been demonstrated that the industry does not always have the right resources (inadequate environmental supports and inadequate tools) and motivation (poor incentives). Risk allocation practice in the Zambian building sector is being inhibited by both environmental supports (lack of RM system) and personal repertory behaviours (inadequate skill in quantitative risk analysis, risk monitoring). Nevertheless, current risk allocation practice in the Zambian building sector has room for improvement. Some of the practices hindering performance are un-formalised and unsystematic risk practices, poor knowledge and skill in risk monitoring and risk analysis, and subjective tools. These could be mitigated by, formalised and systematic risk management practices, offering of incentives for risk liability and improved knowledge and skill through training.

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Key Factors for the Development of Sustainable Stakeholder Management Framework for Construction Projects in Ghana

Emmanuel Eyiah-Botwe¹, Clinton Aigbavboa², Wellington Thwala³

Abstract

Stakeholder management is one of the project management soft skills for enhanced project success in developed countries. This paper identifies the main factors for the development of a conceptual framework for the successful stakeholders management process. It is part of a broader PhD research aimed at developing “Sustainable stakeholder management framework for construction projects in developing countries”. Twelve stakeholder management processes for the developed countries identified in literature were reviewed and validated using Delphi survey technique. The Delphi study identified seven factors namely: external environment; pre-stakeholder identification; stakeholder identification process; stakeholder classification and prioritization; stakeholder engagement, implementation, monitoring, feedback and continuous support as impacting on successful stakeholder management process. It further validated seven outputs: meeting project targets; stakeholder needs; satisfaction; improved delivery and stakeholder relationships. Related attributes will be validated using Delphi and quantitative survey techniques. Project success in developing countries will be enhanced when project managers employ the developed sustainable stakeholder management framework.

Keywords: construction projects, developing countries, Ghana, management, stakeholder

1. Introduction

Many public sector projects are initiated and sponsored by governments in developing countries governments' for socio-economic development objectives (Othman, 2013). Infrastructure development contributes significantly to employment, Gross Domestic Product and growth of other sectors of nation's economy (Ofori, 2012). The successful delivery of these projects is crucial requiring improved project management controls to avoid the mega-costs and schedule (Relle, 2014). Projects have many individuals and organisations involved in the delivery and their diverse interest and needs affect the project outcome. According to Eskerod and Jepsen (2013), carrying out a project as planned is not a guarantee for success. Projects may fail because project management does not take

¹ Doctoral student: School of Engineering Management: University of Johannesburg, South Africa: ebotwe123@yahoo.com

² Associate Professor: Construction Management and Quantity Surveying: University of Johannesburg, South Africa: aigbavboa@uj.ac.za

³ Professor: Construction Management and Quantity Surveying: University of Johannesburg, South Africa: didbhutu@u.ac.za

the requirements, wishes and concerns of stakeholders sufficiently into account. Studies on stakeholder management have increased in recent years (Yang, 2014; Donaldson and Preston, 1995). While developed countries including the United Kingdom, Australia and Finland have embraced stakeholder management process, developing countries are yet to embrace it (Chinyio and Olomolaiye, 2009). Scholars suggest that stakeholder management should entail systematic planning, analysing and coordinating all activities related to project stakeholders for project success (Lock, 2007; Eskerod and Jepsen, 2013).

A study on stakeholder management impact on project delivery in Ghana revealed that this process is not entirely adhered and formally documented (Eyiah-Botwe, 2015). The failure to adhere is partly due to the absence of a framework for formal stakeholder management process. Projects involve a wide array of stakeholders with diverse culture, geographically dispersedly located, different procurement approaches and industry practices which impact on stakeholder management hence the need for the formal process (Olander and Landin, 2005; Rwelelila, 2009; Mok et. al., 2015). The goal of this study is to determine the key factors for the development of a conceptual framework for construction projects stakeholders' management process in Ghana. Three research questions were developed as: "What are the existing stakeholder management processes and frameworks"? "What are the gaps in the literature regarding critical success, barrier factors and industry practices that impact on the successful stakeholder management process"? "What are the major factors and outputs for a successful stakeholder management process in Ghana"? The study adopts a qualitative research approach and content review of the literature on stakeholder management process and frameworks. Factors identified in existing processes are discussed and validated using a Delphi survey technique.

2. Review of Literature

2.1 Construction industries in developing countries

The Ghanaian construction sector is similar to other developing countries, responsible for infrastructure development, which is the determinant of socio-economic and socio-cultural activities (Ofori, 2012). The industry contributes significantly to the global economy, estimated as having 7-10% of the global workforce (Mwanaumo, 2014; Chinyio & Olomolaiye, 2010). The industry is a driver of growth in other sectors due to the extended and varied supply chain (Ofori, 2012). The industry is saddled by several challenges including the many diverse participants, small and medium-sized enterprises, ethical issues, socio-cultural practices, legal, unstable economy, and negative political interference among others. These external factors impact on the construction industry practices and stakeholder management. Othman (2013) mentions challenges encountered by developing countries construction industries as engineering, human development, managerial and political. Ghana is not an exception as many developing countries have cross-country labour force and similarities in their construction industry practices by the geographical location in a region or by colonisation which impact on stakeholder management approach (Mwanaumo, 2014).

2.2 Procurement approach and project delivery

One construction industry practice impacting on project stakeholder management is the procurement approach adopted. Love *et al.* (2002) opines that procurement method assigns specific responsibilities and authorities to the participants. The procurement method shapes the relationships, establishes contractual frameworks, determines the nature of relationships for the period of stakeholders

interaction (Oyegoke *et al.*, 2009). Rwelelamilia (2009) argues that one fundamental aspect of the project construction process that requires early attention for project success in connection with stakeholder management is the building procurement system. Procurement system defines stakeholders roles, creates social relationships, power structure, individual responsibilities, sequence of activities practices and techniques of management (Newcombe, 1996; Rwelelamilia, 2010). Separated, integrated and management oriented systems define the structure, stakeholders involved, needs, interaction and contractual framework (Ren *et al.*, 2012). The Public Procurement Act of Ghana, Act 663 though approves the use of any of the three methods. The traditional method (separated system) is mainly used. The major challenge is the stage of stakeholder involvement and the inability to maintain a set of participants for the same or similar project. Nguyen *et al.* (2009) argue projects have diverse stakeholders with interest and needs and have to be rigorously managed for project success.

2.3 Project stakeholder

The stakeholder and stakeholder management concept has gained prominence in the past three decades (Donaldson and Preston, 1995). Mitchell *et al.* (1997) state that the stakeholder concept has become embedded in managers' thinking and management circles since Freeman (1984) published his book, Strategic Management: A Stakeholder Approach. The stakeholder concept has since gained relevance (Newcombe, 2003; Olander and Landin, 2005, Yang *et al.*, 2014). The questions raised are: "who are and what are stakeholders in a firm", "whom (or what) managers pay attention", "what do project stakeholders expect from a project". Several theories on stakeholder salience have evolved (Donaldson and Preston, 1995; Mitchell *et al.*, 1997). To answer the question "Who is a stakeholder?", Elias *et al.* (2002) later suggested the diversification of stakeholder concept into corporate planning, system theory, corporate social responsibility and organisation theory. Projects irrespective of the size have several individuals and the group that "affect" or are "affected" by the project outcome (Freeman, 1984). The mega the project size the likelihood of the increased number of participants who asserts to have "stake" or some "right" (Carroll, 1989), "legitimate interest" (Donaldson and Preston, 1995). Although there may be several participants, there are those "actively involved" and have "stake" (Newcombe, 2003). These stakeholders include project owners, end-users of facilities, project champion, project manager, facility managers, designers, client representatives, contractors, subcontractors, suppliers, process and service providers. Additionally, sponsors, community representatives, neighbours, government establishments, development agencies, traditional authorities, politicians, statutory approval bodies, town councils and planning departments are considered as project stakeholders (Chinyio and Olomolaiye, 2010).

2.4 Stakeholder management

Projects stakeholders have a wide array of interests and demands that need to be considered in the managerial decision-making to ensure a successful project delivery (Cleland, 1986, Diallo and Thuillier, 2005). Jergeaset *et al.* (2000) emphasizes the need for efficient management of the relationships between the project and its stakeholders as key to project success. Stakeholders' needs should also be brought to the fore, and a stakeholder relationship developed to address the needs (Bourne and Walker, 2005). Project success can be realised if stakeholders' management process entails identifying, gathering information and analysing stakeholders influence through a systematic approach (Young, 2006; Lock, 2007). The research identified stakeholder management process developed between 2000 and 2015 (Table 1).

Table 1: List of identified stakeholder management factors by scholars (2000-2015)

Scholar (Year)	Proposed stakeholder management process
Karlsen (2002)	Identification of stakeholders; analysing the characteristics of stakeholders; communicating and sharing information with stakeholders; developing strategies, following up.
Elias <i>et al.</i> (2002)	Developing a stakeholder map of the project; preparing a chart of specific stakeholders; identifying the stakes of stakeholders; making a power versus stake grid; conducting a process level stakeholder analysis; conducting a transactional level stakeholder analysis; determining the stakeholder management capability of the R&D projects; analysing the dynamics of stakeholder interactions.
Young (2006)	Identifying stakeholders; gathering information about stakeholders; analysing the influence of stakeholders
Bourne and Walker (2006)	Identifying stakeholders; prioritizing stakeholders; developing a stakeholder engagement strategy
Olander (2006) adopted Cleland (1999)	Identification of stakeholders; Gathering information on stakeholders; Identifying stakeholder mission; Determining stakeholder strengths and weaknesses; Identifying stakeholder strategy; Predicting stakeholder behaviour; Implementing stakeholder management strategy.
Lock (2007)	Systematic identification, analysis and monitoring of stakeholders
PMI (2008)	Identify stakeholders; plan communications; distribute information, manage stakeholders expectation; report performance
Walker <i>et al.</i> (2008)	Identifying stakeholder; Prioritizing stakeholders; Visualizing stakeholders; Engaging stakeholders; Monitoring effectiveness of communication.
Jepsen and Eskerod (2009)	Identification of the (important) stakeholders; characterization of the stakeholders pointing out the (a) needed contributions, (b) expectations concerning rewards for contributions, (c) power about the project; the decision about which strategy to use to influence each stakeholder.
Yang (2010;2014)	Stakeholder identification, stakeholder assessment, decision making, action and evaluation with continuous support.
Chinyio and Olomolaiye (2010)	Involves identifying and classifying stakeholders for initial and subsequent engagements with the parties concerned; timely, planned and in a coordinated manner
Bal <i>et al.</i> (2013)	Identify stakeholders; relate with issues; prioritise stakeholder and issues; manage stakeholders; measure performance; put targets into action
Eskerod and Jepsen (2013)	Stakeholder management consist of all purposeful activities carried out in connection to the project stakeholder to enhance project success.
Aapaoja and Haapasalo (2014)	Defining the project purpose and customer constraints; Identifying project stakeholders according to their functional role; Assessing the stakeholder salience and the probability of their impact/ability to contribute; Classifying and prioritizing stakeholders according to four groups.

3. Research Methodology

A qualitative research approach was adopted. Three research questions formulated are: “What are the existing stakeholder management processes and frameworks?”, “What are the critical success, barrier factors and construction industry practices that impact on successful stakeholder management process?” and “What are the major factors and outputs for a successful stakeholder

management process in Ghana”? This necessitated a review of the literature on the stakeholder concept, stakeholder management process and frameworks.

The first stage involved using the University of Johannesburg database and Google search engines. Keywords, “stakeholder”, “stakeholder management”, “construction industry”, “critical success factors” and a combination of the keywords was used to identify the relevant publications. The content review considers papers published between 2000 and 2015. Yang (2014) and Osei-Kyei and Chan, (2015) employed the filtering method for similar studies.

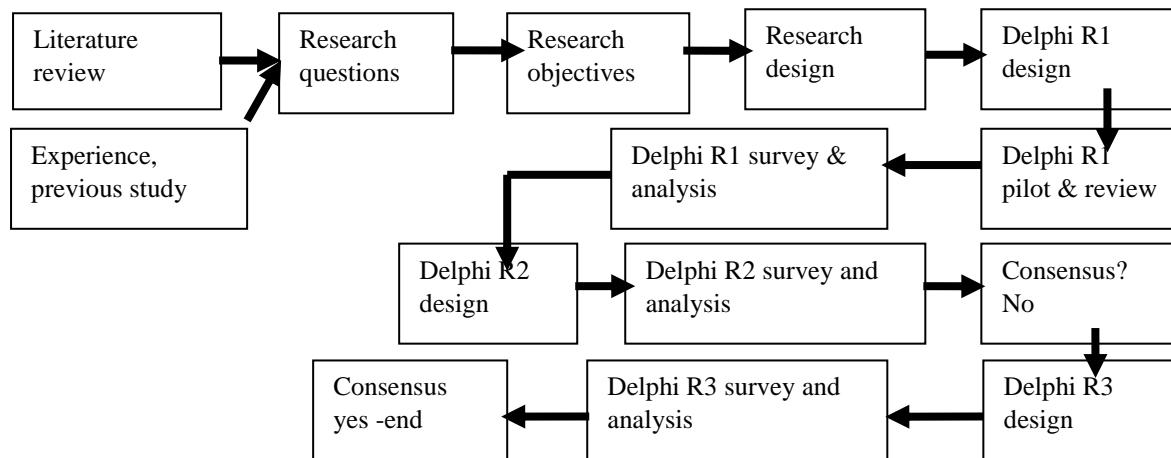


Figure 1: Research design (Source: Authors)

A Delphi survey technique was used to seek the views of experts in the field (Bourne, 2005; Chan *et al.*, 2010). The study considers a set of eight factors criteria outlined by Hallowell and Gambatese, (2010). An expert needed to meet six of the criteria, more than half of the set criteria to qualify (Chan *et al.*, 2010; Hallowell and Gambatese, 2009). Eighteen experts participated through email correspondence. According to Skulmoski *et al.* (2007), Delphi participants’ should meet four “expertise” requirements: i) knowledge and experience with the issues under investigation; ii) capacity and willingness to participate; iii) sufficient time to take part in the Delphi and 4) practical communication skills. Twelve experts who are experienced industry practitioners initially accepted the invitation to participate in the survey. However, ten experts finally responded to the first round of Delphi survey conducted which was open-ended, second round review of summarised factors, third round items and ratings summarised (Hsu and Sanford, 2007). The first round was piloted using two experts and preceded the two principal stages of design, survey and analysis. Each round of the Delphi survey required two weeks minimum. Three criteria were set for consensus at the beginning to include: 1) 80-100% score, ii) 4-5 median range for a five-point Likert scale and a mean of 4.0. The set criteria together with the three rounds and ten experts involved meet the Delphi criteria suggested by many scholars (Chan *et al.*, 2010; Hallowell and Gambatese, 2009).

Table 2: Experts' qualification criteria

Experts' eligibility criteria	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
1 Has extensive professional experience as a PM in the Ghanaian construction industry-At least five years' experience (Chan <i>et al.</i> , 2010)	X	x	x	x	x	x	x	x	x	x
2 Detailed knowledge of construction project stakeholder management, procurement systems and communication	X	x	x	x	x	x	x	x	x	x
3 Authorship of at least five articles in well-rated journal in project management (Roger and Lopez, 2002)		x	x		x	x	x			
4 Conference Presenter: Second peer-reviewed conference, Have attended a minimum of 10 conferences (Roger and Lopez, 2002)	X	x	x		x	x	x		x	x
5 Faculty member, Head of Department related to construction, involved in construction projects, advanced research in the related field	X	x	x	x	x	x	x	x	x	x
6 Qualified member of a professional body, Ghana Institute of Architects, Institution of Surveyors or Engineers. Participated in professionally related forums, workshops, demonstrated the desire to advance the discipline or a Council member	X	x	x	x	x	x	x	x	x	x
7 Currently/Having managed a mega construction project with diverse participants	X		x	x		x		x	x	x
8 Advanced degree in the field of project management-A minimum of MSc, PG (Arc)	X	x	x	x	x	x	x	x	x	x

3.1 Identification and review of stakeholder management process

The study considered three steps during the critical factors identification process as 1) Identification of the existing publications on stakeholder management process; 2) Review of main factors/process outlined and proposed by scholars; 3) Validation of the main factors identified from steps 1 and 2. Publications on stakeholder management and critical project management success factors from the University of Johannesburg database and google scholar mainly were reviewed using a filtering process involving the keywords. This study acknowledges the extensive literature reviews by Yang (2014) and Osei-Kyei and Chan (2015) which described the stakeholder management processes and critical success factors for project management respectively, mainly for developed countries.

3.2 Review of the major factors identified by scholars

Although the most literature suggests stakeholder identification as the first major consideration factor, Yang (2014) opines the need to assess pre-conditions of legal, ethics, economic and social factors. This assertion is buttressed by Osei-Kyei and Chan (2015) and Gudiene *et al.* (2013), both mentioning social, economic, political, cultural, ethics and legal conditions as impacting on successful project management. Gudiene *et al.* (2013) categorise these as external environment factors. Mitchell *et al.* (1997) suggest that stakeholder attributes are socially constructed and need attention. Aerni (2005) argues the need to consider political and socio-cultural stakeholders' whose concerns are as a result of political affiliation. Olander (2006), PMI, (2008), Jepsen and Eskerod (2009) failed to assert. Karlsen

(2002) and Young (2006) suggested stakeholder identification as their first major factor, but recent publications by Yang (2014) and Aapaoja and Haapasalo (2014) suggest the need to consider project purpose and customer constraints before participants identification. Considering Eskerod and Jepsen (2013) definition of stakeholder management process as entailing all activities related to project stakeholders, project planning and development about stakeholder needs and satisfaction becomes essential.

Many studies on stakeholder management agree and stress on stakeholder identification as a major factor for consideration (Karlsen 2002; Bourne and Walker, 2006; Mok, *et al.*, 2015). The ability to successfully identify all project stakeholders is essential for successful stakeholder management process (Jepsen and Eskerod, 2009). Chinyio and Olomolaiye (2009) opines a process of identifying and classifying stakeholders for initial and subsequent engagements with stakeholders; timely, planned and in a coordinated manner. Mitchell *et al.* (1997) suggest that stakeholders have power, legitimacy and urgency claim which needs to be identified and managed on that basis. Further to stakeholders identification, scholars have stated classification and prioritization of stakeholders as essential (Walker *et al.*, 2008; Chinyio and Olomolaiye, 2009; Bal *et al.*, 2013; Aapaoja and Haapasalo, 2014). Project participants are critical or not for the project delivery, may have latent potentials and are primary or secondary to the project. Jepsen and Eskerod (2009) mention characterisation of stakeholders based on the needed contribution.

Scholars seem to agree on the need to analyse project stakeholders. Karlsen (2002) for instance suggests analysing the characteristics of participants, Elias *et al.* (2002) opines process level and transactional level stakeholder analysis. Equally, Young (2006), Lock (2007), Yang (2014) and Aapaoja and Haapasalo (2014) mentioned analyzing or assessing stakeholders as part of the factors/process for successful stakeholder management. Other scholars, however, fail to mention stakeholder analysis or assessment as a major factor/process (PMI, 2008; Bourne and Walker 2006; Bal *et al.*, 2013). Carefully analyzing stakeholders is essential (Lock, 2007). Stakeholder engagement or communication is a major factor. Studies that mention stakeholder engagement and communication includes Karlsen (2002); Bourne 2005; Bourne and Walker (2006); PMI (2008); Chinyio and Olomolaiye (2009) and Osei-Kyei and Chan, (2015). Effective communication is considered a major critical success factor (Yang, 2014). Regrettably, some major scholars failed to include stakeholder communication as a major factor (Elias *et al.*, 2002; Young, 2006; Aapaoja and Haapasalo, 2014). Studies further identified developing strategies, following up (Karlsen, 2002), implementing stakeholder management strategy (Olander, 2006) report performance (PMI, 2008), action and evaluation with continuous support (Yang, 2014) as necessary for successful stakeholder management. Bal *et al.* (2013) emphasized measuring performance and putting targets into action. Although other scholars failed to mention implementation, monitoring and feedback as a key factor, it is considered as a purposeful activity undertaken to ensure successful stakeholder management process (Eskerod and Jepsen, 2013). Yang (2014) also mentions continuous management support. The key factors identified included pre-conditions; external environment; project planning; procurement approach; stakeholder identification process; stakeholder classification; stakeholder prioritization; stakeholder analysis; stakeholder engagement; stakeholder communication; stakeholder decisions implementation; monitoring and feedback and continuous support. These factors were validated using Delphi survey technique.

4. Findings and Analysis

4.1 Delphi survey round one - Identifying the key factors

Ten experts returned the responded questionnaire requesting experts to name major factors to be considered for successful stakeholder management process within ten days while two failed to meet the additional week granted and email correspondences. The first round results were analysed as a Delphi panel of between 8 and 12 is justified (Chan *et al.*, 2010).

Table 3: List of key factors reviewed by experts

	Factors	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10	Frequency of criterion by experts
1	Pre-conditions	x	c	c	x	C		x		x	x	40%
2	External environment	x	c	c	x	X	x		x	x		60%
3	Project planning	x	c	x	x	X	x	x	x	x	x	90%
4	Procurement approach	c	x	c	x	X	c	x	x	x		60%
5	Stakeholder identification	x	x	x	x	X	x			x	x	80%
6	Stakeholder classification	x	c	c	x	X	c	x	x	x	x	70%
7	Stakeholder prioritization	x	x	x	c	X	c	x	c	c	x	60%
8	Stakeholder analysis	x	x	x	c	X	x		x	x	x	80%
9	Stakeholder engagement	x	x	x	x	X	x	x	x	x	x	100%
10	Stakeholder communication	x	c	x	c	C	c	x	x	c	c	40%
11	Decisions implementation	x	c	x	x	C	c	x	x	c	c	50%
12	Monitoring and feedback	x	c	x	x	C	c	x	x	c	c	50%
13	Continuous support	x	x		x	X	x	x	x	x	x	80%
14	Construction industry practices	x	x	c	c	X	x	x	c	c	x	60%

X-Recommended, C- to be combined

Experts in addition to the inclusion of important factor had suggested factors with similar activity and meaning rephrased (Table 3). Five experts suggested that pre-conditions and external environment factors were similar and should combine with external factors. Project planning and procurement approach formed part of pre-stakeholder identification activities and rephrased. Other suggestions included construction industry practices under external factors and combining decision, monitoring and feedback implementation. Finally, stakeholder classification and prioritisation were also combined.

4.2 Delphi survey round two: confirming the key factors

The objective of the second round was for experts to establish the significant factors by ranking the importance of each factor in ensuring successful stakeholder management process and the known outputs. Experts had two weeks to return responded questionnaire. All the ten experts replied the questionnaire within the period after persistent sending of emails and phone calls. The results (table 4) indicate that consensus was however not achieved for all the factors as 90%-100% showed agreement.

4.3 Delphi survey round three: Achieving consensus

With four factors not reaching consensus, experts were offered the analysed round two data and requested to either agree with the majority or maintain their choice with an explanation. Experts had two weeks to respond. Replies were received by the end of the first week as most experts changed only their position about being neutral. The consensus at the end of round three involved using percentages and median marks agreed at the start of the Delphi process. The factors and related attributes will be validated using a Delphi and quantitative questionnaire survey technique for the broader study aimed at the “development of sustainable stakeholder management framework for construction projects in Ghana”. Most reasons offered for a choice of neutral are that either the factor makes a little impact or influence hence not recognised as important or least important. For consensus, a factor should have a minimum of 90% expert ranking as of importance, median of 9-10 and mean of 9.0.

Table 4 - Ranked list of factors by experts after Delphi survey round 2

Factors	Number of experts ranking:						% of experts indicating importance
	Extremely important	More important	Neutral	Least important	Not important at all		
1 External environment	6	3	1				90
2 Pre stakeholder identification activities	8	1	1				90
3 Stakeholder identification process	9	1					100
4 Stakeholder classification and prioritisation	7	2	1				90
5 Stakeholder analysis	8	1	1				90
6 Stakeholder engagement	9	1					100
7 Decisions implementation, monitoring and feedback	7	1	1	1			80
8 Continuous support	6	3	1				90
Outputs							
1 Meeting project targets	6	2	1	1			80
2 Meeting stakeholder needs/satisfaction	7	2	1				90
3 Improved project delivery	7	2	1				90
4 Improved stakeholder relationship/collaboration	5	3	1	1			80
5 Reduced conflicts	5	3	1	1			80
6 Profit and growth for stakeholders	7	2	1				90
7 Increased social value and benefits	6	3	1				90

5. Conclusions

Firstly, twelve processes and frameworks were established in the literature and reviewed. Also, three publications relating to project management success were extensively studied. Secondly, the study identified: external environment factors; pre-stakeholder identification and implementation, monitoring and feedback factors as a gap in the literature. Fourteen factors were validated using three rounds of Delphi survey technique involving ten experts. There was a consensus at the end of third round of the Delphi study conducted. Eight factors identified as critical and impacting on successful stakeholder management process are external environment; pre-stakeholder identification; stakeholder

identification process; stakeholder classification and prioritization; stakeholder analysis; engagement, implementation, monitoring, feedback and continuous support. Seven outputs validated are: meeting project targets; stakeholder needs; satisfaction; improved project delivery; stakeholder relationships/collaboration; profit and growth for stakeholders; increased social value and benefits. As part of a broader study, a Delphi survey will be conducted to identify the related attributes and validated using analysed quantitative data from a questionnaire survey. The study will contribute to the body of knowledge regarding stakeholder management the factors are used to develop a stakeholder management framework for enhanced project delivery in Ghana. The framework would be useful for developing countries with similar construction industry characteristics

Table 5: Ranked list of factors by experts after Delphi survey round 3 (consensus).

Factors	Number of experts ranking:						% of experts indicating importance	Median response	Mean response
	Extremely important	More important	Neutral	Least important	Not important at all				
1 External environment	6	4					100	5.0	4.5
2 Pre stakeholder identification activities	8	1	1				90	5.0	4.7
3 Stakeholder identification process	9	1					100	5.0	4.9
4 Stakeholder classification and prioritisation	7	3					100	5.0	4.6
5 Stakeholder analysis	8	1	1				90	5.0	4.7
6 Stakeholder engagement	9	1					100	5.0	4.9
7 Decisions implementation, monitoring and feedback	8	1	1				90	5.0	4.4
8 Continuous support	6	4					100	5.0	4.5
Outputs									
1 Meeting project targets	6	3	1				90	5.0	4.3
2 Meeting stakeholder needs/satisfaction	7	3					100	5.0	4.6
3 Improved project delivery	7	3					100	5.0	4.6
4 Improved stakeholder relationship/collaboration	5	4	1				90	4.5	4.2
5 Reduced conflicts	5	4	1				90	4.5	4.2
6 Profit and growth for stakeholders	7	2	1				90	5.0	4.6
7 Increased social value and benefits	6	3	1				90	5.0	4.4

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7

HEALTH AND SAFETY IN INFRASTRUCTURE DEVELOPMENT

DII-2016-001

An Evaluation of the Attitude and Behaviour of Management and Casual Workers towards Health and Safety on Construction Sites

Josephine Mutwale¹, Danstan Chiponde², Nondi Lushinga³, Lawrence Mutale⁴,
Gloria Chewe⁵

Abstract

This research investigates casual workers' attitudes and behaviour towards health and safety practices on construction sites and how these affect their health and safety (H&S) at work. The research made use of primary and secondary data. Secondary data was obtained from literature available on health and safety practices. Primary data were obtained through the use of a questionnaire survey to casual workers, health and safety officers, site foremen and project managers. The research data was drawn from Lusaka, Zambia. Data were analysed using Statistical Package for Social Sciences (SPSS 16) to output frequencies and percentages. Casual workers are prone to accidents, in most cases they are as a result of the workers themselves. This is as a result of their poor attitudes and behaviours towards H&S practices on sites. Attitudes and behaviours are a reflection of management, i.e. casual workers lack proper representation to fight for their rights and better working conditions. Educational H&S talks, i.e. training programs and campaigns, formation of trade unions and regular health and safety inspections would go a long way in improving the health and safety of casual workers on construction sites. Proper H&S practices can only materialise if both the employers and casual workers work together.

Keywords: attitude, behaviour, awareness, casual workers, health and safety

1. Introduction

Occupational H&S promotes an environment that allows each worker in the project hierarchy to participate in health and safety (Alli, 2008). Construction H&S should deal with both physical and psychological welfare of workers on construction sites and that of third parties. It is an ongoing process that aims to identify and eliminate jobsite hazards throughout the project. Successful health and safety management requires active management and worker participation and involvement.

The nature and activities of the construction industry are largely labour intensive, fragmented and temporal thereby having a fluctuating nature of job execution. This makes it unattractive for contractors to keep permanent employees and heavily rely on casual labour. According to Rasell *et al.* (1997), casual labour is non-traditional employment in the absence of regular full time work characterised by non-continuing work. It is perpetuated by poverty which plays a crucial role in

¹Lecturer; Construction Economics and Management; Copperbelt University, P. O. Box 21692, Jambo Drive, Riverside, Kitwe; josephinemutwale@gmail.com

creating desperate individuals who take up casual jobs. Kneni (2008) highlights that workers, in their quest to meet their basic needs i.e. food and shelter, often compromise their H&S rights. Danso (2005) further states that about 65% of construction artisans, especially new entrants, do not possess the knowledge of health and safety on a construction site.

2. Review of Literature

2.1 Understanding casual workers

Casualization is prevalent in the Agriculture, Manufacturing, Mining and Construction industries (Petrakis 2006). These are industries that are termed as labour intensive industries. However, there is generally lack of reliable official statistics and information of casualization of labour. The factors identified as leading to increased casualization of labour include high levels of poverty and unemployment, weak labour laws and enforcement mechanisms, a lack of awareness on workers' rights, lack of trade union action to respond to the increasing casualization in the work place (Petrakis 2006). Furthermore, casual workers are faced with increased vulnerability through the casualization of labour in the absence of labour laws to protect them i.e. poor remuneration, poor conditions of conditions of service (Anand, 2000: Blake, 2012). Casual workers are usually characterised by their low levels of education (ILO, 2007), lack or low levels of skill (Grandey, 2009: Anand, 2000: ILO, 2003: Philips, 2000), and come from less privileged areas of society (Anand, 2000).

2.1.1 The plight of casual construction workers

It is always important for both local and foreign investors to have the knowledge of the local labour laws so that they do not end up in conflict with authorities and their employees. Therefore, in order to regulate the relationship between the two parties (employer and employee) the Government has put up labour laws (Grayson *et al*, 2012). According to a research done by Work Safe Australia (n.d.), almost three quarters of employers felt that the worker being careless was the main cause of work-related injury in the industry, followed by just not thinking and manual tasks (38% each). 80 out of every 100 accidents are the fault of the person involved in the incident. Unsafe Acts cause four times as many accidents & injuries as unsafe conditions (Hellman & Associate, 2006).

The law provides for the right of workers to form and join independent unions, conduct legal strikes, and bargain collectively. The law allows unions to conduct their activities without interference. The law also prohibits antiunion discrimination and employer interference in union functions, and provides remedies for workers dismissed for union activity (Bodibe, 2006). Some employers reportedly frequently refused to bargain with workers' unions and often employed casual workers or workers on short-term contracts in order to avoid hiring workers on a long-term basis and consequently empowering them with more bargaining power (Mwila, 2011). In a research conducted Bodibe (2006), the findings point to inadequate and limited trade union actions and responses to casualization of labour in the construction industry.

2.2 Factors that affect casual worker health and safety attitude and behaviour

Attitude is a state of mind an individual has towards something. It can remain unchanged unless it is influenced by external forces (Mullin, 2005). Attitudes are learned behaviour and are personified within our socialization process. Some attitudes such as religious beliefs may be central to us that is a

core construct and may be highly resistant to any change. Other more minor attitudes may change with new information or personal experiences (Glendon, 1987). Accidents at work occur for many reasons and in most instances people tend to look for "things" to blame when an accident happens, because it's easier than looking for "root causes," such as those listed below.

One of the factors that influence the attitude of casual workers on a construction site includes lazy attitudes. According to Hellman *et al.* (2006) most casual workers prefer to take shortcuts to save time because they want to avoid supportive activities. Past experience also plays a crucial role in determining attitudes. Workers having performed a job for a long time become familiar and are reluctant to change when new methods are introduced (Danso 2005; Mitullah *et al* 2003). Nonetheless, these old habits could prevent them from noticing the prevailing hazards, hence increasing the possibility of accidents occurrence (Kittleson, 2009). Sometimes according to WAGA (2012) and Hellman *et al.* (2006) pressure from supervisors to get jobs done quickly can cause the workers to work in hurry and cause workers to disregard good health and safety practices.

Showing off to their peers is a common behaviour amongst them i.e. machinery operators, this can in turn also lead to neglect in health and safety (WAGA, 2012). The International Labour Organization (2007) also revealed that PPE can be uncomfortable, can decrease work performance and can create new health and safety hazards. Some workers for instance, reject the wearing of earmuffs because it makes them feel hot, especially when they are used in hot regions. Being angry, according to WAGA (2012), can lead to accidents because anger nearly always rules over caution. Unresolved anger could cause distraction, proneness to accidents, anxiety, violence and rage. Mental distractions from Work i.e. having a bad day at home and worrying about it at work is a hazardous combination. Dropping your 'mental' guard can pull your focus away from safe work procedures (Hellman *et al.*, 2006). Hellman *et al.* (2006) further adds that one can be distracted when a friend comes by to talk while you are trying to work.

Starting a task with incomplete instructions especially doing it right and safely the first time requires full and complete information. Being hasty in starting a task or not thinking through the process can put you in harm's way (WAGA, 2012). Housekeeping is an accurate indicator of everyone's attitude about quality, production and safety (Hellman *et al.*, 2006). Poor housekeeping creates hazards of all types. A well maintained area sets a standard for others to follow. Good housekeeping involves both pride and safety (Hellman *et al.*, 2006). Purposely failing to observe safety procedures can endanger workers.

The main influences on risk perception attitudes can therefore be summarised as to include affect, voluntariness, familiarity, culture, gender and overconfidence. These factors are what lie in the core of an individual and can and may not be changed overtime. These factors may obscure ones perception of risk, i.e. 'I have been doing this for so long, nothing can happen to me' or 'this is a man's job' (Joffe, 2003). Slovic's (2000) research stresses that 'almost every study of risk perception has found that men seem to be less concerned with hazards than are women'.

2.3 Health and safety training on construction sites

Philips (2000) was of the view that contractors were reluctant to invest in training because of the chances of losing workers to other firms or other countries. Susan *et al.* (2008) attest that employers do not invest in casual workers because it has little long-term benefit for their business. ILO (2007) has claimed that, the high turnover of casual workers poses a considerable barrier to training among

others in the construction industry. Construction accidents were due to lack of training and the accidents were caused by lack of information, provision of health and safety equipment and welfare facilities to casual labourers. It is estimated that at least 250 million occupational accidents occur every year worldwide, 335,000 of these accidents are fatal (result in death) (ILO, 2003). Hazards can be grouped in categories of gradual to harmful hazards, taking physical, chemical and physiological forms.

Attitudes may change with new information or personal experiences. Basically, it appears that positive values and beliefs are driven by knowledge and experience of health and safety and these values are then converted to attitudes by a perception of risk (Goldstein, 2000). As reported in previous studies, communication is one of the dimensions of psychological climate (Decotiis and Koys, 1991). It is believed that a good flow of communication of health and safety knowledge and policy within an organization will enhance workers' awareness and behaviour towards health and safety (Blake, 2012).

3. Research Methodology

The research used a quantitative method of data collection. A review of literature was conducted from which a field questionnaire was developed. Sources such as books, journals and professional papers were consulted. The questionnaire comprised sections three (3) sections, section 1 sought demographic information, section 2 addressed the attitudes and perceptions of the participants towards H&S and section 3 addressed the behaviour of causal workers towards H&S in the Zambian construction industry. The target population comprised health and safety officers, project managers, foremen all acting as the clients representative and casual workers on active building construction sites. Four types of questionnaires were administered, 75 to contracting firms (project managers, health and safety officers, foremen) and 150 to casual workers respectively. This brought the responses effectively to an average of 62% for contracting firms and 91% for casual workers. This response rate is considered adequate as, according to Oladapo (2005), a response rate of 30% is good enough in construction studies.

3.1 Limitation

Most sites did not have site H & S officers; this resulted in a smaller group of H & S officers respondents as compared to the other respondents. Some casual workers were afraid to open up truthfully about the state of the health and safety situations on the site as they thought that their names will be disclosed and hence lose their jobs, hence it was difficult to obtain accurate data. In this case, an addition of two more casual workers was interviewed so as to overcome this problem. Project managers were reluctant to respond to the questionnaires as they thought that the information gathered will be disclosed to the Occupational H & S department which may lead to the construction process to come to a halt or attract penalty fees. This hindered accuracy of the data required. Data was only collected in Lusaka Province of Zambia.

4. Research Findings and Discussion

4.1 Health and safety practices on construction sites

Table 1 presents findings regarding factors affecting casual workers' attitude and behaviour. As can be seen, 78% of the client's representatives and 75% of casual workers agreed that casual workers are prone to accidents on construction sites. Physical, psychological and chemical hazard are the most common hazards at an average of 100%, 69% and 61% respectively. Accidents cause construction delays, cost overrun and sometimes ruin the reputation of the organization, and result in loss of confidence among workforce (Wang *et al.*, 2006). Exposure to these hazards may results in serious injuries or fatalities to workers themselves. But despite this direct correlation that exists between accidents and the worker, they themselves have poor H&S tendencies.

Table 1: Factors affecting casual workers' attitude and behaviour

Factors	Client Rep %	Casual workers %
Occurrence of Accidents	78	74.5
Following HS Instructions	63	57.7
Attendance of HS Meetings	89	43.8
Practice of short cuts at work	79	51.4
Don't refuse to work without PPE	63	70
Not aware of Trade Unions	83	70
Not Appreciative of HS	88	57
Physical Hazards	100	100
Physiological Hazards	75	62
Chemical	71.7	51

4.2 Provision of health and safety training

As shown in figure 1, most of contractors do not provide H&S training to their casual workers. Additionally, H&S awareness and training are not done continually on construction sites. 61 % of the casual workers and 93% of health and safety officers agreed that H&S site induction and orientation are done only at the beginning when workers are employed. The induction is only carried out for a day throughout the life cycle of a project. 70.5% of casual workers said that they are not taught on how to use health and safety facilities and they have to figure it out themselves. 62% of the sites do not have health and safety slogans on sites.

The data shows that H&S awareness and education to site workers though induction and site orientation are done however, health and safety awareness is not an ongoing procedure on most sites owing to the absence of health and safety slogans on site and the lack of training and awareness of workers according to casual workers. The Health and Safety at Work Act 1974 among other regulations, places a duty on employers to provide such information, instruction, training and supervision as is necessary to protect the health and safety at work of employees (HSE, 2002). Casualisation supports mass employment for short periods of time making it unattractive for employers to invest in casual employees (Anand, 2000; Blake, 2012). Hence, offering health and safety training to them would be very expensive.

According to Blake (2012), one of the ways of changing attitude is through the imparting of new information. On top of that, 100% of the foremen find working with casual workers who have gone through health and safety training easier. This may be so due to the fact that the health and safety instructions would be easily communicated and understood by casual workers on site hence resulting in the minimization of accidents.

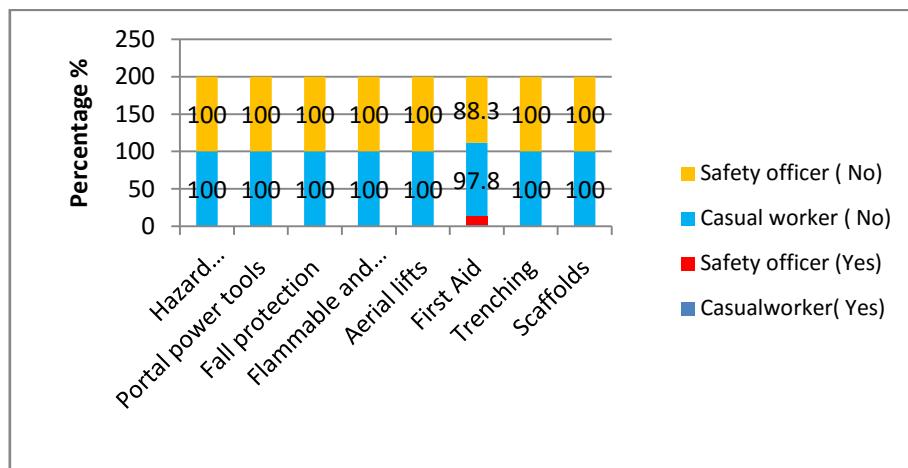


Figure 1: Categories of health and safety training offered to casual workers

4.3 Provision of PPE

From the information given in table 2, the provision of PPE to construction workers by employers is poor especially when it comes to foot protection (0%) and harness safety (0%). Casual workers work by standards set by the employer, his means that if the employer does not provide them with PPE, they still continue to work despite the dangers to their persons. Providing PPE to casual workers increases morale on construction sites to act safely and in event increases their job satisfaction hence lead to a positive attitude (Rodríguez, 2012).

Table 2: PPE received by casual workers

Personal protective equipment	YES		NO	
	Frequency	Percentage %	Frequency	Percentage %
Foot protection	137	100.0	0	0.0
Eye protection	69	50.4	68	49.6
Hand protection	108	78.8	29	21.2
Hearing protection	50	36.5	87	63.5
Respiratory protection	71	51.8	66	48.1
Health and safety Harnesses/ fall	137	100	0	0.0

4.4 Continuing to work despite poor working conditions

Despite being directly affected by injury and accidents, the question remains as to why construction workers continue to work despite the adverse working conditions. The 52% of the project managers said that casualization has a negative impact on OHS because casual workers compromise OHS regulations in an attempt to create income to survival on construction sites. Although 75% of casual workers are faced with such hazards on construction sites, 60% causal workers commented that they continue work because it is their only source of income while 28% of casual workers continue work because of few job opportunities comparable to their skill levels and education while 12% said it is

their only way of reducing the impact of poverty. This shows that casual workers are desperate for survival for both themselves as well as their families, hence are willing to work in poor conditions on site, as suggested by Women in Informal Employment Globalising and Organising (WIEGO, 2016). Construction has the ability to “absorb the excluded” (de Souza, 2000). It provides employment for those with little education or skill, many of them from the poorer sections of society.

4.5 Health and safety awareness through compliance with legal requirements

A 100% of construction sites had a written health and safety policy on site. This tells us that it is up to the employer to impart health and safety awareness in the workers as they carry out daily construction tasks. Most (90%) construction sites have a formal system for reporting, recording and investigation of accidents, injuries and illness on site. Health and safety objectives are regarded in the same way as other business objectives as they become part of the work culture (HSE, 2008). A majority of 81% of casual workers responded that they receive punishment when they break health and safety rules. Disciplinary or corrective action is a process of communicating with the employee to improve unacceptable behaviour or performance (UCSF, 2014). The severity of the issue will determine the appropriate corrective action and can range from verbal warnings to termination of employment (UNH, 2007).

4.6 Belonging to trade unions

The majority (90%) of casual workers do not belong to trade union while 10% belong to trade unions; this means they are not protected from low wages, unfair dismissals and poor work conditions. This information shows that apart from the labour office, most casual workers have no representatives to help protect their rights. Health and safety officers (88%) confirmed that they do not educate casual workers about trade unions while 12% said that they educate casual workers about trade union. This information displays that employers do not educate their casual workers about trade unions. This is because it is a disadvantage to them, as educating them would mean increments of salaries, demand for better working conditions and protection from dismissals. Workers in companies with a recognised union earn 10 per cent more than a comparable non-unionised workplace and also up to 50 per cent fewer accidents in unionised workplaces (Unite the union, 2012). 71% of casual workers said their employers do not comply with minimum wages while 29% said their employers comply with minimum wages. This shows that the majority of casual workers suffer low wages from their employers. One of the reasons for this is that they do not belong to trade unions.

4.7 Job security

A total of 61% of casual workers agreed that the nature of their jobs causes them insecurity while 39% said this type of job did not cause them insecurity. This shows that casual workers are not satisfied with their jobs hence are vulnerable on construction sites increasing the chances of them being involved in accidents. Most (51%) of health and safety officers do not appoint casual workers as assistants among their peers. Targeting casual workers and appointing them as assistant leaders amongst their peers would be a form of motivation for them to work hard in putting effort in observing health and safety rules on site. Casual workers lack motivation to behave safely as their effort in observing health and safety is not rewarded.

39% of casual workers said bulling is one of the reasons they are insecure about their jobs. They feel inferior as compared to other workers because these have better working conditions. The other reason

for insecurity is the fear of losing jobs 34% of casual workers confirmed this, because they have no protection from abrupt stoppage of work. Hence they work to impress and end up compromising their health and safety rights. It further shows that 27% said low wages also cause them insecurity as they fail to fully satisfy their basic needs. This shows that casual workers psychological conditions are not good on site. This negatively affects their behaviour hence making them prone to be victims of accidents.

39% casual workers said bulling is one of the reasons they are insecure about their jobs. They feel inferior as compared to the core workers because these have better working conditions; also because they may be unfamiliar with the construction site hence the core workers intimidate them. The other reason for insecurity is the fear of losing jobs 34% of casual workers confirmed this, because they have no protection from abrupt stoppage of work. Hence they work to impress and end up compromising their health and safety rights. It further shows that 27% said low wages also cause them insecurity as they fail to fully satisfy their basic needs. This shows that casual workers psychological conditions are not good on site. This negatively affects their behaviour hence making them prone to be victims of accidents.

5. Conclusion

Casual workers are the main class of workers responsible for accidents on construction sites and are the main victims. This is as a result of the poor attitudes and behaviours towards proper health and safety practices. The single most powerful source of motivation is employee ownership of the safety process. Management must understand, undertake and implement all or some of the following measures: regular supervision and inspection by safety officials and leaders on site; constant training on the use of tools and equipment; proper use of safety items and PPE; signs and notices should be provided on construction sites and should be located at strategic areas on site; training programs should be provided regularly which should include how to handle tools, equipment and plants, and how to understand and interpret signs and symbols. Furthermore, management must ensure safety policies are obeyed. Plants, machineries and equipments should be maintained regularly, medical test should be carried on employees for drug use and alcohol intake. Punishment for unsafe behaviour or reward for safe behaviour can also go a long way in aiding a positive transformation of attitudes and behaviour of causal workers on construction sites.

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Utilisation of Materials Safety Data Sheet on Zambian Construction Worksites

Erastus M Mwanaumo¹, Sampa Chisumbe², Chipulu Chipulu³

Abstract

A material safety data sheet also known as a safety data sheet (SDS) is an essential document where health and safety is concerned. This document contains information about physical and chemical composition of the materials as well as how it affects the health and safety of workers on worksites. The material safety data sheets utilisation among contractors in the Zambian construction industry was investigated using a case study approach. A construction site in Ndola was purposively selected in line with the set out objective of investigating the utilization of material data sheet on Zambian construction worksites. Targeted interviews were conducted with the site engineer and a foreman while bricklayers and painters were randomly selected to avoid bias. The findings revealed under-utilisation of material safety data sheet (MSDS) on the worksites, and that MSDSs are not used in developing a comprehensive health and safety plan on construction worksites. Further, workers do not read and discuss MSDS before handling materials. This research therefore recommends that employers must make MSDSs available to all people at the workplace who are potentially exposed to the hazardous substance. Employers should therefore, as far as practicable, provide information, instruction, training and supervision so that employees can perform their work safely and are not exposed to hazards without making any alteration to an MSDS.

Keywords: utilisation, materials, safety, data sheet, hazard

1. Introduction

According to the University of California, Los Angeles (UCLA) Labor Occupational Safety and Health (2003) a Safety Data Sheet (SDS) formerly known as material safety data sheet (MSDS) is a document that gives detailed information about the nature of a chemical, such as physical and chemical properties, health, safety, fire, and environmental hazards of a chemical product. Safe Work Australia (2016), however, contends that the safety data sheet does not only provide information about the hazardous nature of the material, but also how it affects health and safety in the workplace.

The safety data sheet has numerous uses in the work place. Safe Work Australia(2003) indicated in their national code of practice for preparation of SDS that it is a recognised information source, which underpins the overall risk management program to control exposure to hazardous as well as dangerous

¹Lecturer, School of Engineering, University of Zambia, Box 32379, Lusaka, Zambia. Email: Erastus.mwanaumo@unza.zm

² Post Graduate Student, Department of Civil and Environmental Engineering, School of Engineering, University of Zambia, Box 32379, Lusaka, Zambia. Email: clechisumbe@gmail.com

³ Post Graduate Student, Department of Civil and Environmental Engineering, School of Engineering, University of Zambia, Box 32379, Lusaka, Zambia. Email: chipulubrude@ gmail.com

materials. It is an integral component of the safety work program. The Canadian Centre for Occupational Health and Safety (2016) indicates that the SDS is an essential starting point for the development of a complete health and safety program.

A review of various SDSs indicated and suggested that this essential safety document contains the following headings and contents: identification, composition and information on ingredients, first-aid measures, fire-fighting measures, accidental release measures, handling and storage, exposure controls and personal protection, physical and chemical properties, stability and reactivity, toxicological information, ecological information, disposal consideration, transport information, regulatory information (Sciencelab.com Inc., 2005; ORCO Block Company Inc., 2009; Company, 2012; Limited Cement Australia Pty, 2014; Lafage, 2016; Oregon OSHA, 2016).

1.1 Aim

The aim of the study was to investigate the utilization of safety data sheets among contractors in Zambia.

2. General Application of Material Safety Data Sheet

MSDSs need to be readily available and accessible in the workplace, so that they can be easily located in an emergency, such as fire (Worksafe, 2009). There are three instances when an MSDS must be supplied; when a hazardous substance is provided to a workplace; when a hazardous substance is subsequently purchased and the MSDS is requested; and when a potential or existing purchaser makes a request for an MSDS.

According to Worksafe (2009) the information in MSDSs must be kept current. MSDSs must be updated by the manufacturer or importer as often as reasonably possible to keep them current and at a minimum of every five years. The employer should check the dates of all MSDSs and ensure that all MSDSs at the workplace are current. An MSDS produced by the manufacturer or importer of a hazardous substance must be obtained and used as the main source of information. "Third party MSDSs" which are produced by other parties and not the manufacturer or importer can be used as supplementary information, but should never be relied upon as the sole source of information.

3. Challenges associated with Material Safety Data Sheets

Inadequate information available on chemicals aspects of protection. There are no OSHA requirements for chemical manufacturers to test their chemicals for permeability through glove materials. While many such tests have been performed voluntarily in recent years, there are many chemicals for which they have not been done (OSHA, 2004). In addition, (OSHA, 2004) indicates that most products marketed are mixtures of chemicals that are often unique to a single manufacturer. Mixtures are tested less frequently than individual chemicals are, and there is often limited information available to predict how mixing the chemicals affects their overall effects and what protective measures should be used. Where mixtures are complex, with numerous ingredients, the MSDSs are complicated as well and the user is required to make some judgments about how to apply the information in their own workplace situation.

Furthermore, regarding accuracy, there have been concerns that the MSDSs are not comprehensible to employees. This criticism results in part from the fact that MSDSs are written for a number of

different audiences, and thus may include technical information not intended primarily for workers. It is important to emphasize that other parts of the HCS the label and training are critical to employees receiving and using the appropriate information on a chemical.

4. Methodology

A case study was used in investigating the utilization of material data sheets on Zambian Construction Work site. Case study is a holistic inquiry whose goal is to gain insight, explore the depth and complexity inherent in a contemporary phenomenon (Tourki, 2010). The main reason for choosing a case study approach is that it enables the reality to be captured in great detail. Zainal (2007) argued that case studies not only help to explore or describe the data in real-life environment, but also help to explain the complexities of real life situations which may not be captured through experimental or survey research.

A construction site in Ndola was purposively selected in line with the set out objective of investigating the utilization of material data sheet on Zambian construction worksites. Targeted interviews were conducted with the site engineer and Foreman while as bricklayers and painters were randomly selected to avoid bias. These were chosen as they are the ones usually involved with the planning of works as well as handling of materials on construction worksites. Paints were considered for the study and using a five point ordinal Likert scale the study aimed at determining the extent to which material safety data sheet were being utilised on the project as structured in the interview schedules. Table 1 shows a five point ordinal likert scale employed in the study.

Table 1: A five-point ordinal Likert scale

Strongly agree	Agree	Not sure	Disagree	Strongly disagree
1	2	3	4	5

5. Findings

5.1 Extent to which workers read and use the material safety data sheet on worksite

An assessment was carried out to determine the extent to which workers read and use the material safety data sheet on worksite. The findings revealed underutilisation of MSDSs on the worksites site as shown in figure 1, with ninety percent of the respondents interviewed indicating as not being sure the extent to which workers use the MSDS and recommended equipment. Furthermore, some respondents interviewed claimed to already have had knowledge of the information provided on data sheets based on their years of work experience emphasising that data sheets are similar across like materials.

5.2 Comparison of data sheets for two similar materials

An assessment was carried out to compare and contrast data sheets for the two similar materials. Similar paints were reviewed in establishing the similarities as well as variances in the material data sheets. The finding revealed some similarities as well as differences contrasting with the workers assertion that the information provided on the data sheet is similar across similar materials. Figure 2 show similarities and variances on two different MSDS for similar PVA paints.

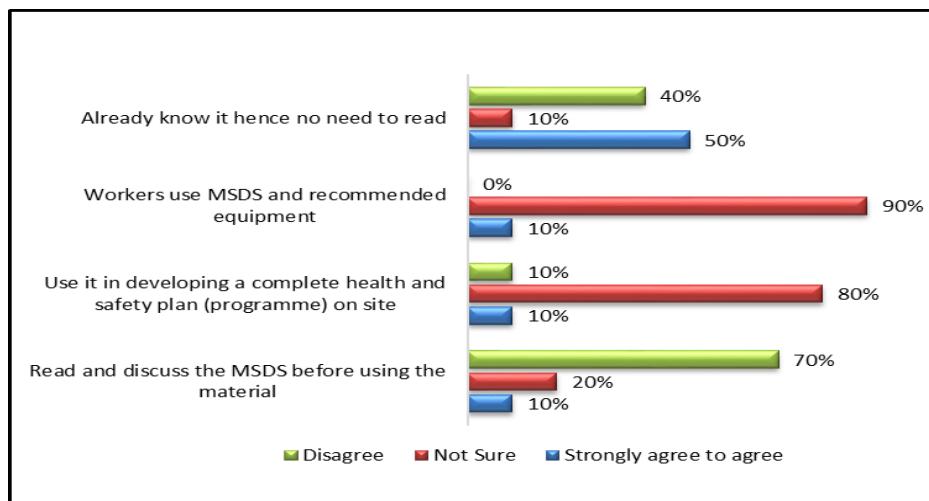


Figure 1: Extent as which workers read and use the material safety data sheet on worksite

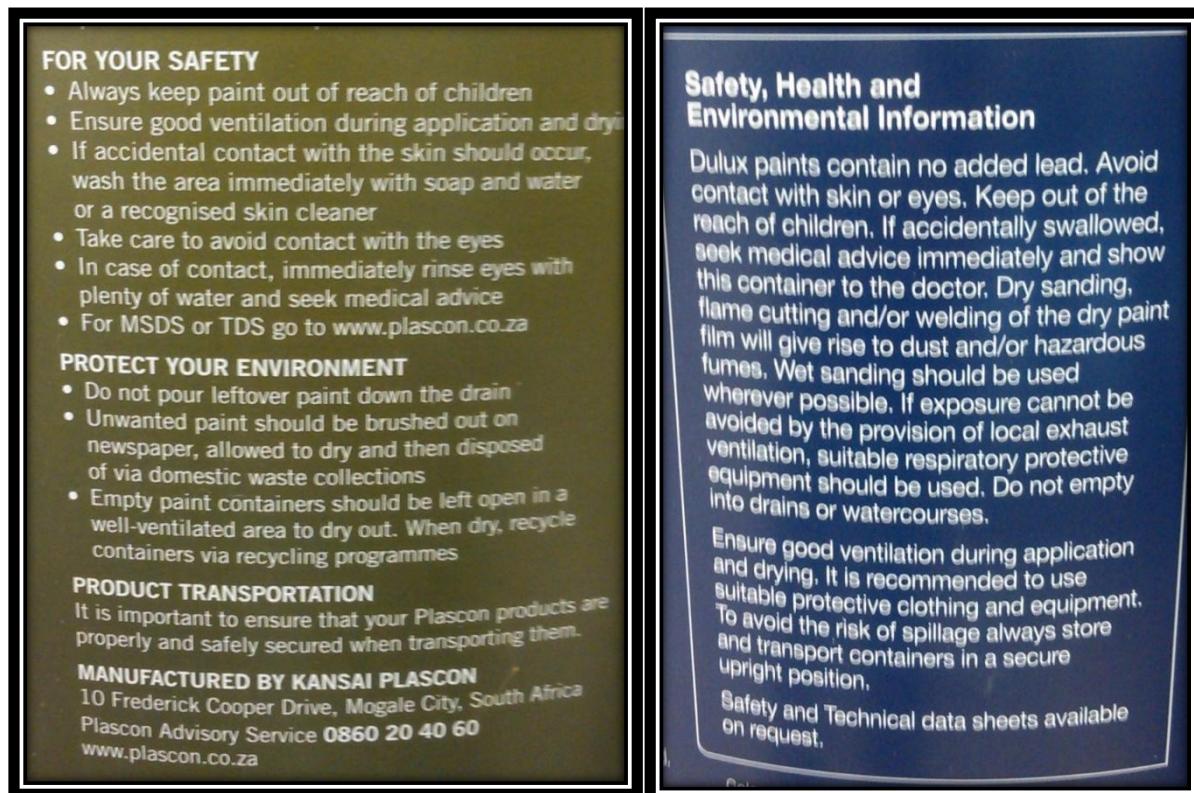


Figure 2: Similarities and variances in two different data sheets for similar PVA paints.

In comparing and contrasting the two PVA water-based paints, the findings revealed that on one particular paint the material safety data sheet just indicated that “ensure good ventilation during application and drying” while the other paint goes further by stating that if exposure cannot be avoided by the provision of local exhaust ventilation, suitably respiratory protective equipment should be used.

Furthermore, whilst one material safety data sheet provides that if swallowed medical advice should be sought immediately with the containers shown to the medical doctor the one does not. More so,

that dry sanding, flame cutting and/or welding of dry paint film would give rise to dust and/or hazardous fumes recommending wet sanding to be used wherever possible whilst the other does not indicate. Similarly, another material safety data sheet on a different PVA water based paint revealed further variances as shown in figure 3.

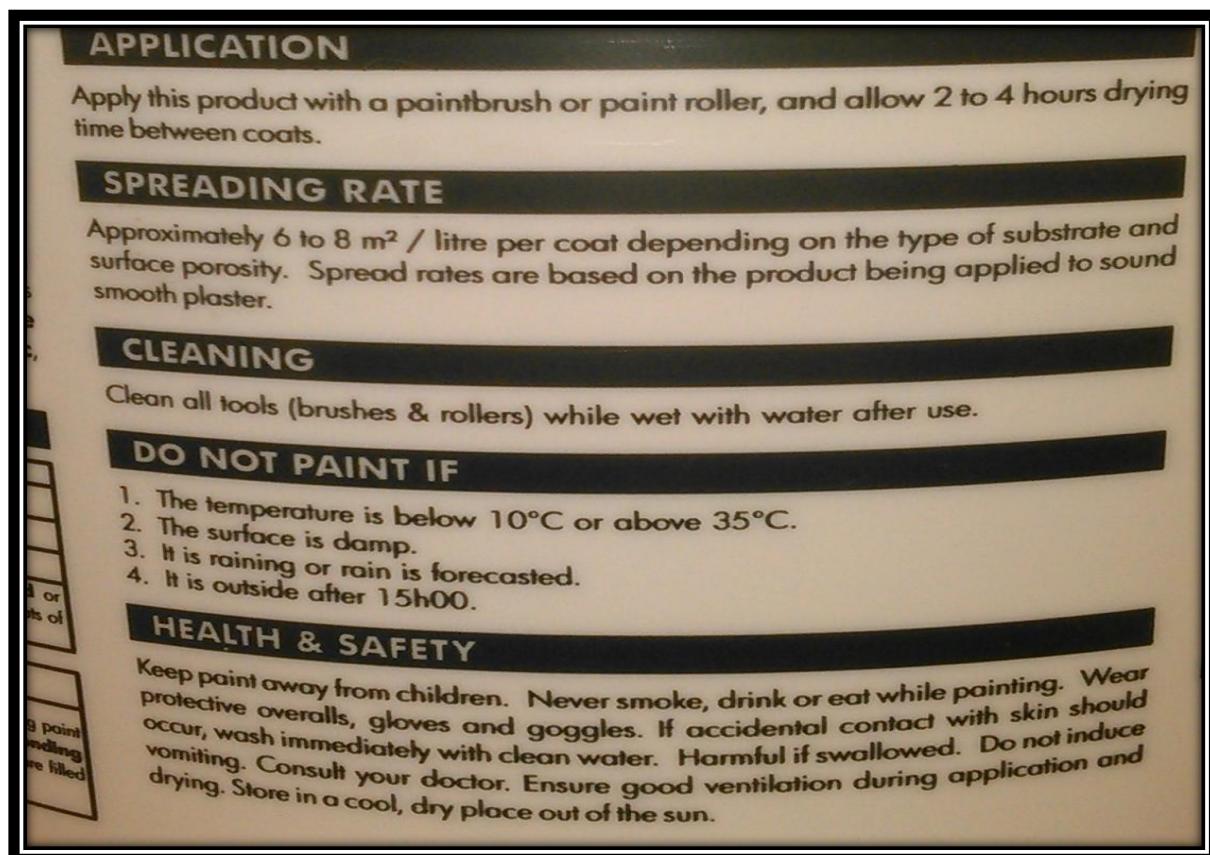


Figure 3: A material safety data sheet from a PVA water-based paint

6. Discussion

The research findings revealed underutilisation of material safety data sheet on the worksites with most respondents' interview indicating that MSDS are similar across like materials. However, the results established variances in information on material safety data sheets of like materials. According to OSHA (2004) most products marketed are mixtures of chemicals that are often unique to a single manufacturer.

Furthermore, research findings established that eighty percent of the respondents were not sure whether MSDS was used in preparation of a complete health and safety plan on construction worksites. The Canadian Centre for Occupational Health and Safety, (2016) indicates that SDS is an essential starting point for the development of a complete health and safety program. If not used in the development of a complete health and safety program certain essential safety consideration may be neglected hence endangering site worker or specifically workers handling materials in question.

7. Conclusion and Recommendations

Construction is a high hazard industry that comprises a wide range of activities involving construction, alteration, and/or repair. Examples include residential construction, bridge erection, roadway paving, excavations, demolitions, and large scale painting jobs. Construction workers engage in many activities that may expose them to serious hazards such as different materials. This therefore necessitates and augments the importance of MSDS utilisation. This is because it provides information about hazardous substance, how it should be used and how to avoid harm when using it at the workplace.

Employers must make MSDSs available to all people at the workplace who are potentially exposed to the hazardous substance. Employers must, as far as practicable, provide information, instruction, training and supervision so that employees can perform their work safely and are not exposed to hazards more so, that no alteration is made to an MSDS.

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The Influence of Workers' Attributes on Organisational Safety Performance

Elizabeth Lusenga¹, Chioma Okoro¹, Innocent Musonda²

Abstract

Attributes of construction workers, including their safety behaviour, are essential for good safety performance in any organization. This paper indicates findings on attributes of construction workers in mining construction sites in South Africa. Data were collected using questionnaires distributed among construction workers including drill rig operators, manitou operators, load haul dump (LHD) machine operators, electricians, fitters and general workers at four mining sites. Empirical data were analysed using Statistical Package for the Social Sciences (SPSS), version 23 to output frequencies. Findings revealed that the workers had knowledge about safety requirements but the level of knowledge and training was less than desirable. Negligence was also found to exist amongst the sampled workers and familiarity with work was found to be the primary cause. The frequency of accident reporting was however, found to be acceptable. These findings are useful to construction managers and supervisors in focusing attention on their workers in a bid to improve their safety and overall organisational performance.

Keywords: construction workers, organisational performance, safety, South Africa

1. Introduction

Mining and construction sectors are two major sectors of industrialised and developed countries which depend on each other and are also depended upon by many other major productive sectors of the economy which rely on their activities and output (Khan *et al.*, 2013). Mining activities are closely associated with construction building materials, and infrastructure projects. Most popular products of quarrying are used in the construction sector without any manufacturing process (eg. as stone ballast in road and railway tracks). The construction sector of the mining industry contributes to socio-economic development in the form of employment creation and contribution to gross domestic product (Gurcanli and Mungen, 2013).

Despite its 12% contribution to the GDP of South Africa, the mining sector still suffers high rates of incidents and fatalities, albeit with a steady improvement over the past decade (Mine Health and Safety Council (MHSC), 2013). The mining industry has been considered one of the world's most dangerous occupations, accounting for a significant proportion of fatal injuries globally (Boniface *et al.*, 2013). Some organisations have health and safety procedures in place of which the workers and managers alike are aware of, but do not implement (Okoye, 2016). However, regulations and

¹Postgraduate student; Department of Construction Management and Quantity Surveying, University of Johannesburg, South Africa; lizzy.m@webmail.co.za; chiomao@uj.ac.za

²Senior lecturer; Department of Construction Management and Quantity Surveying, University of Johannesburg, South Africa; imusonda@uj.ca.za

legislations are no longer sufficient to improve safety performance in these organisations. Fatalities still occur on mining and construction sites around the world (Boniface *et al.*, 2013; Gurcanli and Mungen, 2013). These occupational injuries take a considerable socio-economic toll on workers (through human suffering), companies and the economy at large (through productivity and economic losses). Construction workers, even on mining sites, are also at risk of high rates of injuries and fatalities. According to Gurcanli and Mungen (2013), construction workers are three to four times more likely to die from accidents at work than any other worker and in developing countries, the risks associated with construction work may be three to six times greater than other activities. Globally, at least 108, 000 workers are killed whilst performing construction-related activities, representing about 30% of all fatal occupational injuries. Construction workers on mining sites who are involved in such aspects as constructing of access roads to mining sites, dams and staging areas to house project personnel and equipment (Overview..., n. d.) are also exposed to safety hazards at work.

Numerous studies have blamed these accidents and fatalities on a variety of causes and individuals including owners, client, designers, engineers, manufacturer, architects and project managers (ElSafty *et al.*, 2012). Musonda (2012) focused on clients' role in safety improvement in the construction industry. Research by Nielsen (2014) indicated that improvements in top management's commitment to safety are linked to culture change; while Agumba (2013) dwelt on health and safety management in small and medium construction enterprises. Others like Lester (2006) and more recently, Kadiri *et al.* (2014) incorporated poor maintenance, inappropriate equipment, unsafe practices, negligence, carelessness, ignorance, improper use of working tools, and any number of human frailties as causes of safety performance on worksites. Sunindijo (2015) incorporated all these safety performance influencers but focused on the perceptions of owners and managers in small organisations; and in another South African study, Othman *et al.* (2009) focused on contractors' non-compliance with health and safety regulations. However, these studies were not conducted in the construction division of the mining industry and did not focus on the contribution of workers' characteristics in organizational safety performance outcomes. Therefore, there is a need to conduct research on workers' characteristics including knowledge, attitude and behaviours because as Gurcanli and Mungen (2013) suggested, employee-related acts account for almost one-third of all cases of accidents and/or fatalities on worksites. This view was also echoed in Zou (2011) and Kadiri *et al.* (2014) which revealed that the majority of workplace accidents, injuries and fatalities are attributed to unsafe work practices of employees rather than unsafe working conditions. Employee-related group includes not only victims but also construction workers or craftsmen accompanying the victim at the time of the accident (Gurcanli and Mungen, 2013). Personal characteristics or attributes of individuals or employees impact on team climate and organisational culture (Burke and Cooper, 2013). The workers' behaviours reflect the overall performance of the organization in terms of safety performance (Akpan, 2011).

The paper therefore aims to fill the gap through a review of the literature and questionnaire field survey, by evaluating employee behaviour, culture, knowledge and experience that could affect organisational safety performance. The objective of the paper is to evaluate the attributes of workers' which determine their safety behaviours and thus organisational safety performance.

2. Workers' Attributes which Influence Health and Safety Behaviour

Organisations are made up of individuals who are central features of the organisational behaviour, whether acting in isolation or as part of a group, in response to expectations of the organisation, or as

a result of the influences of the external environment. Every organization and workers therein undergoes change in attitude and behaviours at some stage (Mullins, 2010). The success and sustainability of an organisation is determined by the willingness of the workers to practise good behaviour in the organisation (Darsana, 2013). Different people enjoy working in different types of organisation culture and they are more likely to be happy and satisfied at work if their attributes and personalities are consistent with the culture of that part of the organisation in which they are employed (Mullins, 2010). People bring their own perceptions, feelings and attitudes towards the organisations, with differences in ethnicity, motivation, attitudes, socio-cultural factors, perceptions, intelligence and abilities. The safety performance of organisations or construction projects is partly determined by the various contributions of these diverse employee-related group including construction workers or craftsmen with different levels of expertise, education and experience (Okoye, 2016). These attributes are strengths in some jobs and weaknesses in others. Worker proactive safety culture and behaviour helps to reduce claims and delays, enhance productivity and profitability while strengthening the organisational safety performance and reputation (Cesarini *et al*, 2011).

According to Kadiri *et al.* (2014), accidents occur due to human error, which is partly as a result of failure on the part of the workers, errors in judgement, lack of concentration at work, and lack of awareness of the danger inherent in construction activities. Anecdotal evidence suggested that labourers are the major contributors and causes of accidents on construction sites in Nigeria. This study evaluated the causes and effects of accidents on selected multinational, large and small scale construction firms in Abuja. Negligence or carelessness, improper use of tools, use of defective tools and machines, failure to follow safety rules, improper use of personal protective equipment (PPE), lack of teamwork, poor educational level, poor safety conscientiousness, poor communication and dropping of materials from high rise projects, were also reported as causes of accidents attributable to construction workers on sites, in that study.

In a quantitative study evaluating descriptive factors of injuries among Iranian workers, it was reported that insufficient professional skills, level of education, negligence (which accounted for 75% of deaths), failure to wear PPE, stress and fatigue contribute to injuries. Similar views were shared in Hamid *et al.* (2008) in which it was indicated that, in addition to the afore-mentioned, lack of awareness of safety regulations and poor attitude about safety influences safety outcomes in an organisation. In Hamid *et al.*'s opinion, accidents do not just happen; they are caused by unsafe acts, unsafe conditions or both. However, Zou (2011) argued that the majority of workplace accidents, injuries and fatalities are attributed to unsafe work practices of employees rather than unsafe working conditions. According to Zou, there exists a macho-image among construction workers which causes poor safety performance.

The above studies dwelt on workers on a construction site and did not necessarily include mine site workers. Although the attributes may be similar, a review of workers in mine sites was necessary to explore differences or similarities. On this note, a study by Boniface *et al.* (2013), which employed quantitative methods to identify factors associated with injuries and fatalities among mine workers in Tanzania reported that education, job experience, age, lack of safety training, use of unsafe equipment (for instance using barrel mounted on a cable), and use of rudimentary tools contributed to poor safety performance amongst the sampled workers. The authors concluded that workers (including mining construction workers, that is those involved in the construction phase of mining projects) sometimes do not identify their situation as dangerous. This is probably due to the "I-do-not-care" attitude and belief that since they have always done the job in a certain way without sustaining any injuries, it is

somewhat okay to continue as usual. Sensitization is therefore necessary in order to motivate the workers to take workplace safety seriously (Boniface *et al.*, 2013). Glendon *et al.* (2006) concurred that employees' poor safety attitude contribute to occurrence of injuries and fatalities and further stated that this could be infectious and easily affect other workers around since this negative way of thinking or perception may alter another individual's disposition and underlying values.

Other factors such as communication and information flow amongst project team members (English, 2012; Kadiri *et al.*, 2014), income, job satisfaction, enjoyment and contentment (Okoro *et al.*, 2016) also promote good safety behaviours amongst construction workers and thus improve organisational performance.

3. Research Methods

This paper used a quantitative approach in order to explore workers' characteristics which influence organisational performance. The advantage of using quantitative research method is that it allows for objective measures and numerical analysis of data collected through polls, questionnaires or surveys. A questionnaire was developed from a review of relevant literature. A total of eighty questionnaires were prepared of which fifteen were distributed by e-mail, sixty were handed out to the respondents in person and five were conducted face to face. Data were collected between March and November, 2015. The respondents included drill rig operators, manitou operators, load haul dump (LHD) machine operators, electricians, fitters, general workers, supervisors and managers on four mining sites in three provinces including Mpumalanga, North-West and Northern Cape. A total of seventy-one responses were received. Data from the questionnaires were reviewed, and inputted to SPSS to output descriptive statistical values in the form of frequencies useful to inform the reader about the findings from the study. The output was then presented as graphs, and charts for easy interpretation of the reader, as presented here.

4. Results and Discussion

4.1 Demographic characteristics of respondents

The dominance of males in the industry was evident in the participation of respondents in the survey as the majority (87%) was male; 13% was female. The respondents were mostly middle-aged, with many aged between 31-35 years (56%) followed by age group of between 26-30 years which accounted for 14%; 13% of respondents were between the ages of 36-40 and 8% of respondents were 25 years or younger. Respondents aged between 46 years and above accounted for 3%. The age group of 41-45 years did not respond in this regard.

With regard to categories of work, the respondents consisted of 39% operators/PTV/LHD and winch drivers, 25% general workers, 20% artisans/fitters, and 15% made up of supervisors and management. With regard to work experience, 44% of the respondents indicated that they had 6-10 years working experience in the industry; 39% had worked for a period of between 1-5 years; 13%, for between 11-15 years; and 3% of respondents had worked in the mining construction industry for over twenty years.

4.2 Findings on worker attributes

4.2.1 Level of experience

Figure 1 shows that 44% indicated that they had adequate experience in the job they were doing. On the same note, 37% was uncertain about the adequacy of their job experience; 8% strongly agreed that they had adequate job experience; 10% indicated that they do not have adequate experience.

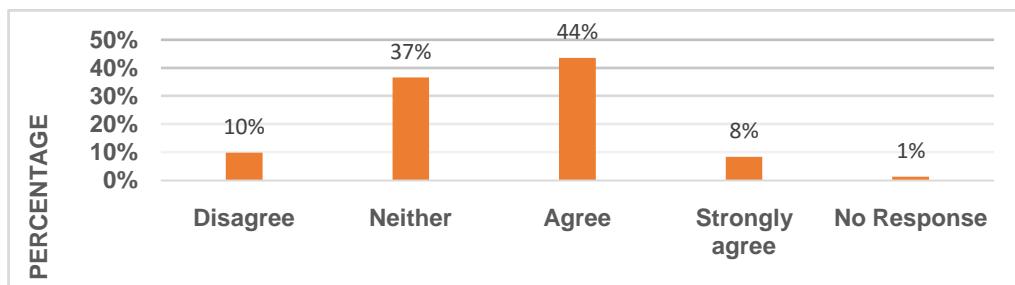


Figure 1: Adequacy of job experience

4.2.2 Level of knowledge about safety requirements

As shown in figure 2, a total of 56% of respondents agreed that they had knowledge about safety requirements for their jobs and this helps to reduce occurrence of accidents and injuries on sites. While 14% of the respondents strongly agreed about the statement, 1% disagreed and about 1% did not respond in this regard.

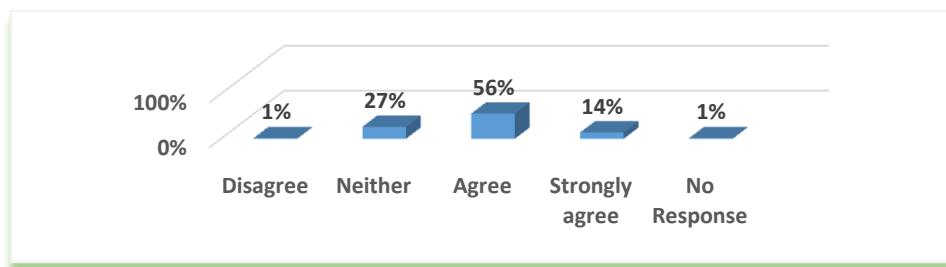


Figure 2: Safety knowledge

4.2.3 Negligence/Carelessness

Respondents were asked if they failed to take safety precautions due to familiarity with specific tasks. Figure 3 showed that 32% of respondents agreed that they do not take precautions during work due to familiarity of the work being undertaken. 31% disagreed with the statement, and 13% of respondents strongly disagreed.

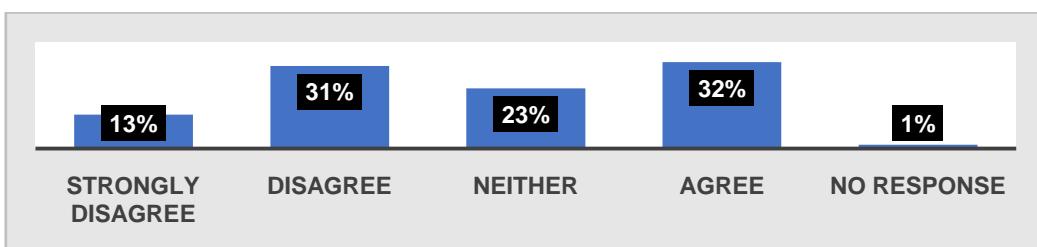


Figure 3: Negligence due to familiarity with current work

4.2.4 Lack of concentration due to constant disturbances and interruptions

Figure 4 revealed that 46% of respondents agreed that they experienced lack of concentration due to constant disturbances and interruptions from a supervisor, or co-workers, when doing their job influences their safety performance; while 11% strongly agreed and were neutral, respectively. 10% of respondents strongly disagree to the said statement and about 6% of respondents did not respond in this regard.

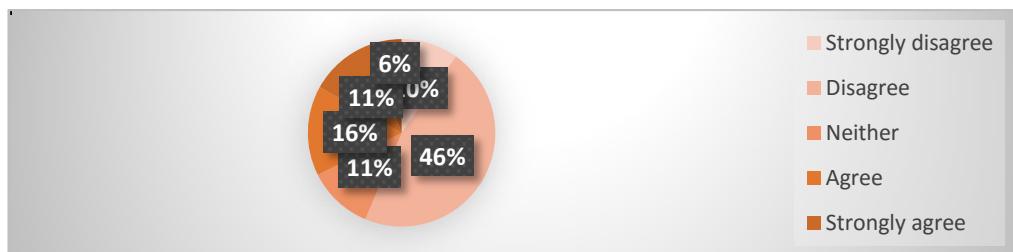


Figure 4: Lack of concentration due to constant disturbances and interruptions whilst working

4.2.5 Lack of concentration due to family problems

Lack of concentration due to worries about family problems was indicated to influence occurrence of accidents, as revealed by the 54% of respondents who strongly agreed that they always thought about their families when doing their job and this influenced their performance (figure 5). 41% of respondents agreed with the statement; while 3% of respondents could not agree or disagree.

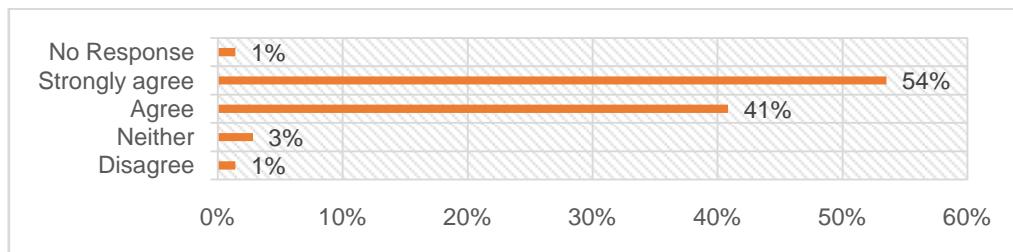


Figure 5: Thinking about families when doing their job

4.2.6 Lack of communication

Respondents were asked about communication being an influence on their safety performance during work on sites. Figure 6 indicated that 31% of respondents strongly disagreed to the statement that they were comfortable to speak to their managers regarding unsafe work environment. Meanwhile, 25% of respondents did not feel comfortable to communicate with their managers when they felt unsafe in their work environment. On the other hand 23% of respondents agreed that they felt free to express their concerns regarding unsafe working environment. While 15% of respondents strongly agreed that they were comfortable to speak to their managers regarding unsafe work environment. However, 4% of respondents did not agree nor disagree to the said statement. About 1% of respondents did not respond in this regard.

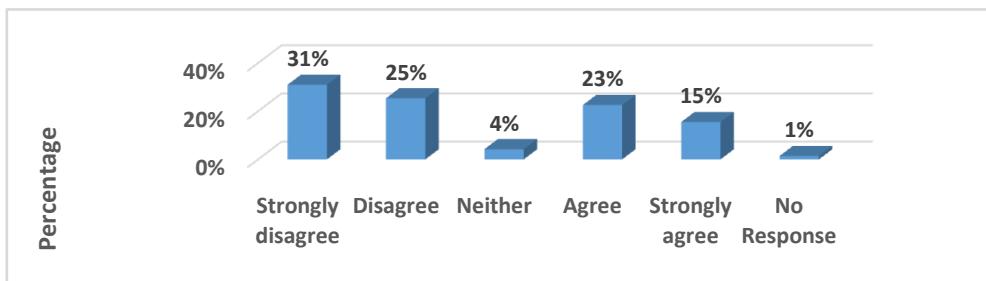


Figure 6: Communication on site

4.2.7 Reporting of accidents and incidents

The chart in figure 7 indicates that 54% of respondents agreed to the statement that they always reported incidents and accidents on the job and about 25% of respondents strongly agreed. On the other hand, 3% did not agree nor disagree that they reported incidents and accidents on the job. Only 1% of respondents disagreed to the said statement.

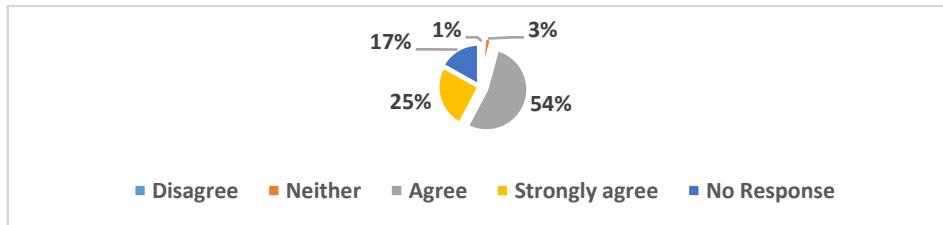


Figure 7: Reporting of accidents

4.2.8 Job satisfaction/enjoyment

Figure 8 indicated that 37% of respondents did not agree nor disagree that they enjoy their job. However 37% of respondents agreed that they enjoyed their job. While 17% of respondents strongly agreed that they love their job and only 10% of respondents disagreed that they enjoyed their job.

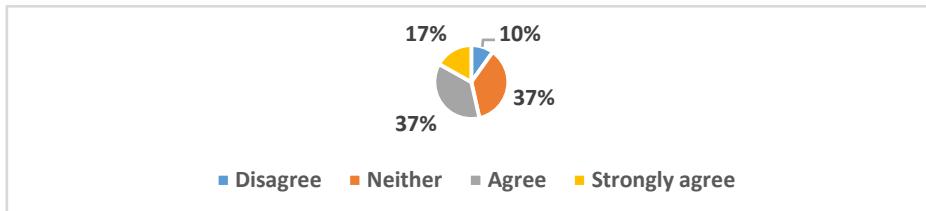


Figure 8: Job satisfaction

5. Discussion of Findings

The finding that the level of experience influences the rate of occurrence of accidents corresponds with results from Hamid *et al.* (2008) and Rahmani *et al.* (2013) in which it was opined that low experience of the work which workers are engaged in, partly contributes to accidents and injuries on site since they might be inclined to use wrong tools. Sufficiency of professional skills may also vary amongst seasonal or shift workers (Rahmani *et al.*, 2013). Limited job knowledge and experience, especially of young adults (aged less than 30 years) increases the risk of injury (ElSafty *et al.*, 2012). Boniface *et al.* (2013) shared these views stating that workers who had a work experience of less than 5 years had a higher risk of mortality due to the fact that they have less knowledge of workplace

hazards and are more exposed to more hazardous working conditions as opposed to supervisors with higher job experience.

That negligence contributes to accidents on site is supported in Kadiri *et al.* (2014) who indicated that negligence or carelessness and a sense of familiarity with the work might lead to workers not assessing risks or taking precautions where necessary or fail to follow safety rules, and this is not necessarily because they are not aware of the inherent danger in their tasks. In the view of Zou (2011), ElSafty *et al.* (2012) and Rahmani *et al.* (2013), negligence is a major contributor to high accident rates on site since workers believe that following safety rules and procedures (such as wearing PPE) is not necessary.

The relationship between thinking about one's family and problems was shown in Rahmani *et al.* (2013) which reported that stress and fatigue can be higher among married workers than single ones because of higher responsibilities in life. As a result, their alertness may be compromised thereby reducing operational efficiency and safety as they indulge in unsafe acts. In general, lack of concentration or cognitive impairment is associated with increased risk of falling (ElSafty *et al.*, 2012). Higher risks of injuries may occur among older workers with decreased physical and mental abilities which in turn alter their ability to notice work environment hazards (Boniface *et al.*, 2013).

It is well known that communication is essential for good safety performance. However, the results showed that workers are not comfortable to communicate freely with management regarding safety issues. Communication is key in disseminating clear and understandable information from employers to employees and building trust, teamwork and co-operation among team members (Aulich, 2013). Poor information flow amongst project partners could lead to lack of interest in safety issues and thus high accident rates on site (Zou, 2011; Kadiri *et al.*, 2014).

The findings that willful reporting of accidents occurs among the sampled workers is encouraging. This however, does not align with results from ElSafty *et al.* (2012) which indicated that there existed wilful under-reporting of incidents or illness, in many worksites in Egypt, due to fear of missing work or being laid off and this affected organisational performance. Reporting of incidents enables timely implementation of preventative measures to improve conditions.

The percentage of respondents who indicated that they enjoyed their work was not satisfactory and this could lead to nonchalance, lack of motivation, divided attention and increased susceptibility to the influence of other co-workers who indulge in unsafe practices. This is consistent with the view in Okoro *et al.* (2016) in which it was indicated that job content and satisfaction brings about an increased sense of achievement which motivates workers to perform at their best. A satisfied employee shows commitment in their job and in return delivers successful projects with regard to safety (Okoro *et al.*, ibid.).

6. Conclusion

The current paper sought to evaluate the attributes of workers which potentially influence their safety and organisational performance. The objective was achieved. The workers sampled in this study reflected their awareness of safety requirements and willingness to report accidents and incidences on sites. However, they were found to exhibit an unacceptable degree of nonchalance about safety practices on site. This was mainly attributed to familiarity with their work.

The perceptions, behaviours and attitude of workers need to be focused on if improvement in organisational safety performance is desired. Workers should be constantly trained and supervised in order to ensure that they engage in safe work practices on sites. As much as it is a norm in the construction and mining industry to work under pressure, it is as much concern with regards to safety of the workers. In addition, a satisfied employee shows commitment in their job and in return delivers successful projects with regard to safety. Therefore, such factors that are partly beyond the workers' control, for instance, level of income and job conditions, and so on, which contribute to reduced alertness and concentration should also be the focus of more discussion.

Although this study focused on mining construction workers in South Africa and used a quantitative approach, it provides useful information that could help construction companies and stakeholders in achieving improved and sustained organisational safety performance. Stakeholders, clients, investors and employees need an assurance of safety in the business and their place of work. Further studies could adopt alternative techniques (such as correlation or multiple regression) to explore relationships between the identified attributes and organisational safety performance in other geographical regions.

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The Impact of Environmental Thermal Changes on Construction Health and Safety in Zimbabwe

Benviolent Chigara¹, John Smallwood²

Abstract

There is a growing body of literature showing widespread consensus that the environment is warming. Although available empirical evidence demonstrate that human health and the environment are related, inadequate attention has been afforded to the climate change discourse in terms of examining the effects of such change on occupational health and safety (H&S). These omissions marginalise the H&S of construction workers who are often exposed to extreme weather elements. This paper uses literature analysis and an exploratory empirical perception based study to explore the effects of increasing environmental temperatures on construction H&S in Zimbabwe. However, due to limited literature pertaining to this subject, especially as it relates to construction H&S, the study borrows extensively from public health literature. Primary data were collected from construction industry practitioners namely contractors, consultants and public clients/regulators using structured questionnaires. The results of the analysis suggest that the construction industry in Zimbabwe has not been spared the effects of rising temperature on H&S and productivity. However, rising ambient temperature is perceived to affect, to a greater extent, the health of workers and productivity as compared to incidents and accidents. Inadequate legislative frameworks, lack of integration of environmental thermal changes and H&S, and inadequate information, among other factors, can constrain sustainable response strategies. Therefore mainstreaming environmental sustainability in construction H&S and implementation of sustainable adaptive strategies on projects will enhance workers' H&S. Further research is needed to assess workers' perceptions regarding the effects of changing environmental thermal conditions on H&S.

Keywords: climate change, construction, health and safety, environmental warming

1. Introduction

There is a growing body of literature showing widespread agreement that the environment is warming (Intergovernmental Panel on Climate Change (IPCC), 2007; World Health Organisation (WHO), 2009; Venugopal *et al.*, 2016) due to emissions of greenhouse gases (GHG) into the atmosphere

¹Department of Construction Management, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa

² Professor, Department of Construction Management, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa

arising from the combustion of fossil fuels (Haines *et al.*, 2006; WHO, 2009). According to the IPCC (2007) changes in the atmospheric abundance of GHG and aerosols, in solar radiation and in land surface properties alter the energy balance of the climate system. According to Patz (1998), there are two primary components of climate change, that is, temperature elevation and rising sea-level due to thermo-expansion. However, more recent studies suggest that increasing temperature is the most common modeled effect of climate change around the world (IPCC, 2013; Kjellstrom *et al.*, 2015). Accordingly, all models of future climate indicate that much of the world will experience a hotter environment in the next few decades (Kjellstrom *et al.*, 2014) and global temperature rises will exceed the threshold of 2°C above pre-industrial average temperature (Lancet, 2009; IPCC, 2014). Climate change causes worldwide higher temperatures with different regional patterns (Hübler *et al.*, 2008). The changing climate will inevitably affect the basic requirements for maintaining health (WHO, 2009) and may impair health and productivity for millions of working people (Kjellstrom *et al.*, 2009). This is consistent with several studies around the world, which suggest that temperatures above locally specific threshold result in higher mortality rates (WHO, 2009; Parsons, 2014). For instance, the extended hot summer of 2003 in Europe produced sustained record high temperatures, which resulted in markedly higher death rates (WHO, 2009). Heat waves have become more frequent over most land areas (WHO, 2009) and tropical countries (Kjellstrom *et al.*, 2015). Despite being less responsible for global GHG emissions, several studies suggest that low income countries are bound to suffer more from the consequences of climate change (Patz, 1998; Haines *et al.*, 2006; Madzwamuse, 2010; Chagutah, 2010; IPCC, 2014; Xiang *et al.*, 2014; UNDP, 2016) due to lack of institutional, financial and technological capacity to adjust (Madzwamuse, 2010; Brazier, 2015). According to IPCC projections, sub-Saharan Africa warming is expected to be greater than the global average (Mathee *et al.*, 2010). Previous studies suggest that most of the worst effects will be felt in the tropical and subtropical regions - also referred to as the "crisis belt" (Brazier, 2015) because levels of heat in many tropical locations are already very high with respect to thermal tolerances (Brazier, 2015; UNDP, 2016). Previous studies suggest that projected climate change will impact human health mainly by exacerbating health problems that already exist (IPCC, 2014). Therefore intensifying heat waves and workplace heat exposure will exacerbate the problem of workplace H&S (Xiang *et al.*, 2014). Increased temperatures will result in heat-related mortalities (Madzwamuse, 2010; IPCC, 2014). According to Madzwamuse (2010) climate change threatens to reverse the gains of development and put pressure on already limited human and financial resources in developing countries. According to IPCC (2014) climate change will amplify existing risks and create new risks for natural and human systems. Although the precise level of climate to trigger the abrupt and irreversible change remain uncertain, but the risk associated with crossing such thresholds increases with rising temperatures (IPCC, 2014). In fact heat stress is an occupational hazard threatening H&S of millions of workers globally (Schulte and Chun, 2009; Venugopal *et al.*, 2016). Several studies suggest that construction workers, among other outdoor workers are at great risk of climate change heat stress (Morioka *et al.*, 2006; Xiang *et al.*, 2014; Rowlinson *et al.*, 2014; UNDP, 2016) due to lack or absence of mechanical cooling (Venugopal *et al.*, 2016), the often informal manner in which the construction industry organises itself (Rowlinson *et al.*, 2014).

Extreme heat induced by climate change will cause profound adverse consequences for work, human performance, daily life, and the economy in large parts of the world (Kjellstrom *et al.*, 2015). Miller and Bates (2007) summarise the consequences of environmental heat stress as a reduction in safety due to impaired concentration, a decreased work capacity, and heat illness. Theoretically, the number of work-related injuries is positively related to the increase of temperature (Xiang *et al.*, 2014). In

South Africa, Mathee *et al.* (2010) found that workers reported a wide range of heat-related effects such as sunburn, sleeplessness, irritability, and exhaustion leading to difficulty in maintaining work levels and output during very hot weather. In a study aimed at quantifying the climate induced health risks for Germany based on high resolution climate scenarios for the period 2071 to 2100, Hübler *et al.* (2008) found that heat increase the number of related casualties by factor of more than three, increase heat related hospitalisation costs six-fold, and reduces the work performance resulting in an estimated output loss of between 0.1 % and 0.5 % of gross domestic product (GDP).

Even though there is a significant body of knowledge addressing the effects of changing environmental thermal conditions on public heath of the general population, research linking workplace H&S and climatic heat stress is limited (Schulte and Chun, 2009). In the construction industry, climate change has not been recognised as a risk factor in accidents until quite recently (Rowlinson *et al.* (2014). Previous studies also suggest that the consequences of ill health from workplaces is often underestimated (Kjellstrom *et al.*, 2009; Xiang *et al.*, 2014). In Zimbabwe research on the effects of climate change mainly focus on agriculture and national food security (Gukurume, 2013), water resources management, energy generation and public health (Chagutah, 2010), various sectors of the economy (Brown *et al.*, 2012), and historic and future projections of climate change (Unganai, 1996). Although these past studies produced valuable information on sectoral vulnerability to climate change in the country, there is dearth of data relating to vulnerability at the workplace. According to the UNDP (2016) the economic, health and social ramifications of rising heat in the workplace requires an urgent response to protect workers. This research adopted a survey of the literature coupled with perception based surveys conducted among construction industry practitioners to explore the effects of climate change altered environmental thermal conditions on workplace H&S and productivity in Zimbabwe.

2. Literature Review

During a study involving scientific publications spanning the period 1988-2008, Schulte and Chun (2009) found seven climate change related hazards: increased ambient temperatures, air pollution to; ultraviolet exposure, extreme weather, vector borne disease and expanded habitats, industrial transmissions and emerging industries, and change in built environment. The current study addresses the impact of increased ambient temperatures on construction H&S and productivity. According to Venugopal *et al.* (2016), the world is getting hotter, and data produced by the IPCC suggest that global average surface temperature has increased about 0.74°C in the last 100 years with more widespread changes in extreme events, temperature and precipitation patterns, and a faster rate of temperature increases reported over the recent times. The World Meteorological Organization (WMO) confirmed the likelihood that the average global temperature change had already reached 1°C (UNDP, 2016). The WMO (2015) suggests that the global average near-surface temperature for 2015 was the warmest on record by a clear margin at about 0.76 ± 0.09 °C above the 1961–1990 average, and approximately 1°C above the 1850–1900 average. The WHO (2009) states that the development paths that the world chooses will have a strong influence on temperature increase. For instance, if the world places high priority on sustainable energy use, temperatures are expected to rise by 1.8°C (likely range: 1.1–2.9°C) and where lower emphasis is placed on sustainability, temperatures are expected to rise by 4.0°C (2.4–6.4°C), with a greater probability of abrupt or irreversible impacts. Even if emissions of greenhouse gases were to halt immediately, many aspects of climate change and associated impacts will continue for centuries. The WHO (2009) argue that temperatures would still to

rise by over 0.6°C in this century. The IPCC (2014) forecast that heat waves are likely to occur very often and last longer, and that more frequent hot extremes will be experienced over most land areas on daily and seasonal timescales.

Unganai (1996) assessed the ambient temperature changes for Zimbabwe for the period 1933 to 1993 and found that maximum temperatures increased by up to +0.8°C nationally, and by up to 1.2°C in Harare from 1897 to 1993. According to the Ministry of Environment, Water and Climate (2015), Zimbabwe is experiencing more hot and fewer cold days as a result of climate change and variability with the period between 1980 to date being the warmest. The Meteorological Services Department revealed that temperature recorded during heat wave period (last quarter of 2015) in Zimbabwe averaged between 33°C and 43°C (Chigogo, 2016). In a more recent study, Brazier (2015) indicate that climate change will cause average temperature in Zimbabwe to rise by between 1°C and 3°C, which is greater than the global average, by 2050 and until the end of the century. In its National Climate Change Response Strategy, the Government of Zimbabwe regards climate change as one of the threats to the country and its people, with the potential to undermine many of the positive benefits made in meeting the country's development goals (Ministry of Environment, Water and Climate, 2015). To show its commitment to climate change issues, Zimbabwe signed and ratified the United Nations Convention on Climate Change (UNFCCC) in 1992 and the Kyoto Protocol in 2009.

Previous studies have shown that rising ambient temperature (climate heat stress) is an occupational hazard in construction work (Rowlinson and Jia, 2014; Rowlinson *et al.*, 2014; Di Corleto, 2012). Climate heat stress is determined by six heat stress factors including: air temperature; humidity; solar radiant heat and wind speed; metabolic heat, and clothing effect (Kjellstrom *et al.*, 2009; Parsons, 2014; Rowlinson *et al.*, 2014). The Canadian Centre for Occupational Health and Safety (2016) define heat stress as the net (overall) to which a worker is exposed from the combined effect of metabolic heat and environmental factors. Other studies have also shown that the impact of heat exposure is more pronounced in outdoor occupations, and among these construction workers are a top priority due to the often informal manner in which the construction industry organises itself (Gillen & Gittleman, 2010 cited in Rowlinson *et al.*, 2014) and the heavy physical work that subjects workers to physical strain as well as inducing metabolic heat gain (Rowlinson *et al.*, 2014; Xiang *et al.*, 2014). On construction projects, metabolic heat is also traced down to two manageable factors, that is, continuous work time and work pace (Rowlinson & Jia, 2014). On the other hand, constant use of machinery and powered tools, working on elevated surfaces, heavy workload, simple accommodation conditions near work sites, being temporarily employed by a sub-contractor on a daily payment basis, and constant and direct exposure to sunlight increase the risk of heat-related illness and injury in the building industry (Xiang *et al.*, 2014).

2.1 The effects of environmental heat stress on health and safety

Working people are at particular risk of health effects of excessive heat exposure (Kjellstrom *et al.*, 2014; Rowlinson *et al.*, 2014; Xiang *et al.*, 2014). Studies show that over-exposure to heat can induce disorders such as heat rash, heat cramps, heat syncope or fainting, heat exhaustion, or heat stroke (Rowlinson *et al.*, 2014). According to Di Corleto (2012) exposure to extreme heat can result in illness, injury and, in extreme cases, death. According to Patz (1998), the direct health impacts from stratospheric ozone depletion, which leads to increased ambient UVB radiation, include: skin cancer; ocular diseases, and immunosuppression. Reporting on survey conducted in 2011, Rowlinson *et*

al.(2014) show that 17 of 37 trades reported cases of heat-induced illness on construction sites. In South Africa, Mathee *et al.* (2010) show that most participants felt that working in very hot weather could have varied impacts on health. The health effects mentioned during the focus group discussions include increased thirst, excessive perspiration, itchy skin, tiredness, dry nose, blister formation, sinus problems, teary or burning eyes, exhaustion, malaise, dehydration, headaches, backache, leg pains, nose bleeds, premature baldness, and dizziness (Mathee *et al.*, 2010). In addition, participants also felt that working in hot weather could aggravate chronic ill health conditions such as hypertension (Mathee *et al.*, 2010). In Hong Kong, Chan (2012) as cited by Rowlinson *et al.* (2014) show that 43 heat stress-related accidents, including 11 fatalities were recorded during the period 2007-2011 on construction sites. In the summer of 2003, an estimated 30 000 people died in Europe as a result of the heat wave (De Bono *et al.*, 2004).

Climatic heat stress also leads to accidents on construction sites through a chain effect brought about by a range of human factors emanating from heat induced illness and fatigue leading to impaired physical and mental capability (Rowlinson *et al.*, 2014). This will potentially lead to a compromise of occupational safety (Xiang *et al.*, 2014). Xiang *et al.* (2014) suggest that without adequate heat dissipation, short-term acute extreme heat exposure can cause a rise in core body temperature and may result in direct heat illnesses, which can also increase the risk of occupational injuries and accidents. According to Bates and Schneider (2008), intense or prolonged physical activity, especially in hot weather may result in fatigue. The US Census of Fatal Occupational Injuries recorded 196 heat-related mortalities from 2003 to 2008, and construction workers occupied the greatest proportion (36%) (Xiang *et al.*, 2014). It should be noted that climatic heat risk varies with types of construction sites as well as stages of a project lifecycle (Rowlinson *et al.*, 2014).

2.2 Effects of rising ambient temperature on work performance

In addition to the effects on H&S, heat stress leads to a managerial risk related to diminished worker capacity (Yassi and Kjellström,1998), reduced labour productivity (Kjellstrom *et al.*, 2009; Mathee *et al.*, 2010; Rowlinson *et al.*, 2014), cost (Kjellstrom *et al.*, 2009), diminished mental task ability, low worker morale, and increased risk of accidents. Several studies suggest that there is a relationship between the thermal environment and productivity. Results of a pilot study conducted in South Africa show that workers reported that very hot weather makes their work more difficult and uncomfortable (Mathee *et al.*, 2010). Based on projected data, Kjellstrom *et al.* (2009) suggest that by the 2080s, the greatest absolute losses of population based labour work capacity (in the range 11% to 27%) is seen in Southeast Asia, Central America, and the Caribbean. Studies involving workers in construction in India show that 48% (Venugopal *etal.*, 2015) and 69% (Venugopal *et al.*, 2016) of the workers reported productivity losses due to heat stress. Cited reasons for productivity losses were extended-work hours due to fatigue/exhaustion, sickness/hospitalisation and wages lost (Venugopal *et al.*, 2015; Venugopal *et al.*, 2016). When working in a hot environment, the natural response of a worker is to slow down his/her physical activity in order to moderate body core temperature(Parsons, 2014). Kjellstrom *et al.* (2014) notes that lack of cooling systems means that workers need to reduce work intensity or take frequent breaks in order to avoid heat exhaustion and heat stroke. Due to this protective mechanism, output is reduced leading to productivity losses (Kjellstrom *et al.*, 2014; Venugopal *et al.*, 2016). Kjellstrom *et al.* (2014) further note that if people cannot work or carry out other daily activities as required, incomes will fall and many families and communities will suffer. Nonetheless, the UNDP (2016) argue that many health professionals and scientists appear to consider

the productivity loss as a 'non-health effect', and therefore not worth including in health impact analysis. But this oversight undermines efforts to achieve decent work, which includes both health protection and fair income protection (UNDP, 2016). The International Organisation for Standardization (ISO) indicate that heat impacts in terms of health and productivity loss start occurring at approximately 26°C (WBGT) for heavy physical labour (UNDP, 2016).

Some previous studies have identified a number of problems that may affect the management of the effects of climatic heat stress on workplace H&S. Such challenges include, but not limited to; non-availability of specific legislation or H&S limits regarding temperature and UV radiation exposure for sun-exposed workers in South Africa (Mathee *et al.*, 2010); heat stress is not listed as an occupational health priority (Xiang *et al.*, 2014); perception that the human body can acclimatise to increasing heat and that high heat exposure is an issue that is only relevant during 'heat waves' (Kjellstrom *et al.*, (2014); lack of mono-causal relationship between temperature and detrimental health effects (Hübler *et al.*, 2008). Rowlinson and Jia (2014) indicate that heat stress management in construction sites is practised in an incremental way, which results in conflicting effects in H&S measures. For example, the safety helmet, designed to protect workers from falling objects, often acts as a head heater during hot summer weather, which places workers in a dilemma of risking one hazard for another (Rowlinson and Jia, 2014; Rowlinson *et al.*, 2014). During an earlier study, Patz (1998) suggests that preventive measures must be systems based.

2.3 Environmental thermal thresholds

Physiologically, humans have a great capacity for thermoregulation (Patz, 1998; Parsons, 2014) up to a threshold temperature. However, weather conditions exceeding threshold temperatures and persisting for several consecutive days cause increased mortality in the population (Patz (1998)). According to Kjellstrom *et al.* (2014) the boundaries of H&S identified in climatic heat risk management are basically environmental thresholds that define safe work limits under certain work-rest regimens. Kjellstrom *et al.* (2009) state that if body temperature exceeds 39°C, heatstroke may develop, and a temperature of 40.6°C is life-threatening. To prevent heat stroke, the American Conference of Governmental Industrial Hygienists (ACGIH) states that workers should not be permitted to work when their deep body temperature exceeds 38°C (Morioka *et al.*, 2006). Therefore, maintaining a core body temperature close to 37°C, which is the human disposition (Parsons, 2014), is essential for health and human performance (Kjellstrom *et al.*, 2014). In that regard, the ability to lose heat by evaporation of sweat is crucial to a person under heat stress. However, high external air humidity, and the clothes worn in some jobs, limit sweat evaporation and core body temperature goes up (Parsons, 2014; Kjellstrom *et al.*, 2014).

Against a background threat to health posed by heat stress, a number of instruments have been developed to quantify thermal strain. A widely used index in many industries is the Wet Bulb Globe Temperature (WBGT) (Bates and Schneider, 2008; Kjellstrom *et al.*, 2009; Rowlinson *et al.*, 2014; UNDP, 2016). The WBGT is used to quantify different levels of heat stress and define the percentage of a typical working hour that a person can work and maintain core body temperature below 38°C, assuming that the remaining time is rest (Kjellstrom *et al.*, 2009). WBGT combines temperature, humidity, wind speed and heat radiation into one number (UNDP, 2016). However, the WBGT suffers from inability to incorporate direct measure of wind speed, and requires estimation of metabolic rates (Bates and Schneider, 2008). Recently developed indices such as the Thermal Work Limit (TWL) have addressed the inadequacies of the WBGT to provide more meaningful and useful

measures of environmental heat stress (Bates and Schneider, 2008; Rowlinson *et al.*, 2014). The TWL is an integrated measure of the dry bulb, wet bulb, wind speed and radiant heat (Bates and Schneider, 2008). In spite of its weaknesses, Rowlinson *et al.* (2014) argue that the WBGT remains a valid heat index for managing occupational heat stress in a convenient procedure.

3. Methodology

An exploratory study was conducted to determine the perceptions of construction industry practitioners regarding the effects of rising environmental temperature on workers' H&S and productivity. According to Babbie and Mouton (2015), surveys are the most frequently used research design in the social sciences and can be used for descriptive, explanatory, and exploratory purposes. Fifty (50) structured questionnaires were self-administered on construction industry practitioners in Zimbabwe's two largest cities of Harare and Bulawayo. Questionnaires were physically delivered to the offices of the practitioners while some were emailed to known email addresses (obtained from the organisations' databases). According to Chigara *et al.* (2013) over 80% of registered contractors and consultants are found in these two cities. However, data collected was not limited to the two cities. Respondents were required to base their assessments on experiences gained from construction sites across the country. Previous literature guided some of the issues included in the questionnaire.

In order to realise a balanced assessment, the study solicited the views of consultants, namely architects, quantity surveyors, engineers, and project managers, and site management staff in construction firms, namely site agents, contracts managers, project managers, and site quantity surveyors, and project management personnel / technical personnel from client organisations. Although workers are directly affected by changes in environmental temperatures, the present study is limited to analysing the perceptions of construction industry practitioners with upstream function in H&S planning and regulation. Data was quantitatively analysed using SPSS (V21.0) and Microsoft Excel was used to generate tables.

4. Findings and Discussion

4.1 Demographics of respondents

A total of 38 questionnaires, representing a 76% response rate, were successfully completed and analysed. Amongst the 38 completed questionnaires, 39.5% were received from contractors, followed by consultants with 31.6%, central government departments (21%) and local authorities (7.9%). The respondents' positions within the various organisations were as follows: Project Manager (21%), Principal/Partner (15.8%), Project Quantity Surveyor (15.8%), Contract Manager (13.2%), Project Engineer (10.5%), Architect (7.9%), Site Agent (7.9%), and H&S Officer (7.9%). The respondents were holders the following qualifications: Master's Degree (24%), Honours Degree (55%), Higher National Diploma (3%), and National Diploma (18%). The mean work experience of respondents was 9.41 years. The respondents' work experience in the industry was useful to provide a valid and reliable assessment of the issues covered in the research instrument.

4.2 The impact of climate variability on workplace health and safety

Table 1 shows the respondents' degree of concurrence relative to climate variability statements and their impact on H&S management in terms of responses to a scale of 1 (strongly agree) to 5 (strongly disagree), and a mean score (MS) ranging between 1.00 and 5.00, the midpoint score being 3.00. The results show that all the aspects have a MS>3.00 which indicates that respondents can be deemed to agree with all the statements.

Table 1: Degree of concurrence with climate change and H&S related statements

Statement	Unsure	Response (%)					MS	Rank		
		Strongly disagree (SD).. Strongly Agree (SA)								
		SD	D	N	A	SA				
Improved access to climate change related information and associated H&S risks can mitigate the effects of such risks to workers	0	0	0	2.6	31.6	65.8	4.63	1		
Rise in environmental temperatures negatively impact worker capacity and productivity	2.6	0	5.3	5.3	36.8	50	4.35	2		
Overexposure to heat while working may lead to health disorders such as fatigue, heat rash, heat syncope/fainting, exhaustion, etc	5.3	0	2.6	7.9	39.5	44.7	4.33	3		
Lack of knowledge increase workers' exposure to climate H&S risks	0	0	2.6	7.9	50	39.4	4.26	4		
Construction sites rarely have systems/technologies to monitor environmental thermal changes	0	0	15.8	5.3	21.1	57.9	4.21	5		
In high temperatures, personal protective equipment (PPE) such as hard hats, safety boots, respirators etc often increase workers' heat strain	0	2.6	2.6	15.8	36.8	42.1	4.13	6		
Climate change is already presenting risks to occupational H&S	5.3	0	5.3	5.3	82.1	26.3	4.11	7		
There is inadequate response from construction stakeholders & government to address H&S challenges presented by climate change	0	0	7.9	13.2	42.1	36.8	4.08	8		
Contractors are not sufficiently empowered, educated, or compelled to protect their employees from health impacts of climate change	0	0	13.2	7.9	50	28.9	3.95	9		
Construction stakeholders do not have sufficient knowledge or information regarding the linkages between climate change and construction H&S	0	5.3	13.2	13.2	31.6	36.8	3.82	10		
Construction H&S systems are developed assuming a steady state and condition and rarely take into consideration the changing thermal environment	0	2.6	13.2	13.2	44.7	26.3	3.79	11		
Existing H&S regulatory frameworks are deficient with regards to the effect of climate change on workers' H&S	0	5.3	10.5	13.2	47.4	23.7	3.74	12		
Rise in environmental temperatures exacerbate work related hazards leading to occurrence of accidents on projects	2.6	2.6	13.2	10.5	65.8	5.3	3.59	13		

Based on the perceptions of respondents, the study results suggest that workers have already started to experience the effects of rising ambient temperatures on their health, wellbeing and productivity. This is concurred with the following statements: "overexposure to heat while working may lead to health disorders such as fatigue, heat rash, heat syncope/fainting, exhaustion, etc" (MS = 4.33), "climate change is already presenting risks to occupational H&S" (MS = 4.11) and "rise in environmental temperatures exacerbate work related hazards leading to occurrence of accidents on projects" (MS = 3.59). These perceptions are consistent with the heat wave experienced in October/November 2015 and January/February 2016 in Zimbabwe. Elevated ambient temperature leads to impaired physical and mental capabilities which may compromise H&S. Previous studies suggest that excessive heat while working at temperatures above 35°C creates occupational health risks (Parsons, 2014). The use of PPE increase workers' heat strain will magnify the problem.

The study also notes that several factors can amplify the H&S problem. Such factors relate to lack of knowledge regarding climate change hazards (MS = 4.26), lack of systems to monitor environmental thermal changes (MS = 4.21), inadequate response from construction stakeholders & government to address H&S challenges presented by climate change (MS = 4.08), inadequate knowledge or information among construction stakeholders regarding the linkages between climate change and construction H&S (MS = 3.82), inadequate integration of the thermal environment in construction H&S systems (MS = 3.79), and insufficient provision of climate change issues in H&S regulations (MS = 3.74).

These results suggest that contractors and other construction stakeholders are not adequately informed regarding climate change hazards and the effects of environmental thermal changes on workplace H&S and productivity. Lack of information on the causal link between climate change and H&S affect the administration of H&S issues. Although the Environmental Management Act (Chapter 20:27) requires people to have access to environmental information, however, Chagutah (2010) suggests that very little information is available. Against this background a casual approach to H&S is likely be adopted. In previous studies hot weather is perceived as a routine seasonal change often ignored in the list of risks in the construction industry (Rowlinson and Jia, 2014). Nevertheless, respondents perceive that improved access to climate change related information and associated H&S risks can mitigate the effects of such risks to workers (MS = 4.65).

Lack of a system to monitor environmental thermal changes further exposes site workers to the effects of rising environmental temperature. The problem is compounded by lack of standard environmental thresholds for workers within H&S regulations. Furthermore, lack of integration of environmental systems and H&S also create gaps in management of environmental hazards and achievement of sustainable H&S. Regrettably where H&S objectives conflict with production objectives, the latter takes precedence thereby compromising H&S for workers especially during hot weather. Failure to specifically prescribe exposure levels to environmental heat within H&S legislative provisions in Zimbabwe compromises H&S. This leaves management of environmental heat exposure hazards to the discretion of construction industry practitioners. Additionally, lack of integration of climate change and H&S also creates administrative challenges. Rowlinson *et al.* (2014) suggest that an incremental approach to heat stress management results in a situation where workers face the dilemma of risking one hazard or another.

Apart from the effects on H&S, respondents also perceive that increase in environmental temperature negatively impacts on worker capacity and productivity (MS = 4.35). The natural response for working in hot conditions is that workers tend to reduce their output levels as they try to adjust to the hot environment. This may arise from increasing the number of water breaks. Some previous studies suggest that productivity is strongly dependent on thermal conditions. Workers reduce productivity when working under conditions of rising ambient temperatures through a chain effect from fatigue to other health related conditions. In a study involving construction workers in India, Venugopal *et al.* (2016) determined that 69% of the workers reported experiencing productivity losses due to heat stress.

4.3 The effect of rising ambient temperature on H&S and worker performance

To further assess the effects of shifts in environmental thermal conditions on H&S, and productivity, respondents were also asked to rate on a scale of 1 (no effect) to 5 (severe / extreme effect) the impact of rising ambient temperature on selected H&S and productivity aspects. The results of that assessment are presented in Table 2.

The results in Table 2 are largely consistent with those in Table 1. The MS values in Table 2 indicate that respondents perceive that increase in environmental temperature has an impact on the majority of the H&S and productivity variables. The results suggest that rising ambient temperatures as a result of climate variability have a major adverse impact on their health and productivity as compared to incidents and accidents (safety). This is exhibited through a higher rating for health and productivity related aspects as compared to incidents and accidents (MS = 2.77). This suggests that respondents perceive that the effect of rising ambient temperature on frequency of incidents and accidents is slight to moderate. However, the latter result does not adequately corroborate with results from previous studies which suggest that increasing environmental temperature increases the risk of occupational accidents (Schulte and Chun, 2009; Xiang *et al.*, 2014). The results also indicate that respondents perceive that increase in ambient temperature does not lead to increased incidence of sick leave (MS 2.66) and absenteeism (MS 2.30).

Table 2: Effect of environmental temperature rise on H&S and worker productivity variables

Variable	MS	Rank
Increased incidence of heat related conditions (heat rash, cramp, fatigue)	3.87	1
Reduced worker output	3.78	2
Reduced worker capacity	3.66	3
Increased incidence of sun exposure conditions (sun burn , eye damage)	3.57	4
Increased frequency of seeking medical attention	3.19	5
Reduced effective time spent on work tasks	3.10	6
Increased frequency of incidents and accidents	2.77	7
Increased incidence of sick leave	2.66	8
Increases frequency of absenteeism	2.30	9

5. Conclusions and Recommendations

The study findings suggest that the construction industry in Zimbabwe is not spared from the effects of changing environmental thermal conditions as a result of climate change. Construction industry practitioners perceive that environmental H&S risks emanating from climate change are not integrated into the broader framework of H&S management. The study findings further suggest that increased environmental temperature is perceived to amplify H&S risks and reduce worker productivity. It is perceived that increase in ambient temperature affect, to a greater extent, the health of workers and productivity as compared to incidents and accidents.

Nevertheless, the absence of workers' perceptions in this analysis is a key limitation to the study. In spite of that, the study provided valuable expert opinion necessary to influence further research and policy direction for H&S in light of changing environmental thermal conditions. Access to information, mainstreaming environmental sustainability principles in construction H&S and implementation of sustainable adaptive strategies on projects, among other factors, will enhance workers' H&S against a background of rising thermal changes. Further research is needed to assess workers' perceptions regarding the effects of changing environmental thermal conditions on H&S.

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Conceptualized Integrated Health and Safety Compliance Model for Contractors in Ghana

Zakari Mustapha¹, Clinton Aigbavboa², Wellington Didibhuku Thwala³

Abstract

Lack of stringent measures in safety and construction laws has been attributed to poor performance in Health and Safety (H&S) in the construction industry. The purpose of the paper is to present how the conceptualized integrated H&S compliance model for contractors in Ghana will be developed. The conceptualized model theory forms the bases of the discussion in this paper. A total number of fifteen studies relevant to accident causation theories were selected out of the total number of thirty studies reviewed, through a rigorous process. The assessment of H&S compliance model for the study was carried out through the combination of objective and subjective attributes. The Domino Theory forms the basis for theoretical and conceptual framework of this paper. The study adopted various constructs from Accident Root Causes Tracing Model (ARCTM) and Domino theory. The hypothesized integrated holistic H&S compliance model is presented in this paper based on an in-depth review of the previous models. Government support and contractor's organizational culture serve as variable constructs identified as gaps in H&S compliance research. Discussions also included the integrated holistic model and the variables of the model, identification of the model and justification for the selected variables. The paper presented the conceptualized H&S compliance model. The gaps identified in H&S compliance research served as the variable constructs. They are government support and contractor's organizational culture.

Keywords: compliance model, construction industry, Ghana, health and safety, variables

1. Introduction

The attitudes of construction companies towards H&S in Ghana as indicated by Kheni and Braimah (2014) have been affected by institutional structure responsible for H&S implementing standards at workplaces. The authors cited poor coordination of the activities of the many institutions responsible for implementing H&S standards, lack of specific H&S regulation and undesirable level of compliance with relevant H&S legislations as the major problems. It is necessary for construction companies to have a positive change in their attitudes to enable Occupational Health and Safety (OHS) to be implemented. This can be achieved by re-structuring OHS administration system in Ghana (Kheni & Braimah 2014). Attempts were made to substantiate whether compliance with H&S

¹PhD Candidate, Department of Construction Management and Quantity Surveying, Doornfontein Campus, University of Johannesburg, P. O. Box 17011, Doornfontein. Johannesburg, South Africa; zakari.mustapha1967@gmail.com.

²Associate Professor, Department of Construction Management and Quantity Surveying, Doornfontein Campus, University of Johannesburg, P. O. Box 17011, Doornfontein. Johannesburg, South Africa; caigbavboa@uj.ac.za.

³Professor, Department of Construction Management and Quantity Surveying, Doornfontein Campus, University of Johannesburg, P. O. Box 17011, Doornfontein. Johannesburg, South Africa; didibhukut@uj.ac.za.

in construction industry will reduce rate of accidents at the construction sites and enhance their performances. Therefore, H&S compliance model for the Ghanaian construction industry is presented based on an in-depth review of the previous models from literature in order to have a lasting solution. In relation to the models reviewed, four measurement variables were finally selected. Two other measurement variables were added. Government support and contractor's organizational culture are the gaps identified in literature. A detailed discussion of the H&S compliance model is given in the succeeding sections. The discussion of the H&S model is based on the selection of variables for H&S compliance. This is followed by the conceptual model of latent features, specification and justification of the models, structural component of the model, H&S compliance model and measurement component. The objective of the present paper is to demonstrate how a conceptualized integrated H&S compliance model was developed from a detailed literature review. The model is proposed for use by contractors in Ghana. The paper is presented in sections including variable selection for the H&S model, conceptual model latent features, justification of variables selected, and model constructs/structure.

2. Selection of Variables for Health and Safety Compliance

Both objective and subjective attributes have been combined in the H&S study models for the assessment of H&S compliance. The Domino Theory by Heinrich (1959) and that of Adams (1976) had similar concept but, the elements were different (Heinrich *et al.*, 1980). Weaver (1971) had similar concepts of elements or factors as Henrich's (Heinrich *et al.*, 1980). Petersen's model developed in the 1971 had different concept with the Domino Theory (1959) that influenced many researchers during Heinrich time. The surrounding factors to the accident would be revealed by applying the multiple causation model. It is believed that the contributing factors, causes, and sub-causes are the main culprits in an accident scenario as inspired by the model (Abdelhamid & Everett, 2000). Behavior model, human factor model, and Ferrel theory relate to human error theory (Hosseini & Torghabeh, 2012; Hughes & Ferrett, 2007; Taylor *et al.*, 2004; Abdul Hamid, Yusuf & Singh, 2003). Rigby (1970) was of the view that human error is 'anyone set of human actions that exceed some limit of acceptability.'

Most of these theories address the human (worker) as the main problem that makes an accident happen such as permanent characteristic of human, the combination of extreme environment and overload of human capability and conditions that make human tends to make mistake" (Abdelhamid & Everett, 2000). Abdelhamid (2000) indicated that there is every tendency of humans to make error under various conditions and situations but, the blame will fall on human most often (unsafe). Many important rules of the ARCTM have been derived from the effort of Heinrich (1959), Petersen (1971), Bird (1974), Ferrell (Heinrich *et al.*, 1980) and Petersen (1982). ARCTM insist on specific issues such as worker training, worker attitude and management procedure problems should be recognized and modified in order to avoid reoccurrence of accident. Research conducted by Abdelhamid and Everett (2000) in identifying root causes of construction accidents concluded that the application of ARCTM should serve as a complement to accident investigation process and should be able to give solutions to accident occurrence and preventive measures in the construction industry. The three constructs proposed by ARCTM in addition to the two construct from Heinrich (1959) are supported and adopted for this paper. Both models have one construct in common. This paper considers the HSC bundle in a typical construction industry to contain SE with 6 variables; SAW with 20 variables; SWC with 7 variables; RWSC with 5 variables, as shown in table 1. Almost all the H&S compliance studies

have these constructs conceptualized on frequent basis. However, the current paper brings into focus GS with 5 variables and COC with 11 variables. The gaps identified in the literature review are these two addition constructs and were found to be peculiar to Ghana as a developing country.

2.1 Safe environment (SE)

The International Labor Organization (ILO) (in The National Occupational Health and Safety Policy of South Africa (2003) indicated that safe work creates no obstacles to being competitive and successful. In fact, no country or industry has been able to jump to a high level of productivity without making sure that the work environment is safe. H&S in the workplace is about preventing work-related injury and disease, and designing an environment that promotes well-being for everyone at work (Safe work Australia, 2013; Heinrich, 1959). Knowledge is the key ingredient in providing a safe work environment - if everyone knows the correct procedures then, accidents and injuries can be kept to a minimum. The employer can achieve safe working environment through the provision of safe and healthy work environment, safe equipment and safe storage and transportation of dangerous substances. Both recklessness and undesirable traits leading to accident can be prevented by providing safe work environment in order to achieve H&S compliance in the construction industry. The current paper looks at safe environment which has been hypothesized for the development of a holistic H&S compliance model. Jamal Khan (in Mat Zin & Ismail, 2012:743) opined that ignorant behavior and attitude of employers and employees contribute to issue on behavioral safety non - compliance to requirements of Occupational Safety and Health Act (OSHA) 1994". "Safety behavior describes the behavior that support safety practices and activities such as, providing safety training and safety compliance explains the core activities that need to be carried by employees according to OHS requirements in order to prevent workplace accidents" as indicated by Mahmood (in Mat Zin & Ismail (2012:743)."Most of the accident causation theories addressed the human (worker) as the main problem that makes an accident happen such as permanent characteristic of human, the combination of extreme environment and overload of human capability and conditions that make human tends to make mistake" (Abdelhamid & Everett, 2000).Safety behavior or acts can be achieved by working with safety devices such as, personal protective equipment, use of equipment that are in good condition, follow the correct work procedure at any time work is to be carried out, employees should have good knowledge level of work and they should also obey work procedures whenever they are carrying out any activity.

2.2 Safe act of workers (SAW)

Smallwood (2010) identified workers' attitude as one of the factors leading to unsafe act of workers. Workers safety behavior contributes to safety practices. A worker conducts safe acts under the condition that he has undergone safety training and has been provided with Personal Protective Equipment (PPE) to protect him from any harm. Hosseinian and Torghabeh (2012: 59), Fang *et al.* (2006), Abdul Hamid, Yusuf and Singh (2003) were of the view that a worker must perform safe acts and this should be in relation to safety standards, namely, by working with PPE, and having enough rest before the day's work in order to prevent any accident occurring. The resultant of unsafe acts or unsafe conditions is accident (Heinrich *et al.* 1980). Heinrich (in Abdelhamid & Everett, 2000) argued that accident prevention is an integral program a, series of coordinate activities, directed to the control of unsafe personal performance and unsafe mechanical conditions, based on certain knowledge, attitudes, and abilities. Occurrence of accident can be prevented if the chain of sequence in the Domino Theory is disturbed (Hosseinian & Torghabeh, 2012; Abdul Hamid, Yusuf & Singh, 2003).

People (human beings) are the main reasons of accident and management has the responsibility of preventing the accident (having the power and authority). It is therefore, mandatory to provide employees with safe work condition to enable them abide by H&S regulations and perform well at their respective work places.

2.3 Safe work condition (SWC)

Heinrich *et al.* (1980) were of the view that the carelessness or fault of a person is a negative feature of a person's personality. Although, these unwanted characteristics might be acquired, they can be corrected. Errors and technical failures as a result of unsafe acts or mechanical or physical conditions can also be corrected to prevent accidents occurring, by performing safe acts and under safe conditions (Hosseini & Torghabeh, 2012; Abdul Hamid, Yusuf & Singh, 2003). According to Heinrich (in Abdelhamid & Everett, 2000) "accident prevention is an integral programme, a series of coordinated activities, directed to the control of unsafe personal performance and unsafe mechanical conditions, and based on certain knowledge, attitudes, and abilities". It is therefore, mandatory to provide employees with safe work condition to enable them abide by H&S regulations and perform well at their respective work places.

2.4 Reaction of worker to safe condition (RWSC)

The ARCTM derived most of its important rules from the efforts of Heinrich (1959), Peterson (1971), Bird (1974), Ferrell (in Heinrich *et al.*, 1980) and Peterson (1982) (Hosseini & Torghabeh, 2012: 59); Jha (2011); Fang, Choudhry & Hinze (2006). ARCTM indicates that the unsafe condition contributes to the occurrence of accident, due to employees' inability to identify the existence of the unsafe condition before the activity is carried out. This can be prevented if employees' actions are performed under safe condition. Reaction of the employee to safe conditions depends on the fact that the employees identify the safe condition before any activity is carried out (Fang *et al.*, 2006; Abdulhamid & Everett, 2000). An employee should be able to identify a safe work condition and conduct his activities under the H&S regulations (Fang *et al.*, 2006; Abdul Hamid, Yusuf & Singh, 2003).

3. Methodology

Fifteen studies relevant to accident causation theories were selected out of the total number of thirty studies reviewed, through a rigorous process. The assessment of H&S compliance model for the study was carried out through the combination of objective and subjective attributes. The Domino Theory was the basis for theoretical and conceptual framework of this paper. The study adopted various constructs from ARCTM and Domino theory. Variables were selected based on the theoretical framework built from literature review. The two basic components of the model in Heinrich (1959), Perterson (1971) and ARCTM are chosen: safe acts and safe condition. This is based on the fundamental underpinning of two models, and the incorporated theoretical perspectives, which has been adopted in other similar studies. The model to be conceptualized within the broad theoretical framework is based on the approach used by Heinrich (1959), Perterson (1971) and ARCTM. Based on the fundamental factors and constructs associated with all the previous models reviewed, the present model or conceptual framework model looks at safe environment (SE), safe act of workers (SAW), safe work condition (SWC) and reaction of worker to safe condition (RWSC), government

support (GV) and contractor's organizational culture (COC). This will in turn predict the construction industry Health and Safety Compliance (HSC).

Table 1: Conceptual model of latent variables

Latent Variable Construct	Measurement Variables
Safe Environment (SE)	<ul style="list-style-type: none"> 1. Safe and healthy work environment. 2. Safe storage of equipment. 3. Safe storage of formwork and false work 4. Safe transportation of formwork and false work 5. Safe transport of equipment. 6. Provision of warning system.
Safe Act of Worker (SAW)	<ul style="list-style-type: none"> 1. Work with an authority on the job. 2. Work at proper speeds. 3. Inspect workplace before commencing any activity. 4. Tidy up workplace at the end of any activity. 5. Use appropriate tools/equipment. 6. Ensure equipment /tools are in good condition before usage. 7. Ensure proper lifting, handling or moving of objects. 8. Ensure proper stacking of objects or materials in safe locations. 9. Avoid annoyance and horseplay at the workplace. 10. Ensure the use of personal protective equipment (PPE). 11. Do not remove safety guards from the workplace or equipment. 12. Do not smoke where flammable materials are stored. 13. Do not leave nails or other sharp objects protruding from timber. 14. Do not throw or accidentally drop objects from high levels. 15. Do not work under the effects of alcohol and other drugs. 16. Ensure proper positioning of tasks. 17. Ensure proper posture tasks. 18. Do not service equipment which is in operation. 19. Concentrate on the task at hand. 20. Work in good physical conditions
Safe Working Condition (SWC)	<ul style="list-style-type: none"> 1. Provision of Training. 2. Provision of good inspection program 3. Provision of insensitive to workers. 4. Provision of safety regulation. 5. Provision of good company safety policies. 6. Provision of good salaries. 7. Payment of Social Security and National Insurance Trust (SSNIT).
Reaction of Worker to Safe Condition (RWSC)	<ul style="list-style-type: none"> 1. Attend safety education program. 2. Attend safety training program. 3. Adhere to warning signs and notices. 4. Follow safety regulations. 5. Adhere to company safety policies
Government Support (GS)	<ul style="list-style-type: none"> 1. Formulate H&S policy of construction. 2. Implementation of H&S policy by government representatives. 3. Monitoring of H&S policy implementation by the government representatives. 4. Provision of H&S training by government representatives. 5. Provision of H&S policy update by government representatives.

Table 1 Continued: Conceptual model of latent variables

Latent Variable Construct	Measurement Variables
Contractor's Organizational Culture (COC)	1. Provision of PPE. 2. Provision of signs/notices on sites. 3. Training of Workers on H&S. 4. Involve workers in H&S programs. 5. H&S staffing. 6. H&S inspection. 7. H&S policy. 8. Communication on H&S information to workers. 9. Assessment of hazard identification and risk. 10. Management commitment in H&S. 11. Consultation on H&S information to workers
Health and Safety Compliance (HSC)	1. Accident on sites will be minimized. 2. Compensations paid on accident victims will be reduced. 3. Reduce cost of training on H&S. 4. Limited number of H&S education by government representatives. 5. Limited number of H&S monitoring by government representatives. 6. Improved in H&S performance. 7. Increased in productivity.

The structural components of the model are: SE, SAW, SWC, RWSC, GS and COC. The measurement component of the hypothesized model comprises of the following HSC factors: SE = 6 measurement variables; SAW = 20 measurement variables; SWC = 7 measurement variables; RWSC = 5 measurement variables; GS = 5 measurement variables; COC= 11 measurement variables and HSC = 7 measurement manifest variables.

4. Model Specification and Justification

The theoretical conceptual framework for the current paper is built on the work of Heinrich (1959) and ARCTM which was also built on the previous accident models. Heinrich (1959) conceptualized that ancestry and social environment, fault of a person, unsafe acts and condition lead to accident. The reason for the cause of accident is people and management is responsible for the prevention of accident. Majority of accidents are due to human error and the accident can only be prevented if management provides a conducive environment for the employees to work. Heinrich *et al.* (1980) indicated that five elements were in both Heinrich (1959) and Adams (1976). Both authors have similar concept but, the elements were different (Heinrich *et al.*, 1980). Weaver (1971) stressed on the importance to recognize the root of unsafe acts or conditions, even though he had similar concepts of elements or factors as of Heinrich's. The role of management in accident prevention was also emphasized in a broader sense taking into consideration the root of unsafe acts or conditions (Heinrich *et al.*, 1980).

ARCTM conceptualized that unsafe condition, reaction of worker to unsafe condition and unsafe acts of worker lead to accident. Peterson (1971) also conceptualized that accident are due to unsafe acts

and unsafe condition. The non-compliance level of H&S in the construction industry are related to the environment, unsafe acts, unsafe condition, reaction of worker to unsafe condition and unsafe acts of worker. Both Heinrich (1959) and Perterson (1971) as well as ARCTM emphasized on unsafe acts and unsafe condition as the main causes of accident in the construction industry. Therefore, the two basic components of the model are: safe acts and safe condition. The models are therefore useful for conceptualizing the present paper as a variety of H&S studies and H&S compliance being conceptualized within the broad theoretical framework. Therefore, the conceptual framework for this paper is primarily based on the approach used by Heinrich (1959) and ARCTM.

The present model or conceptual framework looks at the safe environment, safe act of workers, safe work condition and reaction of worker to safe condition. These factors have been measured in most of the previous studies but, consideration has not been given to government support and contractor's organizational culture; which have been classified as the exogenous variables and their role in predicting overall HSC which is the endogenous variable. These will in turn, predict the construction industry HSC. This paper takes into account the needs of the construction industry and their compliance with the Policy and codes in Ghana as indicated in the other frameworks. It is apparent that some of the variables discussed in Table 1 will be measured by objective means, some by subjective means and some will include both forms of measurements. The reason for combining both objective and subjective indicators within the proposed model is supported by Campbell, Converse and Rogers, (1976), Falah, Al-Abed and Stan, (1995). The conceptual model theorizes that HSC is established by the relationship that exists between the exogenous variables, which include the basic elements by which the subjective and objective measurements are linked. The variables identified from the review of literature are considered the major determinants of HSC. The determinants identified have been adopted to fit with HSC in the Ghanaian construction industry.

4.1 Structural component of the model

The integrated HSC model for the Ghanaian construction industry in the case of developing countries, is derived from safe environment (SE), safe act of workers (SAW), safe work condition (SWC), reaction of worker to safe condition (RWSC), government support (GS) and contractor's organizational culture (COC) in the process of achieving H&S in the construction industry. The postulated model is presented in Figure 1 (Model 1.0). The theorized model was derived from the works of Heinrich (1959) and ARCTM. The conceptualized model is based on the notion that compliance with H&S is related to the evaluation of many variables, such as SE, SAW, SWC, RWSC, GS and COC. It is difficult to discuss the principal variable without reference to variables of government support and contractor's organizational culture and inclusion of the other exogenous variables. The evaluation will depend on the compliance assessment of several indicator variables under each of the exogenous variables. The objective evaluation of HSC in this paper will be assessed by measuring the actual condition of the construction industry which is an exogenous variable in the model as shown in Figure1.

4.2 Measurement component of the model

The measurement component of the hypothesized model comprises of the following H&S compliance factors: SE = 6 measurement variables; SAW = 20 measurement variables; SWC = 7 measurement variables; RWSC = 5 measurement variables; GS = 5 measurement variables; COC= 11 measurement variables and HSC = 7 measurement manifest variables. The success for the consideration of H&S

compliance for the benefit of the construction industry has been theorised in the present model. The Health and Safety Compliance (HSC) model has 7 measurement manifested variables as shown in Table 1 and Figure 1.

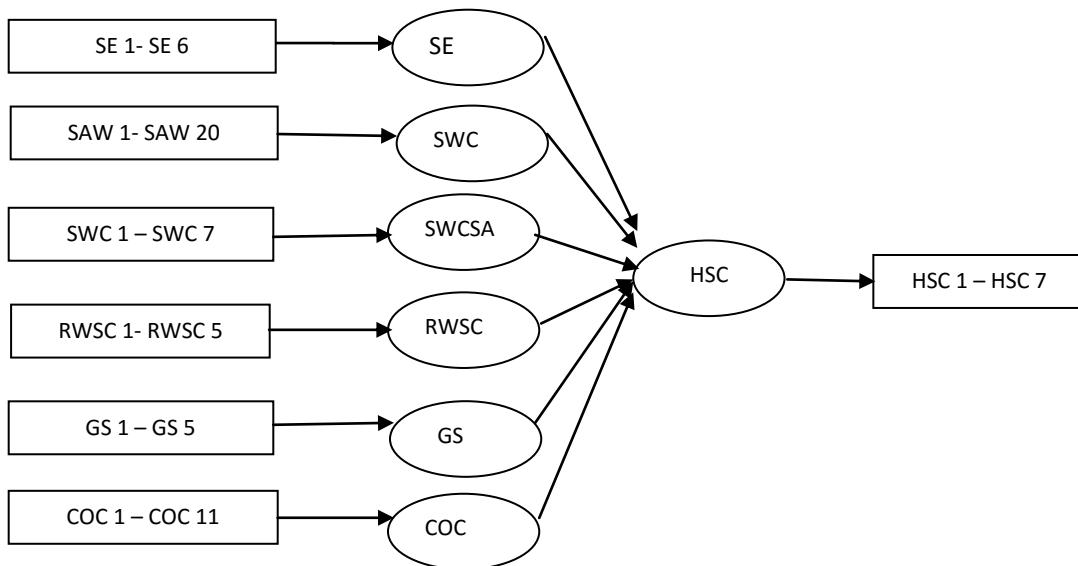


Figure 1: Conceptualised Integrated H&S Compliance Model

4.3 Justification and proposed testing of model

There is a sign of inadequacy and the existence of inconsistent, sometimes conflict in research results about the factors that shape construction H&S compliance. The discrepancies in research are from the differences in samples. As the sample for most studies might not be representative of the population under study and the way the key variables may be defined. It may also be because of how construction research has been carried out in the global context of the studies or how the data was analyzed. The theorized H&S compliance model will guide the Ghanaian construction industry in the enforcement of H&S regulations. The H&S models will help to monitor and guide future use of the model to be developed for the construction industry in Ghana. Models from the Delphi survey and literature will be evaluated to enable the development of the H&S compliance model. Data gathered via the questionnaire survey will be analyzed using Structural Equation Modelling (SEM) software Version 6.2. This will be used to assess the factor structure of the constructs. The conceptual variables will be tested as a prior using SEM of the questionnaire survey results. The SEM process will be undertaken as Confirmatory Factor Analysis (CFA) of the prior model for an integrated H&S compliance. Data from the Delphi and questionnaire survey on H&S compliance will be conceptualized and validated. The final output of the survey will be the model to be presented.

5. Conclusion and Recommendations

The purpose of the paper is to present how the conceptualized integrated H&S compliance model for contractors in Ghana was developed from literature review. The theorized conceptual model is not based on prior study that HSC model is a multidimensional structure composed of seven latent

variables as shown in Table 1. The conceptualized integrated H&S compliance model will serve as a guide to project managers in the execution of H&S in the construction industry. The compliance of H&S by employees will contribute to reduction in accidents and increase in productivity. It is recommended that a Delphi survey should be carried out among experts (construction professionals and academics) to determine the outcome of H&S compliance. A median or inter-quartile ($IQD \leq 1$) should be obtained for a consensus to be reached among the measurement variables.

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Identifying Health Risks related to Construction of Water Supply Infrastructure: Case of Lusaka Water Supply, Sanitation and Drainage Project

Erastus Mwanaumo¹, Gabriel Mubuyaeta², Chipulu Chipulu³, Sampa Chisumbe⁴

Abstract

This article identified probable health risks likely to occur on water supply, sanitation and drainage projects in Zambia. It delved on activities that have been lined up for the project, and then relate them to what is prevailing in the literature. The study was predominantly descriptive in nature, rather than empirical research. For instance, it describes the process used to identify risk followed by a description of the measures put in place to control the identified risks. This is an important point to be borne in mind, as an evidence base does not directly underpin many of the measures to control health risks identified. This is not to say, however, that such measures lack effectiveness. Rather, it means that they are largely untested in the examples provided, but there may be underpinning evidence in the wider risk management domain. The findings are presented in the same format by identifying the activity involved, the occupation handling the activity and then identifying the health hazard likely to occur. Each identified Hazard is described, then the disease is identified and the proposed solution provided. Identified risks include Public health risks such as waterborne disease, airborne and communicable diseases. Measures were suggested including: surveillance programs with a particular emphasis on inspections and microbiological testing. The literature also identified that there may be an increased risk of breathing and other pulmonary risks arising from dust and cement inhalation. The project has works related to all the four components of water supply; treatment, transmission, storage and distribution. This article thus provides useful information to those involved in the project and other future related projects. It is therefore hoped that this paper will reach wider construction community in Zambia and sensitise industry stakeholders on construction related health risks.

Keywords: hazards, health, Lusaka, risks, water supply

1. Introduction

Construction workers perform a large variety of duties concerned with infrastructure construction. The work may include mixing, pouring and spreading concrete, drainage, asphalt, gravel and other materials. Despite the increasing mechanization of construction and the frequent use of pre-cast concrete sections, contact with wet cement still occurs, particularly in developing countries. The work is hard physical labour, often under difficult conditions, including hot, cold, and wet weather. Occupational diseases of the skin in the construction have paralleled industrial development. (Frimat, 2002).

For instance, it is known that cement and concrete are products used widely in the construction sector, with a traditional perception that any hazards that they have are limited to dermatitis in a small number of workers. In some cases, employers and contractors do not think that concrete is a chemical.

However, globally, contact dermatitis is one of the most frequently reported health problems among the construction workers (Frimat, 2002; 52). A review of the available literature suggests that cement has constituents that produce both irritant contact dermatitis and corrosive effects (from alkaline ingredients such as lime) and sensitization, leading to allergic contact dermatitis (from ingredients such as chromium) (Winder and Carmody, 2002).

Construction workers especially those directly involved in site activities such as skilled, semiskilled and labourers almost all belong to lower socio-economic classes. According to Shah and Tiwari (2010), the social status of workers affects their capacity to go for the treatment of their conditions and thus often they neglect their lesion and leave it as it is. This results in further progress of the conditions to a stage where prognosis can be poor. Shah and Tiwari (2010) further contend that high level of illiteracy affects their knowledge regarding the usefulness of personal protective cloths for the prevention of skin conditions and their proper care, once the lesions develop. It was found that majority of those who had some education were using PPE as compared to those who were illiterate.

Although a number of studies have been carried out to find out the respiratory health problems prevalent among construction workers, (Ng *et al*, 1992; Ghotkar *et al.*, 1995), they did not include reports on the different skin problems among these workers in Zambia. This paper does not only intend to provide insight on skin diseases associated with construction works but also shed light on health risks and control that are associated with activities in a water, sanitation, and drainage supply project in Zambia. As such, the following research question was developed in order to provide a clear objective for the literature search:

What are the potential risks to health that are, or may arise before and during construction of a water, sanitation and drainage supply project?

2. Case Study Project Described

The Lusaka Water Supply Sanitationand Drainage (LWSSD) project is a US\$355 millioninfrastructure development project running from 2013 to 2018. It involves civil, building and electromechanical works covering a most of Lusaka city. The wide range of activities being carried out on this project results in a wide range of hazards and consequently a wide range of diseases to which construction workers will be exposed to. Some hazards areas a direct result of the work itself. These could be physical, chemical and biological in nature.Other hazards will be as a result of the construction environment and the social interactions between the construction workers and the community.

The project funder has in place a Health and Safety Manual (MCC, 2014) that requires the contractor to bear responsibility of site health and safety. The contractor develops a site-specific health and safety management plan, which is in accordance with a generic plan provided by the funder and the Zambia Government. Zambia's Health and Safety Regulations, IFC Health and Safety guidelines and the funder's Health and Safety Manual, guide the contractor's health and safety plan and practices.The IFC guidelines and the funder's manual provide an analysis of occupational healthand safety hazards to the LWSSD Project. The American OSHA guidelines complement these by providing further hazard identifications related to both health and safety and their causes.

The Contractors are required in their contract to develop, submit and implement a Contractor's Environmental and Social Management Plan (CESMP), which outline the routine management of

HSE, and social impact aspects associated with the construction phase of the Project. Their employees and the sub-contractors undertake their activities on the site according to the HSMP and in compliance with the relevant Zambian Legislation as well as the following principal contractually referred documents:

- Health and Safety Management Plan and the identified procedures and processes within it
- The funder's Health and Safety Manual (January 2014)
- Technical Specification
- Framework for Contractor's Environmental & Social Management Plan (CESMP Framework)
- IFC General EH&S Guidelines (2007)
- IFC Performance Standards on Environmental and Social Sustainability No. 2 & 4 (2012)

3. Study Design and Results

The study was predominantly descriptive in nature, rather than empirical research. It describes the process used to identify risk (e.g. with a risk assessment by gathering intelligence) followed by a description of the measures put in place to control the identified risks. The findings are presented in the format that identifies activities involved, the occupation handling the activity and then identifying the health hazard likely to occur. Each identified hazard is described, then the disease is identified and the proposed solution provided. Identified risks include public health risks such as waterborne disease, airborne and communicable diseases. Measures that were suggested include surveillance programs with a particular emphasis on inspections and microbiological testing. The literature review was also conducted in order to identify risk of breathing and other pulmonary risks arising from dust and cement inhalation. The results are presented in tables 1 and 2.

4. Discussion

Construction workers working on the water supply sub-projects of the LWSSD Project are exposed to a wide variety of health hazards on the job. Exposure differs from trade to trade, job to job, day by day, as well as hour by hour. Exposure to any one hazard is typically intermittent and of short duration, but is likely to reoccur. Workers not only encounter the primary hazards of his or her own job, but are likely be exposed as a bystander to hazards produced by those who work nearby or upwind. This pattern of exposure is expected due to having many employees with jobs of relatively short duration and working alongside workers of other trades that generate other hazards. The severity of each hazard depends on the concentration and duration of exposure for that particular job.

Apart from health hazards derived from the risk of carrying out the work, there are hazards resulting from the environment in which the construction works are taking place. Several workers may work on site simultaneously, with the mix of contractors changing with the phases of the project. The water supply works on the LWSSD Project spreads over a large geographical area covering most of Lusaka city and construction teams involved in construction of horizontal infrastructure have to move from location to location along the construction path. The resulting health hazards are as a result of proximity with other construction workers and as a result of social interaction with communities along the construction corridors.

It is evident that the site-specific practices have a wealth of information available for guidance. However, in the process of selecting the most relevant hazards, there is a risk of overlooking some

hazards which may cause serious diseases. An example is exposure to wood dust which is not specifically addressed in both the funder's Health and Safety Manual (MCC, 2014) as well as the IFC Guidelines (IFC, World Bank Group., 2007). Such hazards may be addressed by the general health and safety procedures such as training and use of Personal Protective Equipment. These guidelines may not be enough as workers may neglect to protect themselves from hazards they are not aware of.

Table 1: Health hazards on LWSSD project by occupation (Source: Ringen et al., 1998)

Occupation	Activity	Hazard
Bricklayers	Blockwork: Rehabilitation of buildings at water treatment plants and distribution centres.	Cement dermatitis, awkward postures, and heavy loads.
Carpenters	Installation of roof trusses and purlins: Rehabilitation of buildings at water treatment plants and distribution centres.	Wood dust, heavy loads, repetitive motion.
Welders	Welding on steel works. Rehabilitation of buildings at water treatment plants and distribution centres.	Heavy metals in solder fumes, awkward posture, heavy loads, eyes
Electrical power installers and repairers.	Welding on steel works. Rehabilitation of buildings at water treatment plants and distribution centres.	Heavy metals in solder fumes, awkward posture, heavy loads.
Painters	Paint work: Rehabilitation of buildings at water treatment plants and distribution centres.	Solvent vapours, toxic metals in pigments, paint additives.
Structural metal installers.	Steel works. Rehabilitation of buildings at water treatment plants and distribution centres.	Awkward postures, heavy loads, working at heights.
Drillers, earth, rock.	Borehole drilling in the distribution networks.	Silica dust, whole body vibration, noise.
Rehabilitation workers	Rehabilitation of chlorination facilities at the water treatment plant and in the distribution centres.	Chlorine gas
Excavation and loading machine operators	Excavation of foundations for new reservoirs, excavation of trenches for water networks.	Silica dust, whole body vibration, heat stress, noise.
Demolition workers	Demolition of decommissioned infrastructure including old pipe networks	Asbestos, noise.
First Aid Workers	Rendering first aid or medical assistance to parties injured on site.	Blood borne pathogens
All workers	N/A	HIV and AIDS
All workers	N/A	Water and sanitation related diseases on site camps.

Table 2: Diseases and their mitigations

Hazard	Diseases	Description	Mitigation
Exposure to Chlorine	Pulmonary Edema. Skin burns.	When chlorine gas comes into contact with moist tissues such as the eyes, throat, and lungs, an acid is produced that can damage these tissues. Burning pain, redness, and blisters on the skin if exposed to gas. Skin injuries similar to frostbite can occur if it is exposed to liquid chlorine	Training to ensure that workers know how to detect and react to a chlorine Leak. This includes, moving away from the area, removing the exposed clothes and washing the skin. (CDC, 2013)
Exposure to Wet Portland Cement	Cement Dermatitis (OSHA, US Department of Labor) Cement burns.	Inflammation of the skin. Signs and symptoms of dermatitis can include itching, redness, swelling, blisters, scaling, and other changes in the normal condition of the skin. Blisters, dead or hardened skin, or black or green skin. In severe cases, these burns may extend to the bone and cause disfiguring scars or disability.	Use of appropriate PPE Early diagnosis and treatment. Employees who work with wet Portland cement and experience skin problems, including seemingly minor ones, are advised to see a health care professional for evaluation and treatment. (OSHA, US Department of Labor)
Wood dust exposure. May include fine dust, moulds and bacteria.	Hypersensitivity Pneumonitis(Alberta Human Resource and Employment, 2004) occupational asthma (Alberta Human Resource and Employment, 2004)	Inflammation of the walls of the air sacs and small airways. Signs and symptoms may include headache, chills, sweating, nausea, breathlessness, and other fever symptoms), and tightness of the chest. Narrowing of the airways which results in breathlessness. Coughing and a runny nose can also develop. (Alberta Human Resource and Employment, 2004)	Wood dust is not specifically addressed in the MCC manual of IFC Guidelines. However, the procedures for respiratory protection may apply. (MCC, 2014) Respiratory protection programs which address methods used to identify and evaluate workplace respiratory hazards, procedures for selecting respirators for use in the workplace and medical evaluations of employees required to use respirators
Breathing in fumes and heavy metals from welding, cutting	Bronchitis, asthma, pneumonia, emphysema, pneumoconiosis,	Lung problems due to breathing in welding fumes.	Provision of general mechanical or local exhaust ventilation shall be whenever welding, cutting, or heating is performed in a confined space.

of heating.	silicosis, siderosis. (AFSCME, 2011)	Kidney damage caused by exposure to heavy metals such as Chromium and Nickel.	Use of respiratory protective equipment.
	Kidney damage (AFSCME, 2011)		
	Cancer (AFSCME, 2011)	Welders, flame cutters, and burners have shown that welders have an increased risk of lung cancer, and, possibly cancer of the larynx (voice box) and urinary tract.	
Bright Light from welding and cutting.	Flash eye	painful inflammation of the cornea,	Eye protection, such as goggles with safety lenses and screens for side protection, face masks or shields. Welding barrier screens around the specific work station (a solid piece of light metal, canvas, or plywood designed to block welding light from others).
Noise	Temporary change in hearing, permanent hearing loss.(OSHA, US Department of Labour)	Short-term exposure to noise can cause short-term changes in hearing such as ringing or a feeling of stuffiness. Long-term exposure can cause irreversible hearing loss.	Practical engineering or administrative controls, when personnel are subjected to sound-pressure levels exceeding specified limits. When such controls fail, PPE shall be selected, evaluated, provided, and used in accordance with a hearing conservation program.
Body Vibration	Various vibration syndromes.	Changes in tendons, muscles, bones and joints, and can affect the nervous system	Controlled through choice of equipment, installation of vibration dampening pads or devices, and limiting the duration of exposure.
Silica Dust	Silicosis and lung cancer. Dust (OSHA, US Department of Labor).	Fatal lung diseases caused by inhalation of very small particles of crystalline silica.	Respiratory protection programs which address methods used to identify and evaluate workplace respiratory hazards, procedures for selecting respirators for use in the workplace and medical evaluations of employees required to use respirators.
Asbestos	Mesothelioma(HSE)	A cancer of the lung lining. It is always fatal and is almost exclusively caused by exposure to asbestos.	Avoidance of contact with asbestos pipes that are to be decommissioned. Pipes to be left buried.
	Asbestosis(HSE)	A scarring of the lungs. It is not always fatal but	

		can be a very debilitating disease, greatly affecting quality of life
	Diffuse pleural thickening(HSE)	A thickening of the membrane surrounding the lungs. This can restrict lung expansion leading to breathlessness
Social Interactions	HIV and AIDS	Sexually transmitted. HIV stands for human immunodeficiency virus. If left untreated, HIV can lead to the disease AIDS (acquired immunodeficiency syndrome).
Malaria World Bank Group., 2007)	(IFC, Malaria	Malaria is a mosquito-borne disease caused by a parasite. People with malaria often experience fever, chills, and flu-like illness. Left untreated, they may develop severe complications and die.
Blood Borne Pathogens	Human immune-deficiency virus (HIV), Hepatitis B virus (HBV), Hepatitis C virus (HCV) and Hepatitis A virus (HAV).	Transmitted via contact with infected blood. Blood-borne pathogen program for employees designated as responsible for rendering first aid or medical assistance. They are to; Be instructed in the sources, hazards, and avoidance of blood-borne pathogens and be provided the training provided with, and shall use and maintain, PPE (i.e., Breathing barrier, latex-free gloves, gowns, masks, eye protectors, and/or resuscitation equipment) Post-exposure protocol which includes a plan to ensure immediate medical evaluation of exposed individual(s) per current recommendations of the Centres for Disease Control (CDC)

5. Conclusion

This article provides useful information to those involved in the project and other future water supply projects as the LWSSD Project works represent the entire value chain of water supply from treatment to distribution. It is therefore hoped that this paper will reach wider construction community in Zambia and sensitise industry stakeholders on construction related health risks.

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Assessment of Employees Excessive Exposure to Solar Radiation on Zambian Construction Worksites

Erastus Mwanaumo¹, Sampa Chisumbe²

Abstract

Construction workers regularly labour outside in hot, humid weather leaving them vulnerable to long hours of exposure to solar radiation. Excessive exposure to solar radiation results in a variety of heat-induced disorders. Therefore, in assessing excessive exposure to solar radiation on employees' wellbeing on Zambia construction worksites, the research adopted a mixed approach with both probabilistic stratified random as well as non-probabilistic purposive sampling used to sample the population. A structured questionnaire and interviews were administered to the site management personnel, skilled and unskilled workers working on various representative construction sites. Contractors registered with National Council for Construction in all grades were sampled and considered. The research established that Zambia has no regulations specifying standards for maximum temperatures on construction worksites. Furthermore, that there is poor provision of resting facilities on construction worksites and in case of excessive sun employees resort to using either; any available shade on site, unfinished buildings or under trees. More so, that rashes on skin, itchiness and skin dryness, deterioration of the skin, premature ageing, damage to the eyes, loss of skin elasticity, heat exhaustion, fainting, headache as well as dizziness were the common complaints. The research recommends, *inter alia*, that contractors provide workers with information, instruction and training on recognising heat-related illness and on first aid. More so, that safety measures should be emphasized by the contractors and relevant regulatory authority.

Keywords: exposure, solar radiation, wellbeing, workers

1. Introduction

Solar radiation is the radiant energy emitted by the sun. Sunlight consists of visible light (400–700 nm), infrared radiation (>700 nm) and UV radiation. The quality (spectrum) and quantity (intensity) of sunlight are modified during its passage through the atmosphere. The stratosphere stops almost all UV radiation <290 nm (UVC) as well as a large proportion of UVB (70–90%). Therefore, at ground level, UV radiation represents about 5% of solar energy, and the radiation spectrum is between 290 and 400 nm. An individual's level of exposure to UV varies with latitude, altitude, time of year, time of day, clouding of the sky and other atmospheric components such as air pollution (IARC, 2005).

¹Assistant Dean Postgraduate, School of Engineering, University of Zambia, Box 32379, Lusaka, Zambia.
Erastus.mwanaumo@unza.zm

²Post Graduate Student, Department of Civil and Environmental Engineering, School of Engineering, University of Zambia, Box 32379, Lusaka, Zambia. Email: clechisumbe@gmail.com

Ultraviolet radiation is ubiquitous. Almost everyone has some exposure to ultraviolet radiation on a daily basis. It is an exposure we cannot entirely avoid and to strive for zero exposure would create a huge burden of skeletal disease from vitamin D deficiency (WHO, 2006). However, evaluation of the burden of disease created by excess exposure to UVR is very important; human exposure to solar ultraviolet radiation has important public health implications. Evidence of harm associated with overexposure to UV has been demonstrated in many studies. Skin cancer and malignant melanoma are among the most severe health effects, but a series of other health effects have been identified (Lucas *et al.*, 2006).

According to Cherrie(2015)today the risks associated with excessive sun exposure are well known and widely understood. However, in many industry sectors, the risks are not acknowledged or managed properly. This is due to unawareness of the scale of the issue and because of the myths around how sun damage can actually happen as well as misunderstandings around potential vitamin D deficiency from lack of UV exposure. For workers in many industries, hot, humid and hard-working conditions are a fact of life and Construction workers regularly toil outside in hot, humid weather. Excessive exposure to a hot work environment can bring about a variety of heat-induced disorders.

2. Working Outdoors

When working outdoors the weather can have influence an individual's effectiveness and this is not readily managed using just engineering controls. According to EHS (2001), the human body maintains a fairly constant internal temperature, even when exposed to varying environmental temperatures. To get rid of excess heat, the body varies the rate and amount of blood circulation through the skin and the release of fluid onto the skin by the sweat glands.

As environmental temperatures approach normal skin temperature, cooling of the body becomes more difficult as blood brought to the body surface cannot lose its heat (*Ibid*). At that point, sweat evaporation becomes the principal means to maintain a constant body temperature. Sweating does not cool the body, however, unless the moisture is removed from the skin by evaporation, which is difficult under conditions of high humidity or when wearing heavy protective clothing. Moreover, profuse and prolonged sweating can also disturb normal cardiovascular functions, according to the American Conference of Governmental Industrial Hygienists (ACGIH) (EHS, 2001).

Excessive exposure to a hot work environment can bring about a variety of heat-induced disorders. In fact, after just two hours of moderate work, workers may begin to feel the initial stages of heat stress (Cherrie, 2015). After another hour, they may start to lose strength, energy and focus. At its most severe point, heat stress can result in collapse or unconsciousness.

2.1 Challenges associated with excessive exposure to heat from the sun

Too much sunlight is harmful to the skin. It can cause skin damage including sunburn, blistering and skin ageing and in the long term can lead to an increased risk of skin cancer (WHO, 2006). Prolonged human exposure to solar UV radiation may result in acute and chronic health effects on the skin, eye and immune system. Excessive sweating leads to loss of water from the body, dehydration and loss of salt, resulting in potentially serious health effects (Shukor, 2012).

Excessive heat causes increase in the likelihood of accidents due to reduced concentration; slippery, sweaty palms; increase of discomfort of some personal protective gear, resulting in reduced protection and unsafe conditions (OSHA, 2014). Health Canada (2011) opines that “excessive heat may result in dehydration which causes clammy, moist skin, weakness and fatigue, nausea, vomiting, headache and giddiness. Reduced blood flow to the brain may lead to fainting”. Additionally, excessive exposure to the sun results in hot, dry skin and rapidly rising body temperature which can lead to collapse, loss of consciousness, convulsions, even death (Leithead and Lind, 1964).

According to Shukor (2012), in Canada some of the problems and their symptoms experienced in the temperature range between a comfortable zone (20C - 27°C) and the highest tolerable limits (for most people) are summarized in the table 1.

Table 1: Problems and symptoms caused by hot temperatures (Adapted from Shukor, 2012)

Temperature range (°C)	Effects	
20 - 27 °C	Comfort zone	Maximum efficiency
As temperature increases.....	Discomfort Increased irritability Loss of concentration Loss of efficiency in mental tasks	Mental Problems
	Increase of errors: Loss of efficiency in skilled tasks More incidents	Pyscho-physiological problems
	Loss of performance of heavy work: Disturbed water and electrolyte balance Heavy load on heart and circulation Fatigue and threat of exhaustion	Physiological problems
35 - 40°C	Limit of high temperature tolerance	

2.2 Safety measures when working in sunny condition

A review of various regulations and literature discussing safety measures when exposed to excessive Solar heat recommended the following safety measures to be put in place as a way of minimising risks and modifying workload (Worksafe, 2012; OSHA, 2014).

- rescheduling work so the hot tasks are performed during the cooler part of the day
- doing the work at a different location
- wearing light clothing that still provides adequate protection
- reducing the time spent doing hot tasks (e.g. job rotation)
- arranging for more workers to do the job
- providing extra rest breaks in a cool area
- using mechanical aids to reduce physical exertion
- keeping people away from hot processes
- Providing cool drinking water near the work site. During hot weather, workers should be encouraged to drink a cup of water (about 200 mL) every 15 to 20 minutes, and not rely solely on soft drinks or caffeinated drinks

- Providing personal protective equipment (PPE) such as reflective aprons and face shields for reducing exposure to radiant heat. Outdoor workers should be provided with protection against ultraviolet exposure, such as wide brim hat, loose fitting, long-sleeved collared (preferably cotton) shirt and long pants, sunglasses and sunscreen
- Providing workers with information, instruction and training on recognising heat-related illness and on first aid. Adequate supervision of workers is also required
- providing first aid facilities and access to medical help

2.3 Rest facilities

Health and Safety Executive (2010) and the National Road Construction Sector Occupational Health and Safety Code of practice Draft (2016) provides for every site to have a resting facility and that it should provide shelter from wind, sun and rain. It further states that these facilities should have adequate numbers of tables, seating with backs, and access to water, and that rest areas are not to be used to store plant, equipment or materials. The Code also recommends further that it should be positioned in an area which is free from work related hazards such as traffic, noise and dust.

With regard to working outdoors, in Canada, there are no regulations specifying standards for maximum temperatures in the workplace(Victorian Trades Hall Council, 2015).However, employers have a duty under the Victorian Occupational Health and Safety Act (2004)to provide and maintain for employees, as far as practicable, a working environment that is safe and without risks to health. This includes providing a safe system of work, information, training, supervision, and where appropriate personal protective equipment. The employer also has the duty to monitor conditions at the workplace - including the temperature(Occupational Health and Safety Act, 2004).

Similarly, in Germany the employer is obligated under the German Occupational Safety and Health Act (Arbeitsschutzge-setz) to help employees avoid or minimize damage from excessive UV exposure through appropriate protective measures though there are no legal limits for the amount of exposure to natural UV radiation. However, regarding exposure to artificial UV radiation, since 2006 there has been an exposure limit, as stated in the Guideline 2006/25/EG of the European parliament (radiation Heff 30 J/m² over 8 hours). The limit of exposure to artificial UV radiation was determined to avoid acute skin damage. Though delayed effects were not considered in calculating this value (Fartasch *et al.*, 2012).

3. Methodology

The methodology adopted in and for the purpose of this research was a mixed method research approach. Mixed method research is a type of research in which a researcher mixes or combines qualitative and quantitative research philosophies/paradigms, methodologies, methods, techniques, approaches, concepts, or language into a single research study Johnson (2014).When different approaches are used to focus on the same phenomenon and they provide the same result, you have "corroboration" which means you have superior evidence for the result. Other important reasons for doing mixed research are to complement one set of results with another, to expand a set of results, or to discover something that would have been missed if only a quantitative or a qualitative approach had been used (Escalada and Heong, 2009).

A total number of contractors in grade one to six contractors were drawn from the population of interest. The sample was drawn from target groups and summarized as shown in table 2. Contractors were divided into six strata according to their respective NCC grading with samples selected using proportionate method of stratified random technique for three strata namely grade one, two and three. For the other strata disproportionate stratified random technique was adopted this was due to huge discrepancies in numbers for contractors in higher grades and those in low grades making it difficult to use only proportionate method as this agrees with Latham (2007) assertion that “to choose an appropriate sampling technique for a research project, the researcher must be aware of the various numbers of members in each subgroup”.

Table 2: Population sizes, sample sizes and response rates (Source: NCC, 2014)

Population category	population size	Sample size	Successful responses	Response rate (%)
Grade 1	134	22	17	77.27%
Grade 2	60	10	6	60%
Grade 3	124	20	15	75%
Grade 4	382	30	19	63.33%
Grade 5	736	30	20	66.67%
Grade 6	1987	30	24	80%
Total	3427	142	101	70.38%

4. Findings

4.1 Management's knowledge level of the acceptable maximum temperature for employees to work on a construction site

An assessment was carried out to ascertain the management's knowledge level of the acceptable maximum temperature for employees to work on a construction site. 15% of the respondents indicated that they had knowledge of the acceptable maximum temperature for employees to work on site. 51% were not sure while 34% had no knowledge as shown in figure 1. Interviews revealed that though some employers claimed to have had knowledge of the acceptable maximum temperature for employees to work on site. Occupational Health and Safety Institute of Zambia revealed that Zambia has no regulations specifying standards for maximum temperatures on the workplace.

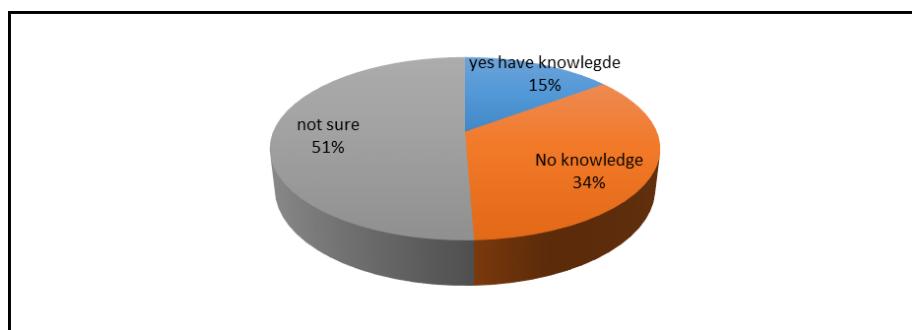


Figure 1: Management knowledge of acceptable temperature for employees to work on construction site

4.2 Provision of resting facilities

On resting facilities the study revealed that only 14% of the contractors surveyed had provided resting facilities on site for employees. This means that in case of rains, excessive sun, lunch time or resting time employees resort to using either; any available shade on site, unfinished buildings, under trees or anywhere they can find shelter as shown in figure 2.

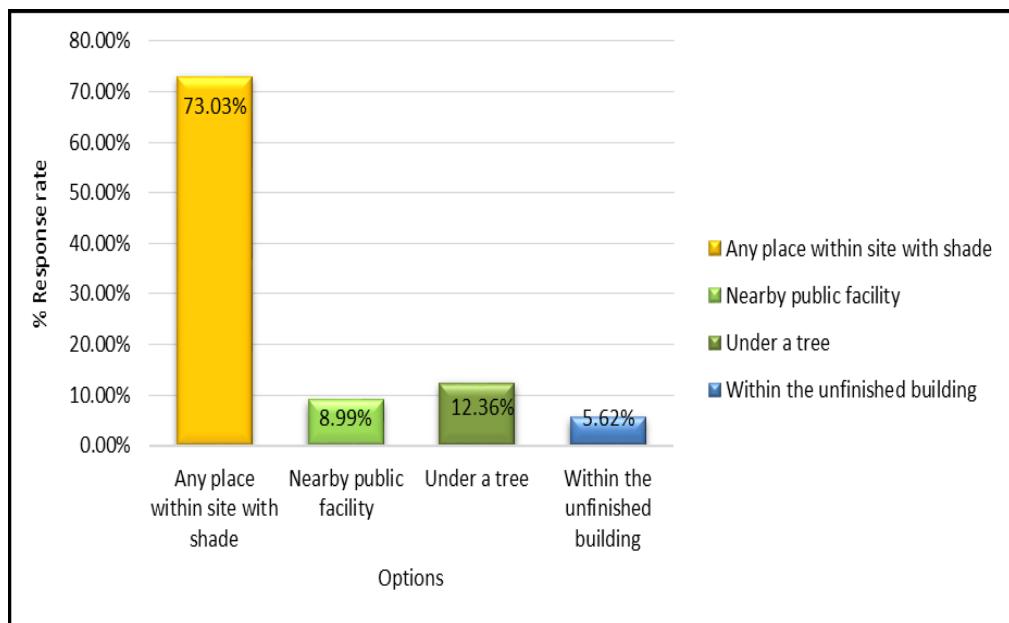


Figure 2: Options of where workers rest from on Zambian construction sites

According to the findings, only 14% of the contractors surveyed had provided resting facilities on site for employees as suggesting poor provision of resting facilities on construction worksites. The research further revealed that in case of rains, excessive sun, lunch time or resting time employees resort to using either; any available shade on site, unfinished buildings, under trees or anywhere they can find shelter. Figure 3 shows workers on a construction site in Lusaka resting under a tree during lunch time



Figure 3: Workers on a construction site in Lusaka resting under a tree during lunch time

The HSE (2010) opines that rest facilities should provide shelter from wind and rain. It further states that these facilities should have adequate numbers of tables, seating with backs, and access to water. According to the HSE (2010), rest areas are not to be used to store plant, equipment or materials.

As a result of failure to provide for such facilities, some workers on Zambian sites tended to go far from site to where they can get good rest hence resulting in late return to work and sometimes even drunk hence slowing down productivity.

4.3 Workers' common complaints resulting from excessive exposure or working in sunny condition on a construction site

An assessment was carried out to establish the workers' common complaints resulting from excessive exposure or working in sunny condition on a construction site. The research revealed that the most common complaints resulting from excessive exposure or working in sunny condition on a construction site among respondents included the following; rashes on skin, itchiness and skin dryness, deterioration of the skin, premature ageing, sunburns, damage to the eyes, loss of skin elasticity, heat exhaustion, fainting, headache, thirst and dizziness as shown as in Figure 4.

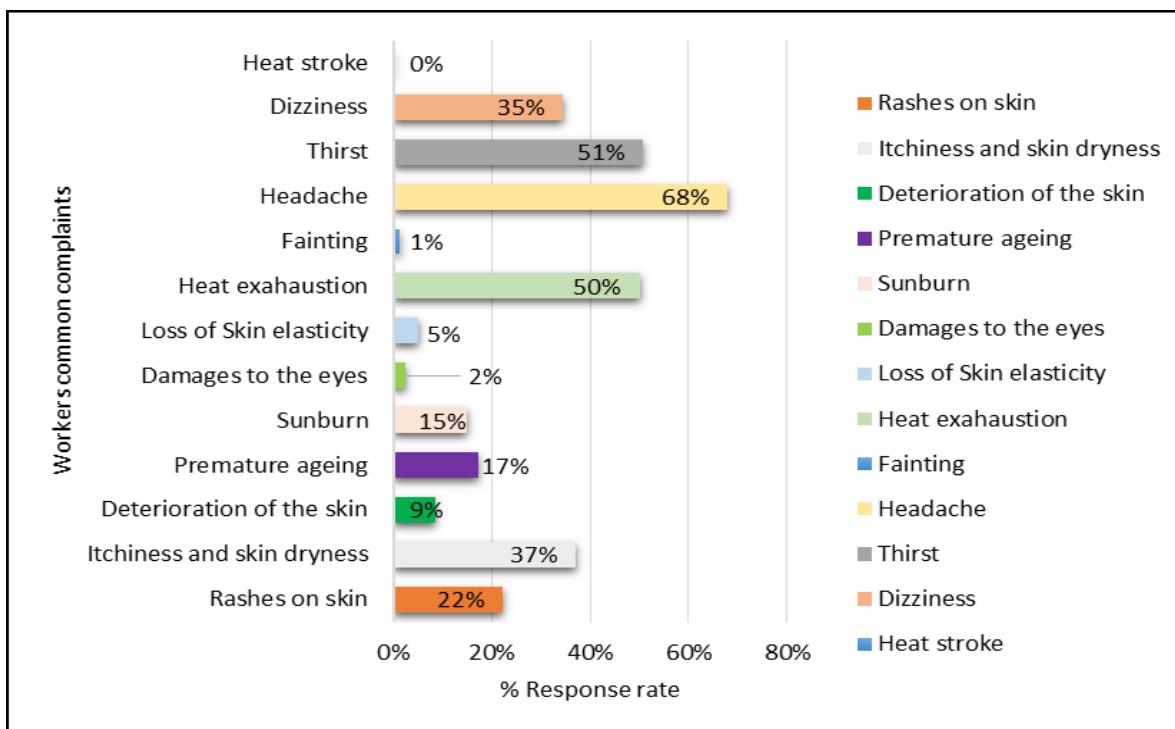


Figure 4: Common complaints from employees working on site when exposed to heat or excessive sun light

The findings revealed that; rashes on skin, itchiness and skin dryness, deterioration of the skin, premature ageing, sunburns, damage to the eyes, loss of skin elasticity, heat exhaustion, fainting, headache, thirst and dizziness as the common complaints by due to prolonged exposure to sunlight. This confirms WHO (Online, 2016) that “too much sunlight is harmful to the skin. It can cause skin damage including sunburn,

blistering and skin ageing and in the long term can lead to an increased risk of skin cancer. Prolonged human exposure to solar UV radiation may result in acute and chronic health effects on the skin, eye and immune system. Sunburn (erythema) is the best-known acute effect of excessive UV radiation exposure. Over the longer term, UV radiation induces degenerative changes in cells of the skin, fibrous tissue and blood vessels leading to premature skin aging, photodermatoses and actinic keratoses. Another long-term effect is an inflammatory reaction of the eye. In the most serious cases, skin cancer and cataracts can occur”.

4.4 Safety measures when exposed to excessive sun on Zambian construction sites

On the safety measures employed by management when workers are working or exposed to heat or excessive sunlight on a Zambian construction the respondents' indicated the following: 41% provided sufficient cool drinking water, 30% encouraged workers to take plenty water to replenish the body fluids lost through sweating, 1% allowed workers to cool down and reduce their exposure to hot environment through taking regular breaks and rotating duties and worksites; 7% made arrangements for workers to rest in cool or shady place during hot periods; 1% provided shower and washing facilities for washing and external cooling; 2% indicated wearing clothing that is light-colored and loose-fitting as a safety measure in place. 35% recommended use of naturally ventilated helmet and lastly 42% of the respondents had target based way working (umugwazo i.e. workers are given targets which upon finishing they can knock off and will be considered to have worked a full shift) as shown in figure 5.

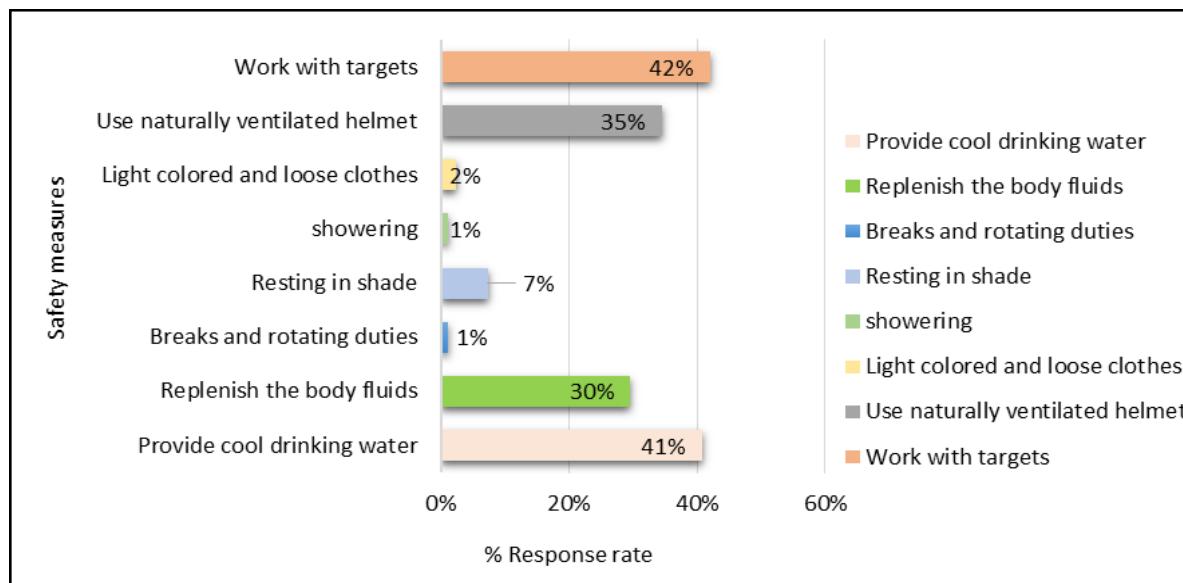


Figure 5: Safety measures when working in excessive sun light on site

5. Discussion

The findings revealed that only 41% of the contractors had cool drinking water provided for employees on site. According to Worksafe (2012) cool drinking water should be provided near the work site and that during hot weather, workers should be encouraged to drink a cup of water, and not rely solely on soft drinks or caffeinated drinks. The results suggest that most workers on Zambian construction are not

provided with cool drinking water,lack of drinking water during prolonged period of exposure to solar radiation leads to dehydration.Health Canada (2011) opines that“excessive heat may result in dehydration which causes clammy, moist skin, weakness and fatigue, nausea, vomiting, headache and giddiness,reduced blood flow to the brain may lead to fainting”

Furthermore, the research established that only 2% of the contractors surveyed used light coloured and loose fitting clothes as a safety measure for employees during the periods of prolonged exposure to Solar radiation (hot season). OSHA (2014) opines protection against ultraviolet exposure, through providing personal protective equipment (PPE) such as wide brim hat, loose fitting, long-sleeved collared (preferably cotton) shirt and long pants, sunglasses and sunscreen.

On provision of extra rest breaks, the findings revealed that only 7% had considered breaks as a safety measure for employees’ when exposed to prolonged solar radiation. Worksafe (2012) opines providing extra rest breaks in a cool shade as a safety measure. More so, according to HSE (2010), rest facilities should provide shelter from sun, wind and rain. It further states that these facilities should have adequate numbers of tables, seating with backs, and should not to be used to store plant, equipment or materials. The results of this research suggest that most employees on Zambian construction sites are excessively exposed to sunlight especially during the hot season leaving them vulnerable to excessive UV related diseases.This agrees with Leithead and Lind (1964) that “excessive exposure to the sun results in hot, dry skin and rapidly rising body temperature which can lead to collapse, loss of consciousness, convulsions, even death. Furthermore, it can lead to aggravation of other medical conditions and illnesses such as high blood pressure or heart disease due to increased load on the heart as well as reproductive disorders through affected sperm count or the health of the foetus”.

6. Conclusion and Recommendations

Zambia has no regulations specifying standards for maximum temperatures on construction worksites. Therefore, employers have no local regulation governing their operations in outdoor working environment. Furthermore, there is poor provision of resting facilities on construction worksites resulting in employees resorting to use either; any available shade on sites, unfinished buildings or under trees in case of excessive sun. More so, rashes on skin, itchiness and skin dryness, deterioration of the skin, premature ageing, damage to the eyes, loss of skin elasticity, heat exhaustion, fainting, headache as well as dizziness are common complaints among employees on construction sites in hot season.

The research therefore recommends that, contractors provides workers with information, instruction and training on recognising heat-related illness and on first aid. More so, that safety measures should be emphasized by the contractors and relevant regulatory authority.

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Leadership Influence on the Health and Safety Behaviour of Construction Workers: A Review

Victor N. Okorie¹, Chioma S. Okoro², Innocent Musonda³

Abstract

Leadership in construction health and safety (H&S) management has drawn great attention from scholars in the western world. This paper reviews existing literature on the role of project leaders in H&S management programmes and how their active involvement/ participation, from the inception of projects, could reduce the numbers of injuries and at-risk behaviors among workers. A review of existing literature was conducted from Google, ASCE and Science Direct. Findings revealed that positive H&S behaviour of workers could be influenced by: a) incorporation of H&S into the work programme by the project manager; b) facilitation of financial provisions for H&S into the contract documents by quantity surveyors; c) demonstration of commitment and visible H&S leadership towards workers' H&S by contracting firms at all levels of management; and d) key projects leaders' H&S leadership and behaviour. Client H&S visible leadership manifests through appointment of competent design team, allocation of adequate financial resources for H&S, and designing H&S into construction projects at the early design stage. These findings will increase awareness on the importance of leadership and commitment in improving H&S behaviour of construction workers on sites. The study recommends that key leaders on a project should demonstrate visible leadership and commitment towards workers' H&S.

Keywords: construction, health and safety, leadership, project leaders, worker behaviour

1. Introduction

Globally, accident and fatality statistics in the construction industry have remained roughly the same over the years (Luria, 2011). There is a strong argument that legislation, regulations, trade unions and Health and Safety (H&S) management systems alone cannot improve construction H&S performance. Though H&S legislation, regulations and management systems have brought success to accident and injury prevention in the workplace (Construction Industry Development Board (CIDB), 2011), Lees and Austin (2011) argue that such successes are limited as workplace accidents are on-going. The typical top-down control approaches to H&S management and rules enforcement no longer achieve the desired results at most worksites (Lees and Austin, 2011). Arguably, most of the risky work practices or unsafe behaviour of

¹Department of Quantity Surveying, University of Benin, Edo State, Nigeria; v.okorie@yahoo.com

²PhD Candidate, Department of Construction Management and Quantity Surveying, University of Johannesburg, South Africa; chiomao@uj.ac.za

³Senior Lecturer, Department of Construction Management and Quantity Surveying, University of Johannesburg, South Africa; imusonda@uj.ac.za

workers on sites can be traced back to the roles played by the key project leaders during the project conception stage.

The inadequacies in rule enforcement and management oversights have led to an on-going search for better ways of managing construction H&S. One of those ways is through H&S leadership, commitment and behaviour of the key project leaders, which have been found to have both direct and indirect relationships with workers' H&S behaviour (Zou, 2011; Okorie, 2014). Performance-based leadership can change at-risk behaviours by first understanding and analyzing the reasons people behave in certain ways and then using behavioural modification techniques to improve human performance (Zou, 2011).

Previous studies have focused on leadership and commitment to project H&S by clients (Musonda and Smallwood (2008) and designers, project managers and quantity surveyors (excluding clients) (Okorie, 2014). Others have dwelt on contractors' leadership and commitment to workers' H&S at all levels of management (Lu and Yang, 2012), and examined leadership, commitment and safety risk assessment on two different levels: workers and corporate management (Zou, 2011). Smallwood (2013) incorporated different categories of stakeholders and their role in assuring H&S on construction sites. Some literature have focused on direct investigation of the roles of site managers as leaders of their team and the range of managerial styles they adopted in managing site operations (Cooper, 2010; Lees and Austin, 2011). Leadership of site managers on its own cannot bring about significant improvement in construction site workers' H&S behaviour. It is the collective leadership of the key project leaders, as Cooper (2010) and Lees and Austin (2011) opined that can impact positively on the workers' H&S behaviour. Oloke (2010) argues that there are fundamental differences between leadership in construction process and contractor's site H&S management. Leadership in the context of workers' H&S behaviour are not common. In addition, it appears that limited research has been conducted into leadership and construction H&S management and specifically, on the various leadership roles which key project stakeholders could play to improve worker H&S on sites. Better understanding of all leadership roles and behaviour of the key project leaders will lead to a positive workplace H&S culture (Okorie, 2014). The current paper incorporates all key project stakeholders in leadership roles to examine their potential influence on workers' H&S behaviour. Attention to workers' H&S behaviour is necessary because they are the main assets of any construction company; their productivity can be maximised without sacrificing their H&S; and they need the right mindset, beliefs, values and attitudes to indulge in safe practices (Zou, 2011).

The objective of the present paper is to investigate the influence of various project leaders on workers' H&S behaviour on construction sites. A review of empirical and qualitative literature, based on international and African context, on leadership and construction H&S with particular interest in workers' H&S behaviour improvement, was conducted. Databases including Google, ASCE Library and Science Direct were consulted. Search phrases including construction worker behaviour, construction H&S improvement, leadership roles, construction project leadership, causes of site accidents, and construction H&S management were used. Materials which had one or more aspects related to the different categories of leaders (clients, contractors, designers, quantity surveyors and project managers) were included in this study. The findings are presented in the next section. Section 3 presents the lessons learnt and model of key project leaders' influence on workers' H&S behaviour developed from the review; and section four concludes.

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2. Literature Review

2.1 Health and safety management through leadership

Leadership in construction H&S is a complex and often subjective issue, but an understanding exists that ‘good H&S is good business’ (Flin and Yule, 2003). Nonetheless, Sunindijo and Zou (2011) argued that poor leadership not only impacts on overall project performance and stakeholders’ profit margins, but also has a serious negative impact on workers’ H&S behaviours. The CIDB (2011) report on construction quality in South Africa noted that lack of integrity and openness among construction leaders manifests as poor construction quality, cost overrun and workers’ poor H&S performance. Poor leadership such as lack of integrity, transparency, nepotism and corruption, existing particularly in the public sector client, leads to award of contracts to contractors without H&S competencies.

The relevance of leadership in today’s competitive world is evident in all areas that require strategic planning. Hopkins (2007) and Lees and Austin (2011) asserted that leadership is the single most important factor that influences workers’ H&S performance and determines the ultimate success or failure of a project or an organisation. Naoum (2011) contends that leadership is the personal values that lead to outstanding managerial performance. Leadership and leaders’ commitment to workers’ H&S are very important for effective H&S management in any organisation (Zou, 2011). Flin and Yule (2003) contended that no amount of detailed regulation for H&S improvement could make up for deficiencies in effective leadership. However, Naoum (2011) argued that leadership is not a panacea to all management problems and state that leaders have been found to often lose focus and become overwhelmed. Nonetheless, leaders have the ability and personality to direct, influence and motivate groups or workers/employees to achieve organisationally set goals including H&S. Thus, such leadership qualities are needed in the construction industry for improvement of workers’ behaviour.

Personal and organisational effectiveness including workers’ H&S behaviour has been linked to leadership. It can be argued that improvement of workers’ H&S behaviour is largely dependent on the quality of leadership. Without strong leadership at every level, involving guidance and motivation of others to want to do what is right and in the right way, accidents would continue to occur on sites (Zou, 2011). Accidents do not occur without a reason as they are partly caused by a failure in leadership and unethical behaviour (Sunindijo and Zou, 2011). Leaders have responsibility for establishing the best practice standards to which an organisation must adhere to. Failure of leadership could manifest in many forms including clients’ lack of commitment in the appointment of competent professionals (Okorie, 2014), lack of supervision by clients agents (Behm, 2005), poor designs (Gibb and Bust, 2008), and absence of building plan approval (Iyagba, 2009). Unethical behaviour exists in the form of fraud, unfair practices and corruption among public office holders (CIDB, 2011). Arguably, achieving sustainable improvement in

workers' H&S behaviour in the industry could be achieved through commitment and behavioural change of key project leaders.

Collective leadership of the key project leaders can impact positively on the workers' H&S behaviours (Cooper, 2010; Lees and Austin, 2011). Oloke (2010) argues that there are fundamental differences between leadership in construction process and contractor's site H&S management. He further stated that leadership in construction project is a strategic function that involves the input of all the key project leaders during the project planning stages, while project H&S management is an operational function of a contractor. Leadership with regard to workers' H&S behaviour must start during the project planning stages to completion.

2.2 Key project leaders' influence on worker health and safety behaviour

Leadership and commitment of key project leaders towards project H&S are critical factors for workplace H&S culture. Okorie (2014) contended that key project stakeholders' H&S leadership and commitment have potential to create healthy and safe work environment that optimizes workers' H&S behaviour. The author further observed that effective construction H&S management depends on a leadership-driven model that identifies the H&S leadership roles of all the key project leaders involved in construction from the early design stage to construction. According to Smallwood (2013), construction is a multi-stakeholder entity in which all parties influence H&S, either positively or negatively. Luria (2011) observed that it is the quality of leadership demonstrated by the key project leaders- client, designer, project manager, quantity surveyor and contractor - during the project conception/design stage that determines or influences workers' H&S behaviour on site. Therefore, the right attitude and behaviour must come from key project leaders to achieve the optimal workers' H&S performance in the industry. Thus, a positive change at the upstream will manifest at the downstream (safe behaviour of workers). The key project leaders and their potential influence on workers' H&S behaviour are discussed in the next section.

2.2.1 Clients' health and safety leadership role

The client as the initiator and financier of all construction projects has important roles to play with regards to workers' H&S behaviour. Clients' visible leadership and commitment in the appointment of competent professionals is the first step towards the realisation of optimal workers H&S performance (McAleenan, 2010). Clients are required under the law to appoint competent professionals (architects, engineers, quantity surveyors and project managers) who will bring in their technical expertise into the projects. The clients and their project consultants' commitment are important since the leadership qualities exhibited by the clients and their appointed consultants set best practice standards for the contracting organisation to meet workers' H&S needs and enable compliance with the national regulatory agencies and industry standards (Lutchman, Maharaj and Ghanem, 2012).

Clients through their appointed consultants should ensure that adequate financial resources are allocated for H&S. Geller (2008) contends that investment in H&S should be justified on a similar basis as other competing projects' parameters such as cost, quality and time. Workers' H&S should be considered equally important as other projects parameter, as workers are most valuable assets of any organisation. Therefore, clients and their appointed consultants should demonstrate visible leadership and commitment towards workers' H&S for sustainability of workplace H&S culture leading to improved workers' H&S behaviour.

Clients are also required to provide all necessary information regarding the site in advance. This is very important at the project conception/initiation stage as lack thereof will lead to site accidents (Hinze, 2006). Spangenberg (2009) asserts that on projects where competent professional were not appointed at the early stage such projects are characterized with site injuries and fatalities.

At-risk work practices or unsafe behaviour of workers on site have been linked to clients' poor H&S leadership and lack of commitment to projects' H&S (Howarth and Watson, 2009; Musonda and Smallwood, 2008). According to Oloke (2010), the desirability of client commitment and involvement stems from the high rates of site accidents and incidents. The CIDB (2011) reports noted that clients' visible leadership, commitment and active involvement are the critical factors that can sustain positive workers' H&S behaviour in the industry. Haupt(2010) asserted that at-risk practices or unsafe behaviour of workers are caused by inappropriate response by client to certain constraints and the environment. Clients' failure to act positively to the constraints such as early appointment of competent professionals, robust procurement methods, project budgeting, prequalification of consultant and contractors on H&S are manifestations of poor leadership. The consequences are at-risk worker practices and unsafe behaviour of workers.

2.2.2 Designers' health and safety leadership role

Research conducted in both the developed and developing countries indicated that design-related aspects have direct and indirect impact on workers' H&S behaviour (Behm, 2005). According to European Foundation for the Improvement of Living and Working Condition, 60% of fatal injuries in construction are as a result of decisions made before work begins at the construction site (HSE, 2007). Haupt (2011) argues that the thrust of designing H&S into project leads to a reduction of at-risk worker practices and unsafe behaviour. Oloke (2011) and Smallwood (2013) concurred that designers (architects/engineers) have a duty and responsibility to incorporate H&S into projects during the design process. They further stated that designers can use their knowledge and influence to design-in safety features that will improve the actual construction of the projects itself, as well as its maintenance after completion. Designers' lack of integrity and commitment in their design decisions can result in unsafe practices and unsafe behaviour (Behm, 2005). Inadequate and faulty designs (Gibb and Bust, 2008) and specification of substandard materials during design phases (Gambatese, Toole and Behm, 2008) were also cited as factors contributing to site accidents. The ILO (2010) emphasizes that those involved with the design and planning of construction projects should demonstrate visible leadership and commitment towards workers' H&S.

Gambatese *et al.* (2008) concurred with the aforementioned and stated that design of project is a function of skill, talent, knowledge, and leadership ability. Despite the important roles of designers relative to project H&S performance, there are also legislative frameworks that exist in almost all countries that designers should integrate workers' H&S into their design decision. However, designers tend to perceive construction site H&S as the responsibility of the contractor (Choudhry, 2007). This myth is a serious challenge in the area of improving workers' H&S. Regardless of this long-lived myth, designers should demonstrate visible leadership and commitment to their professional duties and design-in H&S into projects to improve workers' H&S behaviour on construction sites.

2.2.3 Project managers' health and safety leadership role

Project managers, in terms of their contractual relationship with clients have important H&S leadership roles to play in ensuring that workers' H&S are taken into consideration during projects design/inception

stage to completion (Lutchman *et al.*, 2012). The Project Management Body of Knowledge (PMBOK) identifies project managers' activities that can influence project performance as: review of concept design; design coordination; site inspection and meetings; design reviews, including details and schedules; facilitation of financial provision for project during planning phase and tendering stage; pre-qualification of contractors, and advice regarding choice of procurement system. These scopes of work place important leadership roles on the shoulders of project managers. In contrast, Nigeria has no such regulations that define the duties and responsibilities of the project managers concerned with health, safety, welfare of the workforce (Idoro, 2004).

Project managers as project leaders can influence workers' H&S during the upstream phases of project design. It has been noted that on projects where project managers were not involved during the upstream decisions those projects encountered problems such as poor quality work, cost overrun, delay, poor worker H&S performance and complete abandonment (McAleen, 2010). The CIDB (2010) notes that project managers' leadership role is more visible on project sites when they monitor contractors' quality plans, conduct site meetings and inspections and ensure that workers' H&S is maintained. It can be argued that poor leadership and lack of commitment by project managers relative to inadequate project monitoring and irregular site inspection and meetings are manifestations of poor leadership resulting in poor workers' H&S behaviour.

2.2.4 Quantity surveyors' health and safety leadership roles

Paucity of funds is one of the major factors contributing to contractors' poor site H&S intervention. Inadequate allocation of financial resources for H&S during the early project planning or at the tendering stage by quantity surveyors is one of the major factors contributing to at-risk work practices or unsafe behaviour on site (Olatunji, Sher and Gu, 2011). Arguably, when a contractor compromises workers' H&S due to lack of funds, the resultant effect will be accidents and incidents. Inadequate financial provision for H&S at the project tendering stage or during projects negotiation by quantity surveyors points to poor leadership and lack of commitment to professional ethics.

Almost all construction projects are normally paid for as the work proceeds, so interim valuation at monthly intervals during the progress of the work is utmost important to contractors. This monthly valuation helps contractors to have a steady cash-flow, as lack thereof will lead to poor project performance including workers H&S (Olatunji *et al.*, 2011). It has been noted that lack of commitment in preparation of interim monthly valuations by quantity surveyors has a direct link with the workers' H&S behaviour. Thus, prudent management of financial resources on construction projects is linked to safe work practices.

2.2.5 Contracting organisations' health and safety leadership roles

Contractors tendering for construction projects must adequately provide for H&S in their tenders. They have duties and responsibilities under the law to carry out construction activities without causing harm to workers/employees and the general public. These are achieved through planning, organising, controlling and monitoring of the construction phases and coordinating activities of other contractors on site (Hawarth and Watson, 2009). It is the leadership styles demonstrated by contracting organisation at all levels of management that determines how construction process will be plan, organise, control, and monitor to ensure workers' H&S are optimised. Leadership and commitment to workers' H&S exhibited at all level of management are the critical factors that drive organisational H&S performance (Zou, 2011). Hopkins

(2008) maintains that to achieve the desired workers' H&S behaviour in the industry, the key project leaders required leadership skills not only management skills.

Top management H&S leadership is crucial to workers' H&S behaviour. John (2009) stated that positive behaviour of top leaders sends messages to workers on value management placed on workers' H&S. This was also echoed in Lutchman *et al.* (2012) in which it was stated that 'workers hear what we say, but what they do reflected on what we do'. This statement vividly explains the importance of top leaders' behaviour and commitment relative to workers' H&S behaviour.

Howarth and Watson (2009) argued that managers play important roles in promoting positive workers' H&S behaviour on site, which reduce accidents. Studies comparing cases of low and high rates of injuries on construction sites reported excellent performance in both workers' safety and quality of work where managers demonstrated good quality leadership, planning, organisation and role modelling to others (Hinze, 2006). In Hinze's opinion, a site which is characterised by unsafe behaviours or at-risk work practices is one with an autocratic leader who is dogmatic and lacks human relational skills. He further argued that when these attributes are lacking among site managers, and thus there is less optimal performance among workers. Hopkins (2007) and Sunindijo and Zou (2012) concurred that most site managers lack intelligence and interpersonal skills and this negatively impacts on workers' H&S behaviours on site. These leadership qualities are lacking among site managers in Nigeria, and they impose serious challenges to the improvement of workers' H&S (Okorie, Okolie and Ajator, 2015). The huge challenge of identifying and training site managers in the areas of leadership and interpersonal skills that would improve their H&S behaviour is exacerbated by the high levels of bribery and corruption, which have become a part of the social life in Nigeria (Okorie, Okolie and Ajator, 2015).

3. Model of leadership influence on workers' H&S behaviour (Lessons learnt)

Most construction site disasters could be prevented by collective efforts of the key project leaders at all stages of construction, from design/planning to completion (Oloke, 2010). All at-risk work practices, unsafe conditions and unsafe behaviour emanating from construction site activities are preventable. Researchers and scholars such as Lees and Austin (2011) and Wu and Fang (2012) argue that if the causes of unsafe conditions and unsafe behaviour emanating from construction site activities are traced back to the H&S management practices of clients, designers, project managers, quantity surveyors, and contractors at all levels of management, workers' unsafe behaviour can be prevented. The literature survey indicated that the root causes of construction site accidents, injuries and fatalities originate/emanate from the decisions of the identified key project leaders during the project conception and construction stage. Emphasizing the importance of behaviour-based health and safety, Hopkins (2007) reiterated that attention should be directed to the critical related behaviour of the upstream factors who are the creators of the work environment.

Better understanding of the leadership roles and behaviour of the key project leaders will lead to a positive workplace H&S culture. Figure 1 below illustrates how the collective H&S leadership roles and behaviour of key project leaders identified in this study could result in safe or unsafe behaviour of construction site workers. The key project leaders, identified in Figure 1, play important H&S leadership roles at different

stages of the construction project process. The assumption is that unsafe conditions or unsafe behaviour of workers arise from a failure in leadership between the clients, designers (architects/engineers), project managers, quantity surveyors, and contractors, at different stages. In other words, their poor leadership and unethical behaviour at different stages of construction processes allow the potential incident to become a reality.

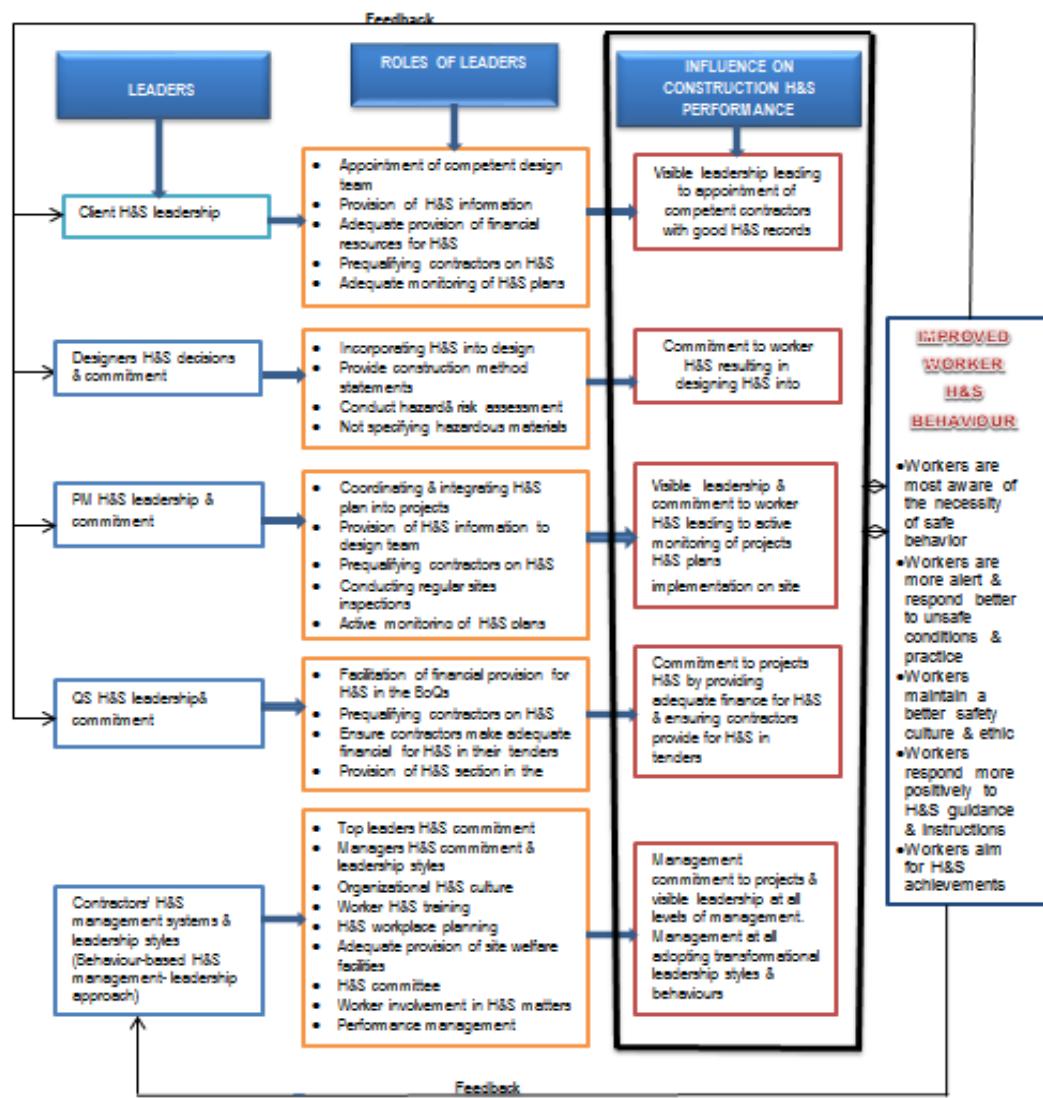


Figure 1: Model of leadership influence on worker H&S behaviour

Behm (2005) identifies clients' poor H&S leadership in terms of appointment of incompetent design team and inadequate allocation of financial resources for project H&S. In addition, H&S not being designed leads to poor H&S, as suggested in Hinze (2006) and Goldswain and Smallwood (2015), in which it was stated that construction H&S can be addressed through design interventions during the conception/design

stage, with detailed specifications providing information along with their designs to ensure that potential risks and associated issues are identified.

Project managers' poor H&S leadership relative to lack of commitment in prequalification of contractor on H&S and ensuring that adequate funds were allocated for project H&S, quantity surveyors' poor H&S leadership in terms of inadequate provision of financial resources for project H&S in the contract documents and lack of visible leadership and commitment towards workers' H&S management in contracting organisations at all levels of management, influence worker H&S behaviour (Hopkins, 2006; Olatunji *et al.*, 2011; Sunindijo and Zou, 2012). It has been noted that addressing workers' H&S behaviour during the projects planning and at the construction phases can have positive impacts on site workers' H&S behaviour in the followings: workers are most aware of the necessity of safe behaviour; workers are more alert and respond to unsafe conditions and practices; workers maintain a better safety culture and ethic; workers respond more positively to H&S guidance and compliance, and workers aim for H&S achievement and awards.

4. Conclusion

The present paper sought to identify the influence of various project leaders on workers' H&S behaviour on construction sites. The objective was achieved. It was possible to extrapolate from the studies that have been conducted internationally on causes of site accidents and construction H&S management. The paper revealed that H&S leadership responsibilities of key project leaders influence workers' H&S behaviour. The client has a duty and a responsibility under the law to appoint a competent design team, provide information regarding the site, prequalify contractors on H&S, and regularly visit site to ensure that contractors are conforming to project H&S plans. At-risk work practices or unsafe behaviour of workers have been linked to designers' lack of commitment and unethical behaviour towards workers' H&S. Top management's behaviour and commitment to workers' H&S determine the behaviour of managers and workers on site.

There is a need for behavioural orientation among project leaders in the construction industry, particularly those involved in contracts procurement and award. Behavioural change is imperative at all stages of the construction process in order to reduce the number of site accidents and incidents. Proper documentation and licensing could also ensure that project designers and managers engage in and enforce H&S practices on their sites. The major limitation of this research is evident in the fact that it is a review paper. Future studies could adopt alternative techniques such as a quantitative approach to explore the relationship between project leaders' roles and responsibilities and worker H&S behaviour.

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8

SOCIAL

INFRASTRUCTURE AND

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Failure of Small and Medium Contracting Firms in Gauteng Province, South Africa

Clinton Aigbavboa¹, Ayodeji Oke², Felicity Kakanyo³

Abstract

Organisations are established to address a particular issue of the society and their success or failure in achieving their set goals and objectives largely depend on both external and internal factors. In this study, sources of failure of small and medium businesses in the construction industry were examined and remedies that can be implemented to reduce the failures were evaluated. Data for the study were collected through administration of structured questionnaire on owners of small and medium construction companies. It was revealed that the major causes of small business failure are lack of financial managerial ability and general administration of the business. Challenges faced by these firms include inadequate managerial skills and planning, lack of access to work opportunities, prolonged economic recession, lack of financial skills, competition, incompetent employees and lack of basic business, technical and pricing skills. Small construction businesses need to be supported by government and other stakeholders in order for them to be sustainable and this will also guarantee job security for construction professionals and other form of workforce employed in the companies. The managers and directors of these firms should attend and participate in conferences, workshops, seminars and other forms of leadership meetings within and outside the country to improve their leadership, business and organisation skills.

Keywords: construction industry, contractors, entrepreneurs, market environment, small and medium enterprises (SMEs).

1. Introduction

Entrepreneurs in disadvantaged townships experience problems of low demand due to inadequate knowledge of competitors, which results from a lack of market research on their competitors and needs of their customers (Lazarus, 2005). However, Thwala and Phaladi (2009) stated that small and medium enterprises (SMEs) in South Africa have to deal with the challenge of a lack of capacity due to the chronic skills shortage in the country and the difficulties they face in obtaining desperately needed capital. In the country, government recognises the importance of SMEs that a new Ministry of Small Business Development was established in early 2014 (Bureau for Economic Research, 2016). Isaacs and Friedrich

¹Associate Professor; Department of Construction Management and Quantity Surveying; University of Johannesburg; P. O. Box 17011, Doornfontein 2028, South Africa; caigbavboa@uj.co.za.

²Post-Doctoral Research Fellow; Department of Construction Management and Quantity Surveying; University of Johannesburg; P. O. Box 17011, Doornfontein 2028, South Africa; emayok@gmail.com.

³Graduate Student; Department of Construction Management and Quantity Surveying; University of Johannesburg; P. O. Box 17011, Doornfontein 2028, South Africa; kakanyof@gmail.com.

(2006) stated that the construction business is large in size and significant in the role it plays in the economy, but in recent years it has witnessed an increasing number of financial failures.

According to Ladzani and Seeletse (2012), competent entrepreneurs and construction business managers often have good ideas but they do not have proper and basic knowledge of running a business and lacks fundamentals principles to sustain it. This implies that failures of SMEs firms are largely due to lack of training programmes in business management and solution to the problems does not necessarily lies with their managers but with external agencies and concerned stakeholders. Schaefer (2006) noted that certain issues are important for a business to succeed and these includes finances or capital, general management actions and knowledge of the impact of macro-environmental aspects on business activities.

Government's role within the construction industry is a vital one. Chandra (2001) noted that SMEs perceive government to have a vital responsibility in their development, noting that a number of interventions from the government will increase their competitiveness, marketability, and visibility beyond their locality. It was further stated that in recent years, political economy considerations in the South African economy have led to the perception of SMEs development as a social imperative. According to Thwala and Phaladi (2009), this has contributed to the notion that SMEs empowerment can become an important source of employment and income generation, and thus increase living standard of the citizens, minimise poverty and reduce inequality. Therefore, failure of SME construction firms in term of various challenges in raising them and internal problems affecting their progress were examined in this study with a view to highlight success factors to remedy the challenges.

2. Literature Review

The building construction industry which is also called the built environment is the third largest employer in South Africa (Ladzani and Seeletse, 2012). Therefore, this industry is a significant employer of professionals, skilled, artisans and other indirect workforce. It creates many different opportunities for SMEs and general development of the country. However, previous studies have reported that the survival rate of SMEs is relatively low (Thwala and Phaladi, 2009; Berisha and Pula, 2015; Yoshino and Taghizadeh-Hesar, 2016). Ladzani and Seeletse, (2012) concluded that it is so bad that less than half of newly established businesses survive beyond five years. Brink *et al* (2003) observed that this is not only true for South Africa, but a common occurrence in the rest of the world. The small businesses are regarded as the answer in the economic growth and job creation in both developing and already developed countries; hence the need for improvement in the management of the firms.

2.1 Causes of failure of small and medium contractors

Business failure can be defined as the inability of an organisation or established business to discharge its duties and pay its obligations when they are due. Brink and Cant (2003) reported that SME businesses form an integral part of the national economy but they are influenced by various factors. It is mostly a consequence of a sharp decline in sales in demand, as a result of recession, loss of an important customer, shortage of basic and required resources such as raw materials, management, etc. Yoshino and Taghizadeh-Hesar (2016) noted the major challenges to include limited access to finance, lack of

databases, low research and development expenditures, undeveloped sales channels, and low levels of financial inclusion, which are some of the reasons behind the slow growth of SMEs. Thwala and Mofokeng (2012) opined that the problems of SMEs in conducting a fruitful business are mostly categorised as external and internal environment.

Market environment and competition are the major external factors affecting small and medium contractors (Deakins and Freel, 2003). Thwala and Phaladi (2009) reported that there are a large numbers of small contractors or businesses entering at the market environment at the lower end, thus, the sector has become highly competitive, thereby making it difficult for new entrants to keep a sustainable cashflow and workflow. This inability to sustain workflow impacts on their ability to achieve sustainable employment and economic empowerment (Deakins and Freel, 2003). Hence, for a company to withstand the effects of competition, a market research on their competitors and customers should be conducted before choosing a location so as to understand their customers and their demand.

The internal causes according to Deakins and Freel (2003); Lazarus (2005); and Thwala and Phaladi (2009) are financial managerial ability, lack or of finances, insufficient capital, poor estimating and job costing, debt, strategic planning issues, lack of comprehensive business plan, diversifying into unfamiliar types of projects, lack of managerial maturity, strategic implementation/control issues, increase in project size, poor cost-estimating and planning skills, lack of equipment control, poor internal communications, financial management issues., poor use of accounting systems, excessive debt, etc.

2.2 Remedies for contractors' failure

Previous studies have established that there is not one critical success factor that can make small contractors to be successful but a combination of factors (Chandra *et al*, 2011; Ladzani and Seeletse, 2012; Thwala and Mofokeng, 2012). In the North West Province of the country, Thwala and Phaladi (2009) identified critical and some less critical factors affecting SME contractors. The following factors were therefore recommended as key to the success of SME contractors in the country: government intervention, leadership development and skills training workshops; business skills; management skills; access to capital; good record keeping; and well managed cash flow.

2.2.1 Government intervention

The South African construction industry will continue to provide jobs for individuals but without necessary intervention, small and medium sized contractors that form the basis of the industry will remain unsustainable and their performance satisfaction will be affected. In order to address problems and challenges faced by small businesses contractors in South Africa, Chadhliwa, (2015) noted that it is critical for the government to review policies with regard to Contractor Development Programmes (CDP) and Construction Education and Training Agencies (CETAs) to ensure that the government contributes to the success of small contractors in the country.

2.2.2 Business skills

Business enterprise expenditure on research and development (BERD) is an important driver of innovation and economic growth (Yoshino and Taghizadeh-Hesar, 2016). Location of business premises is very important in the growth of SMEs. According to Thwala and Phaladi (2009) SMEs are to set specific targets for their business, carry out market research, employ qualified personnel and accord them responsibilities

according to their skills, knowledge and experience. It is also necessary for managers of SMEs to understand existing skills needed and attend refresher courses on business management skills.

2.2.3 Management skills

Thwala and Mofokeng (2012) discussed management factors affecting SMEs and stated that experience in any kind of management is very important as it plays a vital role in making sure that a business fails or succeeds. This implies that poor management is one of the main causes of failure of small enterprises, this is due to lack of experience and management skills that enable managers to make bad business decisions within the construction industry. It was further observed that financial mismanagement and management incompetence are among the attributes that lead to construction failures. Thwala and Phaladi (2009) noted that financial management should be emphasized as well as networking with other people with similar businesses and keeping records of workers to help in evaluation of the performance of SMEs.

3. Research Methodology

The population for the study comprised small and medium enterprises within the construction industry in Gauteng province, South Africa. The Construction Industry Development Board (CIDB) register of contractors was adopted as the target population for this research. The CIDB is a public entity that was formed by an act of parliament to promote a regulatory and developmental framework for the South African construction industry. The register provides a comprehensive list of all contractors that are eligible to undertake government projects in South Africa and subdivided them into various classes of works i.e. civil engineering, building works etc. and the contractors are graded from 1 to 9.

The data used in this paper were derived from both secondary and primary sources. The primary data was obtained through the survey method, while the secondary data was derived from the review of literature. The primary data was collected through a structured questionnaire with focus on the employers and owners in the construction companies. These were self-administered using convenience sampling technique. To eliminate bias, the research field procedures were examined to ensure that the samples chosen and the questionnaire method used provides an unbiased and accurate research data

4. Findings

4.1 Background information

Respondent profession revealed that 6% were quantity surveyors, same for civil/structural engineers, 25% were project managers, 25% were architects and 38% were construction managers. For job procurement, the study revealed that 12% of the firms' jobs were procured from private section, 13% from the public section, and 75% from both the private and public sectors. On the company's CIDB grading, 6% are grade 4, 13% are grade 2, same for grade 3 and grade 5 while 44% are grade 1.

On the annual turnover of the SME companies after its first year of operation, 38% were below R500,000.00 while 62% are above R500,000.00 out of which only 12% record above R15 million. The current turnover of the company revealed that 13% are still below R500,000.00 against 38% after their

first year of operation. More so, about 26% currently have a turnover of over R15 million indicating an improvement in the earlier 12%.

Company's total projects value in its first year of operation indicates that 31% were below R500,000.00, 57% are between R500,000.00 and R10 million while 12% are above R10 million. Currently, the company's total projects value revealed that only 13% are below R500,000.00 against 31% at their first year, 37% are between R500,000.00 and R10 million while the remaining 50% are above R10 million. More so, among these 50%, 13% now have a turnover of over R30 million indicating progress and development in their businesses.

4.2 Challenges in raising SME construction firms

Table 1, on the challenges encountered in raising the company, revealed that shortage of skilled employees is not really a problem indicating vast availability of workmen. The major challenges encountered in raising the SMEs are inadequate managerial skills and lack of access to work opportunities. Other challenges include prolonged economic recession, lack of financial, business, technical and pricing skills as well as competition from other similar and experienced firms.

Table 1: Challenges encountered in raising SME contracting firms

Challenges	Mean	Standard deviation	Rank
Managerial skills and planning	4.13	3.11	1
Lack of access to work opportunities	4.13	3.11	1
Prolonged economic recession	4.00	2.59	2
Financial skills	3.94	3.56	3
Competition	3.94	2.59	4
Incompetent employees	3.94	2.49	4
Business skills	3.81	2.95	5
Technical skills	3.81	2.17	5
Pricing Skills	3.69	2.28	6
loss of skilled personnel	3.63	2.17	7
Shortage of skilled employees	3.31	2.17	8

4.3 Internal problems affecting SME construction firms

Table 2 presents the internal problems that affect the smooth running of small and medium construction companies. The most significant internal problems are lack of financial resources and proper strategic planning. The least variables are lack of managerial maturity, diversifying into unfamiliar types of projects and lack of comprehensive business plan.

Table 2: Internal problems that affect the smooth running of the company

Internal problems	Mean	Standard Deviation	Rank
Lack of financial resources	4.31	3.96	1
Lack of Strategic planning	4.00	2.68	2
Lack of Financial control skills	3.63	2.77	3
Lack of comprehensive business plan	3.44	3.49	4
Diversifying into unfamiliar types of projects	3.38	3.96	5
Lack of Managerial maturity	3.19	2.49	6

4.4 Success factors to remedy failure

The major factors that can act as remedies to the company failure as indicated in table 3 are well managed cash flow, Constant Entrepreneurship training and Access to capital and finance. Effective record keeping and recruitment of new qualified professionals are also important success factors. The least important factor is related to family/domestic situation which is not directly related to the day to day activities of the company, therefore has little effect.

Table 3: Success factors that can act as remedies to the company

Success factors	Mean	Standard deviation	Rank
Well managed cash flow	4.75	5.22	1
Constant Entrepreneurship training	4.38	3.70	2
Access to capital	4.38	3.63	2
Good record keeping	4.31	3.42	3
Recruiting young qualified professionals	4.06	3.27	4
Family/ Domestic situation	3.20	2.35	5

5. Discussion of Findings

Shortage of skilled employees is not influential in causing failure of SMEs, same as pricing skills and loss of skilled personnel. However, business skills and technical skills are critical to SMEs failure. In view of this, Bureau for Economic Research (2016) observed that the SMMEs in South Africa have adapted themselves to the new circumstances in their environment through adequate training and development. Most influential internal problem that affects the smooth running of a construction business is lack of financial resources and inability to access the market. Bureau for Economic Research (2016) opined that the inability of SMEs to access markets has been noted as one of the major factors threatening their longevity while Bergthaler, Kang, Liu and Monaghan (2015) identified loan recovery as a major challenge of SMEs in developing countries. However, lack of financial control skills and lack of strategic planning are also important factors. Owing to the significance of SMEs to any country, Yoshino and Taghizadeh-Hesar and (2016) suggested that it is important to find ways to provide them with stable finance through effective borrowing and repayment plan with low interest rate.

6. Conclusion and Recommendation

The most significant internal and external factors that affect SMEs within the construction industry are market environment which is concerned with competition. Internal causes are mostly related to financial and managerial issues such as insufficient capital and excessive debt as a result of late payments from clients that affect their cashflow. However, the following factors can reduce failures in the construction industry; effective and efficient cash flow management, good record keeping, access to capital, entrepreneurship training and recruitment of young qualified professionals. Thus, recruiting the right personnel and developing existing employees' business skills especially in the area of financial business skills is a basic factor in the development and sustenance of SME contractors.

Small and medium enterprises should emulate management skills from other successful construction owners or contractors in their environment. They should learn to network with different successful contractors in order for them to get experience and understanding of their business environment. SME owners should recruit young professionals that have business skills and hire professionals according to their skills, knowledge, experience and business strengths. More so, owners of these firms should establish a record of books of accounts on daily, weekly, monthly and yearly basis as the case may be, because good record keeping enhances effective financial record and thus aid in sorting cashflow and other financial issues. Cashflow forecast and budget should be accurate and continuously monitored to keep the project within financial boundaries and affordable loans from financial institutions and advance payments from the clients should also be considered. Several workshops and training by Construction Education and Training Agencies (CETAs) and Construction Industry Development Board (CIDB) development programmes, can also benefit owners and personnel of SMEs in their quest to understand and implement basic skills for the growth and development of their businesses.

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Adoption of Best Value Selection Method in the Zambian Road Sector

Balimu Mwiya¹, Mundia Muya², Chabota Kaliba³

Abstract

The intricacies of bidding and procurement in public infrastructure investment, if well managed, dictate the success of a project. They provide value for money (VfM) in the use of public funds. The prominence of VfM in the development agenda is that there is no fixed price of public infrastructure delivery. Two roads with the same parameters built in the same geographical location will never have the same price. However, assessing VfM is not a simple task in a developing country like Zambia because of limited standards, non-adherence to regulations and non-availability of reliable statistics. This is compounded by multiple stakeholders and their perspective of value for money. The traditional method of procurement is the most common in the Zambian road sector. Contractor selection is based on least cost. However, evidence suggests that this approach accounts for poor performance, delays and cost overruns. The aim of the paper is to propose the adoption of the Best Value Selection (BVS) method which utilises the concept of VfM for the Zambian road sector. The results presented are from a broader study carried out on the analysis of unit rates for road works in Zambia. The research method involved a desk review of 254 project executed during a ten year period from 2005 to 2014. Using findings from desk study and questionnaire survey a comparative analysis was made between least cost selection (LCS) and BVS. With the provision of accurate Engineer's estimates, the Zambian road sector can migrate from LCS to BVS in procurement of works. BVS involves consideration of cost, preliminary and project specific indicators. Findings show that for BVS adoption, open and transparent accurate Engineer's estimates are a requirement and bidders would decide at the onset whether to bid for the work or not. The Engineer's estimate is viewed as a baseline in terms of cost efficiency, effectiveness and economic variables.

Keywords: best value selection, procurement of works, value for money, Zambian road sector

1. Introduction

Road infrastructure provides a fundamental foundation to the performance of national economies, delivering a wide range of economic and social benefits. For a landlocked country, the Zambian road network is one of the country's largest public sector assets. The Government of the Republic of Zambia

¹Lecturer; Department of Civil and Environmental Engineering; University of Zambia; P.O. Box 32379, Lusaka, Zambia; Email: balimu.mwiya@unza.zm or mwiyab49@gmail.com

²Dean; School of Engineering; University of Zambia; P.O. Box 32379, Lusaka, Zambia; E-mail: mmuya@unza.zm or mundiamuya2000@yahoo.co.uk

³Lecturer; Department of Civil and Environmental Engineering; University of Zambia; P.O. Box 32379, Lusaka Zambia; Email: chabota.kaliba@gmail.com

(GRZ), through the Road Development Agency (RDA) embarked on a ten year Road Sector Investment Programme (RoadSIP II) from 2003 to 2013. The focus of RoadSIP II was to bring the Core Road Network (CRN) into serviceable and maintainable standards to facilitate connectivity, poverty alleviation, agricultural and marketing activities (RDA, 2008). GRZ's proactive initiatives were aimed at transforming Zambia into a truly land linked country in the Southern Africa sub-region (GRZ, 2010). Road infrastructure requires appropriate funding and good management to ensure maximum value is achieved. Inadequate levels of investment or poor management of the road network have serious consequences for economies and social well-being of citizens.

The major source of funding for infrastructure development in developing countries has been by Multilateral Development Banks (MDB). Without support from MDB or Cooperating Partners (CPs), projects in poorer, unstable or high-risk developing countries would often not get implemented. World Bank-financed projects result in 40,000 contracts being awarded annually and account for one third of total international contracts in developing countries (Hawley, 2004). Given their major role in financing and facilitating funding for infrastructure projects in low income countries such as Zambia, MDBs and CPs have a critical role to play in ensuring value for money (VfM). The concept of VfM is key in the use of public funds. In Zambia, public procurement is estimated at 10 percent of gross domestic product (GDP), and is therefore one of the top three types of spending besides salaries and debt re-payments. Assurance is required that public infrastructure is being purchased at the correct price, and not necessarily the lowest. The question is what is the correct price for one (1) km of a road? The prominence of VfM in the development agenda is that there is no fixed price of public infrastructure delivery. Two roads with exactly the same parameters built in the same geographical location will never have the same price. In fact, highway experts contend that the price of a road varies depending on the chainage from the project start point. However, assessing VfM is not a simple task in a developing country like Zambia because of limited standards, non-adherence to regulations and non-availability of reliable statistics. This is compounded by multiple stakeholders and their perspective of value for money. The National Audit Office (NAO) in the United Kingdom uses four criteria in assessing VfM of government spending (NAO, 2014):

- a) economy (spending less);
- b) efficiency (spending well);
- c) effectiveness (spending wisely); and
- d) equity (spending fairly).

From the four criteria, it is hoped that the Zambian road sector achieves VfM through efficient spending. While significant steps have taken place in recent years in ensuring VfM, serious vulnerabilities remain.

2. Literature Review

Project managers consider cost estimating to be an art (Vojinovic *et al.*, 2000). The accuracy of cost estimates is so important that a contingency for errors is incorporated in the estimate. However, Flyvbjerg (2006) stated that forecasts of cost, demand and other impacts of planned projects have remained consistently and remarkably inaccurate for decades. He further stated that inaccurate cost forecasts were a major source of risk to project management. Therefore accurate cost estimation has the potential to reduce project risk. The construction of a road is considered a long term project. Without accurate data, it is a

daunting task to predict the future cost of goods and services. Inaccurate determination of cost escalation could result in non-viability of a project. Therefore, cost estimating is seen as one of the critical project success factors. It forms the basis for further planning and decision-making. By integrating cost estimation and cost control, the consequence of a failed or cancelled project is reduced.

2.1 Accurate Engineer's estimates

Cost estimation is essentially a computational process that attempts to predict the final cost of a future project, even though not all of the parameters and conditions are known when the estimate is prepared (AACE, 2013). The analysis of rates is a critical part of the project development process and when incorporated with quantities, provides the Engineer's estimate. The Engineer's estimate is important as it:

- a) serves as a basis for probable construction cost;
- b) supports decision-making on project scope; and
- c) serves as a guide to evaluate bidders' proposals.

Confidence in the accuracy of the estimate should be established to make the Engineer's estimate an effective tool. Accurate cost prediction is perhaps one of the major requirements on any road construction project. A lack of understanding of the estimating process and cost control on road projects can result in under or over estimation. Estimating and bidding is not an exact science because of subjectivity from the estimator's experience, project scheduling, site supervision and productivity factors. In addition, the volatility of global prices such as those relating to oil based materials can adversely affect project cost estimates. Given the myriad of factors that affect cost estimation, it is important to understand them in order that some semblance of standardisation is obtained. Even though each project is unique, certain activities may be repetitive, similar or standard providing an opportunity for computer based cost estimation. This can be achieved through first principles estimating.

2.1.1 First principles estimating

The Oxford Advanced Learner's Dictionary (2014) defines first principles as the fundamental concepts or assumptions on which a theory, system, or method is based. A famous quote by Harrington Emerson (1911) states that "As to methods there may be a million and then some, but principles are few. The man who grasps principles can successfully select his own methods. The man who tries methods, ignoring principles, is sure to have trouble."

Estimating from first principles or cost based estimating is the preferred method for heavy highway-type bidding by contractors. Such estimates reflect the cost to construct the specified work in the most economical manner based on the contractor's capability and contract duration (Molenaar *et al.*, 2011). Estimating from first principles requires careful review of work crews and equipment completing tasks at assumed rates of productivity. Bid items are broken down into detailed task-by-task work activities. The direct cost for each task is developed with separate costs for the labour, equipment, subcontractor, and material components of the work required to complete a task (Molenaar *et al.*, 2011). By using the latest price data for materials, equipment and labour, an accurate estimate is produced unlike bid-based estimating that uses historical data. Since most contractors utilise this approach to prepare bids, it becomes

advantageous to use the same estimating method to prepare an Engineer's estimates. Although more time and skill are required in first principles estimating compared to historical data based estimating, once the appropriate labour and equipment production data sources and material price database are created, the process is routine and manageable.

2.2 Contractor selection methods

In Zambia, industry regulators and public institutions have indicated that there was a notable trend in varying costs of construction from project to project and from one public institution to another, that it had become increasingly difficult to ascertain the true cost of projects and thereby unable to guarantee value for money (ZPPA, 2014). The traditional method of procurement is where the designer is responsible for design and the contractor for execution. Selection of a qualified contractor in the process of construction management is critical as contractors influence project success (Huang, 2011). The invitation of bidders to tender for construction works by the employer is to select the most responsive bidder in terms of cost and technical ability. There are various selection methods used in the construction industry. However, the study focuses on contractor selection using Least Cost Selection (LCS).

2.2.1 Least cost selection

In the case of the LCS, the selection is based on the lowest bid or "evaluated" price among those that achieved the stated minimum technical score. LCS for procurement of contracts is about comparative analysis and cost effectiveness. The utility industry which coined the term, has had tremendous success using its methods to identify the least expensive options for providing a finite amount of electricity to its customers. In the utility sector, LCS considers a wide variety of options from the demand as well as the supply side; from peak periods pricing to offering energy efficient light bulbs to customers for free or at a discounted price. As a result of this success, many have argued that the LCS criteria be translated for use in the road sector. However, this translation has proved difficult as tradeoffs in the road sector are more complex (HDR, 2010). In Ghana, like Zambia there is overwhelming acceptance to award construction projects to contractors who submit least cost bids. However, evidence suggests that this approach accounts for delay in projects, poor performance and project cost overruns (Oppong, 2013). Rather than automatically accepting the lowest price, the tender evaluation process should apply weighting factors for skills, quality, experience and previous performance in a manner to ensure value for money (Tasmania, 2014).

2.2.2 Best-value procurement method

Best-value procurement process is where price and other key factors are considered in the evaluation and selection process to minimize impacts and enhance the long-term performance and value of construction. Scott (2006) explains that best value may encompass the concepts from and variation of current highway procurement methods including prequalification, post qualification, A+B bidding, multi-parameter bidding, bid alternates and extended warranties. Scott (2006) further states that best-value procurement has been employed under traditional design and build contracting. In 2007, the Minnesota Legislature enacted a law that enables public agencies to select contractors based on best value, rather than low bid (MnDOT, 2012).

2.2.3 Weighted Criteria Procurement Method

The weighted method of tender evaluation requires that selection criteria, in addition to price, are included in tender documents and form part of the tender assessment process. A system of weighting the selection criteria is used to compare tenders and identify the tenderer with the best performance record in terms of time, cost and VfM (Akram and Zareba, 2012).

Construction procurement is often the subject of joint funding, with the different stakeholders having varying degrees of interest and objectives in the outcome of the project. Recent literature on this subject review that traditional processes of selection should be radically changed because they do not lead to best value and therefore the recommendation is that an integrated team, which includes the Client, should be formed before design and maintained throughout delivery (Akram and Zareba, 2012). The guide on better cost predictability in construction emphasises that current and accurate information should be shared between stakeholders.

3. Methodology

The results presented are from a broader study carried out on the analysis of unit rates for roadworks in Zambia. Data was collected using desk study and questionnaire survey. The desk study involved the review of 254 projects which were made available by the RDA. These projects were executed during a ten year period from 2005 to 2014. The research included the review of the contractor selection criteria in order to identify areas of migration from LCS to BVS in procurement of works. A total of 58 questionnaires were distributed to investigate the estimating methods used in the Zambian road sector.

The paper considers a combination of various aspects of the best-value procurement method and weighted criteria procurement method to result in the BVS which utilises the concept of VfM. The paper recommends BVS for adoption in the Zambian road sector.

4. Discussion of Findings

The desk study revealed that the traditional method of procurement is the most common in the Zambian road sector. The two most common types of selection methods in the Zambian road sector are: the Quality Cost Based Selection (QCBS); and the Least Cost Selection (LCS). In the Zambian road sector, QCBS, where bids are ranked according to their combined technical and financial scores, is applied to the selection of consultants. LCS is the method used to select a contractor.

Results from a questionnaire survey indicated that a limited number of construction personnel estimated from first principles. The findings showed that 27 percent of respondents built up rates from first principles compared to 55 percent who used historical rates. This could be attributed to lack of documented production rates and construction specific indices required for first principles estimates in the Zambian road sector. From literature, it was not clear which software was commonly used among contractors and practitioners in the Zambian road sector as no published research could be cited. The questionnaire survey findings indicated that only 4 percent of the respondents used software.

The desk review indicated that the current evaluation process in the Zambian road sector considers a preliminary, financial and post qualifying evaluation. BVS recommends cost, preliminary and project specific indicator evaluation.

4.1 Cost indicator

From literature, both the best value and weighted criteria procurement indicate cost as a major indicator. Therefore, BVS relies on an accurate Engineer's estimate. One of the principles of obtaining VfM is openness and transparency. Therefore, the Engineer's estimate for a project where bids are solicited should be known by all stakeholders. The Engineer's estimate should be included in the advertisement and solicitation documents. Succeeding steps would be to only consider contractors whose bids are within ± 25 percent. A difference of ± 25 percent is selected because that is the acceptable standard percentage for variations to a project in the Zambian road sector.

The first step in BVS is evaluating bids by checking the correctness of the bill of quantities (BoQ) and verify that the total bid amount is within ± 25 percent of the Engineer's estimate. The bid that is below but closest to the Engineer's estimate scores higher than a bid that is above but closest to the Engineer's estimate. The proposed ranking for the cost indicator is shown in Table 1. The table shows that where a number of bids have the same variance from the Engineer's estimate, the bid with a negative variance will be ranked higher than a bid with a positive acceptable variance.

Table 3: Proposed ranking of bids using BVS cost indicator

Bid variance from Engineer's estimate	Ranking
-5 %	1
+5 %	2
-10 %	3
+10 %	4
-15 %	5
+15 %	6
-20 %	7
+20 %	8
-25 %	9
+25 %	10

4.2 Preliminary indicators

After consideration of the cost indicator, preliminary indicators are then analysed. The basic requirements are assessed using the 'yes/no' criteria for items such as availability of contractor registration certificate in the right category and grade, power of attorney, bid security, site visit certificate and any other specified requirements. An example of preliminary indicator queries is shown in Table 2. From the table, BVS requires that all preliminary indicators are compliant. A 'NO' response to a preliminary indicator would affect the final VfM score.

Table 2: Preliminary indicator assessment (Adapted from RDA evaluation criteria)

Preliminary indicators		Compliance (Yes / No)
1	Is the bid security amount indicated compliant?	
2	Is bid security validity period in days compliant?	
3	Is period of validity of the bid compliant?	
4	Is power of attorney compliant?	
5	Is certificate of incorporation of firm valid?	
6	Have names of shareholders and directors for a company and names of proprietors for a firm been indicated?	
7	Is NCC registration in grade and category valid and compliant?	
8	Is there proof of site visit?	

4.3 Project specific indicators

The last step in BVS is the project specific indicator (PSI) evaluation or detailed qualification. The PSI scored out of 100 include contractor general and specific experience, the company's financial status, subcontracting methodology, method statement, safety record, HIV awareness strategy, key personnel and equipment requirements. An example of project specific indicators is shown in Table 3. Details of PSI are specified in the bidding document. For instance, from Table 3 qualifications of a team leader may indicate PhD holder with 20 years experience in engineering. Bids with team leaders meeting that criterion would score 15. The total PSI score out of 100 is used to determine the VfM score.

Table 3: Project specific indicator assessment sheet (Source: adapted from RDA evaluation criteria)

Project specific indicators (PSI)	Weight A	Marks B	Score A x B
Specific Experience (10%)			
(a) Experience of the firm	4		0.00
(b) Assignments of a similar nature	4		0.00
(c) Experience in the Southern African Region	2		0.00
Subtotal	10		0
Adequacy of the proposed work plan and methodology in responding to the TOR (25%)			
(a) Technical Approach and Methodology	10		0.00
(b) Work Plan	7.5		0.00
(c) Personnel and Activity Schedules	7.5		0.00
Subtotal	25		0.00
Qualifications and competence of the key professional staff (55%)			
Team leader	15		0.00
Pavement Engineer	11		0.00
Traffic Engineer	8		0.00
Transport Economist	8		0.00
Surveyor	7		0.00
Environmentalist	6		0.00
Subtotal	55		
Local Participation (6%)			
(a) Nationals among staff	3		
(b) The firm	3		
Subtotal	6		
Training (4%)	4		
Total Score for each contractor	100.00		0.00

4.4 VfM score calculation

The VfM score is then calculated by dividing the cost indicator by the PSI score. The bid with the lowest VfM score is the best value selected bidder. Comparison of the existing and proposed BVS process is shown in Figure 1.

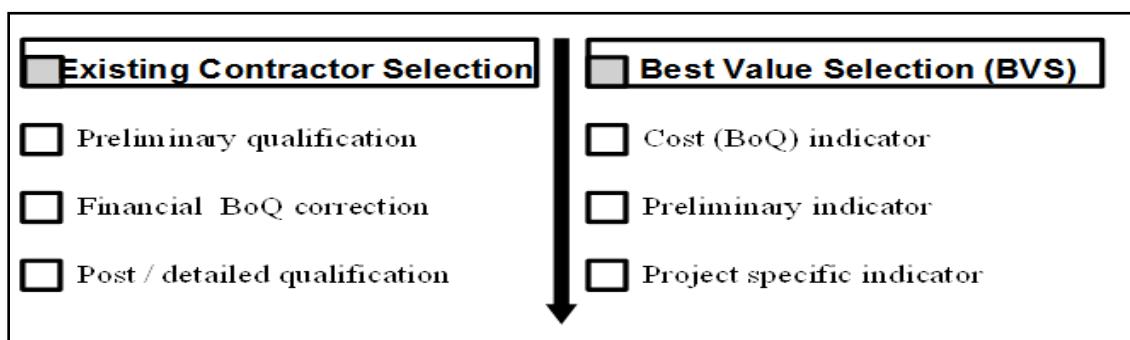


Figure 1: Comparison of existing and best value contractor selection process

4.5 Migration to BVS

The Engineer's estimate is paramount in BVS. Guidelines on awards or rejections of bids at a set level above the Engineer's estimate would have to be established. Therefore, migration to BVS would require laws or regulations regarding release or protection of the Engineer's estimate. This entails a standardised or uniform pricing mechanism to be put in place through development of a computer based unit cost estimation model. With the Engineer's estimate known, contractors can decide whether they would bid for the work or not at the onset.

Estimating in the Zambian road sector is carried out by a wide range of personnel who subscribe to protocols that are broadly understood, but are not consistently well documented. Desk study revealed that government units do not have primary basis for establishing estimated unit prices. In addition, the road sector estimating department does not have an official library for labour production rates, cost, tender, and construction material price indices. The government should therefore ensure that the estimating department denotes the primary basis for establishing estimated unit prices. The estimating department should also have an official road sector library with annual publications accessed online. There are various factors that affect construction costs in Zambia (Mwiya *et al.*, 2015). These factors depend on a country's political, economic, social and technological environment. The estimating department would ensure periodic review of identified cost factors. Guidelines in cases of poor competition or excessive difference between the estimate and the low bid have to be clearly spelt out. For instance, questions regarding adjustment of estimates after receipt of bids would be clarified. In BVS, due to transparency, pressure to award an apparently excessive bid will be eliminated.

5. Conclusion

The Government of the Republic of Zambia continues to invest in the construction of roads in all geographical regions of the country which have different topographical setups. The different regions have varied sources of materials and climatic conditions that may affect the pricing of road activities. Desk review of 254 projects reveals that the LCS method has been used for the past ten years from 2005 to 2014. But stakeholders perceive that Zambia does not always get value for money in infrastructure delivery. To achieve VfM in road infrastructure delivery, it is necessary to standardise cost estimation methods of road activities. By computing an accurate Engineer's estimates, the best value selection process can be used to achieve VfM.

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Exploring Strengths and Weaknesses of Growth among Small and Medium-Sized Construction Firms in Ghana

Bernard Martin Arthur-Aidoo¹, Clinton Aigbavboa², Didibhuku Thwala³

Abstract

Small and medium size construction firms are recognised as drivers of socio-economic development in most nations. This is because the operations of small and medium enterprises (SMEs) impact on both job creations and poverty alleviation programmes in many countries. Although construction SMEs in Ghana are generally considered to have a low level of managerial structures, their dominance, and activities within the sector enable them to fill gaps and also execute projects in numbers and at locations where large firms will be available and prepare to operate. This attribute makes the growth of these construction SMEs imperative to the Ghanaian economy. The purpose of this study was to establish the strengths and weaknesses in enhancing firm's growth among construction SMEs. The methodology adopted was solely a comprehensive review of the literature on existing models. The review was conducted via journals, conferences publications supported by other electronic information. The conclusion of the study stressed that strength of firm's growth refers to its competitive advantage and distinctive competencies. This includes strong customer service, positive employees attitudes, excellent stakeholders relations, lower cost in production and high integrity of the staff among others. Further conclusions to the study pointed that weakness of firm's growth, on the other hand, refers to the constraints that impede a firm to grow or what the firm does not do well. The study also concludes that weakness in firm's growth among SMEs include frail organisational structure, inadequate training of staff, lack of clear corporate goals and complex levels of reporting systems of the firm.

Keywords: construction industry, growth, Ghana, SMEs

1. Introduction

Small and medium-sized construction firms do not only create jobs for labour but also provide significant social, economic development which brings about the high level of poverty alleviation. The literature on SMEs has confirmed this category of firms as an engine of growth for lots of developed and developing countries. This implies that the well-being of most economies in terms of socio-economic development both at macro and micro levels are dependent on SMEs. According to Olebogeng (2015), the economic

¹Doctoral student: Construction Management and Quantity Surveying: University of Johannesburg, South Africa: bernardmartins@hotmail.com.

²Associate Professor: Construction Management and Quantity Surveying: University of Johannesburg, South Africa: aigbavboa@uj.ac.za

³Professor: Construction Management and Quantity Surveying: University of Johannesburg, South Africa: didbhukut@u.ac.za

development of a nation can be regarded as a process of growth and change aimed at raising people's living standards. This involves growth in total and per capita income which is accompanied by primary changes in the structure of an economy and mostly impacted by the construction industry. The construction sector is characterised globally to be a labour intensive and particularly in Ghana, the industry is notable for having a low level of barriers to entry. This has brought about the ease of springing-up of SMEs and had resulted in the dominance of small and medium-sized construction firms with a low level of managerial structures. Despite the feature of these SMEs, they are also able to execute the project at locations where large firms are not interested in executing such projects. Further, SMEs are also considered as a catalyst for most nations' development due to their significant impact on job creation, innovation, poverty and poverty alleviation amongst others. This implies that exploring the strengths and weaknesses of the construction SMEs within the industry is prudent. This will enable both opportunities of firm's growth as well as their associated threats to be known so that mitigation measures are provided in order to foster growth. This study, therefore, seeks to establish the strength and weakness among Ghanaian construction SMEs that affect their growth.

1.1 Purpose of the study

The purpose of this study was to explore the strength and weakness in the growth of small and medium-sized construction firms in order to establish ideas that will facilitate growth among these SMEs.

1.2 Research Methodology

In order to achieve the aim of the study, a comprehensive review of the literature on previous models was used. Further, this technique was found suitable for this study due to the nature of the qualitative information needed which included previous and existing information on SMEs and their growth pattern. Vivid review of literature on the small and medium-sized construction firm was made and from a total of nine existing models of the growth of SMEs, only three were considered applicable for detail analyses on the study. The three existing models considered include Hashi and Kransnigi (2011), Fadhunis (2012) and Gupta et al., (2013). Out of these models, the strength and weaknesses of firm's growth were convalesced and applied to the study. In addition, the adopted qualitative technique of retrieving existing models on firm's growth was embarked via electronic medium using published internet based resources and supported by other related unpublished materials.

2. Review of Literature

2.1 What are SMEs?

The term small and medium-sized firms (SMEs) cover a broad spectrum of definitions (Dalberg, 2011). According to Storey (1994) cited in (Eyiah, 2004), the literature on small and medium enterprises have up till now not established any universal definition for SME's. Different countries and organisation set their guide for defining SMEs. However, some of the common features used to describe SMEs in Ghana are the number of employees, sales values and size of capital, as well as turnover (Eyiah and Cook 2003). The World Bank considers SMEs as those enterprises with a maximum of 300 employees, \$15 million in annual revenue and \$15 million in assets and the Inter-American Development Bank, on the other hand, describes SMEs as having maximum of 100 employees and less than \$ 100 employees and less than \$

3million in revenue (Dalberg, 2011). Small and medium-sized enterprises are increasingly being recognised as productive drivers of economic growth and development for developing countries. Similarly, a study by Mahemba (2011) emphasised that small and medium-sized firms in most economies have historically played an imperative role in the creating jobs, stimulating innovations and new product and thus contribute growth in the economy. In Ghana, the construction industry is directly linked to the economy because Government is the biggest client that has engaged most of the SMEs with projects (Yirenkyi-Fiako and Chileshe 2012). The National Board for Small Scale Industries (NBSSI) (1996) define Small and medium Scale Enterprises as those that employ 6-29 persons or have fixed assets (excluding realty) of value \$100,000. The Ghana Statistical Services (GSS) on the other hand considers a firm with up to 9 employees as SMEs (Kayanula and Quartey, 2000). Eyiah and Cook (2003) similarly defined construction SMEs as contractors registered in financial classes 2, 3, and 4.

2.2 Small and medium-sized construction firms

The construction industry is not only a key component of a nation's economy but also a primary feature in the quality of people's lives, and the ability of the government to accomplish many of its policy plan (Bosher *et al.*, 2007). The sector constitutes a cluster of firms that operate under the categories of micro, small, small to medium size and large. The industry sector is dominated by the small and medium-size companies. These SMEs are engaged in construction activities such as altering, erecting, repairing, demolishing, civil engineering works and other similar structure. The work of the SME also embraces assembling and installation on-site prefabricated components, building and engineering services. Dlungwana and Rwelamila, (2004) demonstrated that the construction SMEs undertakes specialist work outsourced by large construction firms through a subcontract arrangement. Definitions of construction SMEs vary from one country to another. Small and medium construction firms do the majority of the actual work in many construction industries but often receive the least attention. The Bolton committee (Bolton, 1971) categorised construction firms with 25 employees as SMEs. The committee also considered market share, management style and level of autonomy in making decisions as some of the broad qualitative characteristics of these SMEs. Ribeiro and Fernandes (2010) acknowledged that construction industry is organisational complex and highly fragmented with a predominance of small and medium size firms. According to Egan (1998), the issues of organisational complexity and fragmentation of the construction industry are well captured in the Egan (1998), and Latham (1994) reports as the primary attributes of poor performance in the construction sector.

2.3 Small and medium size construction firms in Ghana

In Ghana, construction SMEs as well as their counterparts operating in other sectors of the economy, contributes immensely to employment, poverty reduction and income generation (Kisi *et al.*, 2015). The Government of Ghana through the Senchi report (2014) stressed the need for the country to encourage and promote indigenous entrepreneurship as well as providing further steps to support small and medium scale enterprises. Undoubtedly, these enterprises have been recognised as the engines through which the growth objectives and the core strategic intents of firms are achieved (Abor and Quartey 2010). There is lack of accessible data on SMEs in Ghana, but the working available statistics from the Registrar General's

Department (RGD) recommend that 92 percent of companies registered are micro, small and medium enterprises (GOG, 2007)

According to Abor and Quartey (2010) in Ghana, SMEs are now exposed to greater opportunities than ever for expansion and diversification of the sectors. While developed global markets may be shrinking on account of the financial and economic crises prevailing, Ghana's market size is growing, and opportunities within Africa are also beginning to look attractive for SMEs construction contracts in Ghana involve huge sums of financial resources and, as a result, small and medium-sized construction firms must assess credit facility from a financial institution to enable them to execute projects. Abor and Quartey (2010) affirmed that SMEs in Ghana have always not obtained the required support from the concerned Governmental Ministry, Department including the Banks and other financial institutions. This lack of support impedes developing competitiveness among SMEs both locally and globally. According to Tagoe *et al.* (2005), some researchers, business executives and managers of SMEs have attributed the failure of their firms in Ghana and Africa to owner and manager's inability to access credit. Abor and Quartey (2010) further stressed that SMEs face numerous of problems such as limited capital and knowledge, ineffective marketing strategies, low production capacity, lack of capacity to identify new markets, challenges on modernization and expansion, non-availability of highly skilled labour at affordable cost amongst others.

Kayanula and Quartey (2000) cited in Mofokeng (2012) embarked on a study on policy and environment for promotion SME's in Ghana and Malawi and established that small and medium-sized firms are posed with some barriers to growth that include: Weak institutions' capacity, lack of management skills and training, the survival of entrepreneur, oppressive laws and lack of access to appropriate technology. To mitigate these characterised challenges among SME's in Ghana, successive Governments have initiated changes to address the needs of SME's through donor support funds (Abor and Quartey, 2010). Despite the collaborative support funding systems through non-bank financial institutions and traditional banks, assess and capacity gaps continue to exist among SMEs in Ghana (Abor and Quartey, 2010). In addition, Urinyo *et al.* (2004) stressed that there are many challenges to construction development and growth. These include policy regulations, inadequate financial infrastructure, firm regulations, trade regulations, tax regulations, changing government policies, tax rates, corruption, labour regulations, the cost of capital, and keen competition for limited opportunities. Similarly, Appiah-Feninget *et al.* (2008) discovered that in Ghana, the SME's contribution has fallen short of its potential due to lack of effective quality management and coordinated effort to support SME operations by the central government to facilitate growth.

The Government of Ghana as part of its promotion and assistance to the SME sector set-up some institutions such as the Ghana Enterprise Development Commission (GEDC). The commission was mandated to strengthen the SME sector both financially and technically (Kayanula and Quartey 2000). In addition, the Economic Recovery Programme established in as early 1983 has broadened the institutional support for SMEs. Furthermore, Kayanula and Quartey (2000) stressed that the National Board for Small Scale industries (NBSSI) was also established within the Ministry of Industry Science and Technology to collaborate and address the needs of small to medium businesses. In order to enhance the full mandate of NBSSI, an entrepreneurial development programme, intended to provide training and assistance to individuals with entrepreneurial abilities to develop their skills was estimated. The Ghanaian economy also witnessed the establishment of the Ghana Appropriate Technology industry service (GRATIS), which was to supervise the operations of (Intermediate Technology Transfer Unit (ITTU) Kayanula and Quartey

2000). The mandated public agencies to implement and enforced these policies seems to be weak and are not adequately resourced (Kayanula and Quartey 2000). According to Kulemaka *et al.* (2015), most governments have outsourced to the private sector the implementation activities of policies which were previously executed by government departments.

2.4 Definition of growth

The term growth is used in discourse with two different connotations. It sometimes denotes merely increase in an amount such as sales, outputs, etc. Sometimes, growth is used in its primary meaning implying an increase in size or an improvement in quality as a consequence of a process development, biological processes (Penrose, 1980). According to Kirkwood (2009), firm's growth has long been a focus of attention among researchers in entrepreneurship. This is because growth is seen as synonymous with entrepreneurship Sexton (1989) cited in (Kirkwood, 2009). Growth in firmshas however been recognised as a complex process through studies (Baum *et al.*, 2001). Massey *et al.* (2006) supported that firm's growth is not homogenous amongst SME's. As a result, the growth trend can change over time. It can also be measured in the form of qualitative features like market position, quality of the product and goodwill of the customers. In addition, Moreno and Casillas (2007) postulated that the growth of firms vary and may be measured by various levels of sales and employees growth over a particular period. Barringer *et al.*, (2005) further stressed that firm's growth is not an automatic event to happen and as such managers and owners must endeavour to institute schemes and measures that will bring in growth within companies. Gopinath (2012) augmented that firm's growth is defined as an increased in specified attributes such as sales employment or profit between two points in time, and it is an important determinant of firm's performance. It can, therefore,be concluded from this diverging collection of definitions that there is no accepted definition of firm's growth rather, the growth definition is dependent on some determinates from a classification.

2.5 Classification of firm's growth

According to Miriam (2006), firms grow in two ways; by internal expansion (organically) and through integration (inorganically). Growing organicallymeans a firm needs to retain sufficient profits to enable it to purchase new assets, including new technology. Over time, the total value of a firm's assets will rise, which provides collateral to allow the firm to borrow to fund further expansion. Mognetti (2002) as cited in Miriam (2006) affirmed that organic growth is widely referred to as internal procedure where the firm relies primarily on intrinsic skills of individuals and the firm itself to grow from within. This is done by a number of methods such as building increased customer relationships, delivering more value to the client, creating more demand in the markets among others thereby increasing returns of firms (Miriam, 2006); whilst with the second route, to achieve growth inorganically, a firm needs to integrate with other companies.

2.6 Strength in firm's growth

Bradford *et al.* (2000) defined strength in the context of firms as its resources and capabilities that can be used as fundamentals for developing a competitive advantage. Construction SMEs as captured in the

literature facilitate the socio-economic development of a nation. Therefore when there is growth in SMEs, it implies there will be a corresponding growth in the social and economic developments of a country. Growth within firms ensues in order for companies to achieve their objectives including increasing sales, maximising profits or increasing market share. Barringer *et al.*(2005) remarked that regardless of the exact definition of what firms entails, it is often realised that very few companies accomplished growth. The strength of firm's growth in the context of this study refers to the firm's competitive advantage and distinctive competencies this includes strong customer service, positive employees attitudes, excellent stakeholders relations, lower cost in production and high integrity of the staff. The strength of firm's growth is prudent to be explored in order to aid the firm in matching their competencies in the market of jurisdiction. Abor and Quartey (2010) supported that in Ghana, SMEs that are able to identify niche market grow faster and impact their competencies. Similarly, firm's growth strength is as a result of employee's loyalty and maintained culture. Firms growth apart from minimising poverty within an economy, and improving job creation also brings about incremental sales value turnover of a firm and develops a new channel for a product.

2.7 Weakness in firm's growth

Weakness in relation to a firm is defined by Bradford *et al.* (2000) as the absence of certain strengths the firm considers as essential. Despite significant impact of SME growth in Ghana, there are still peculiar weaknesses that hinder SME growth (Abor and Quartey 2010). The weakness of firm's growth also refers to the constraints that impede a firm to growth or what the firm does not do well. These weaknesses in growth among SMEs include weak organisational structure, inadequate training of staff, lack of clear corporate goals, complex levels of reporting system of firm among others. More so, SMEs are notable encountering challenges in assessing finance at the bank due severe as their Also SMEs mostly lacked the peculiarly needed skills to execute a unique section of a project and as a result outsources that part to a subcontractor with the specialised skills (Dlungwana *et al.*, 2012). Ribeiro and Fernandes (2010) similarly stressed that construction SMEs compared with large firms are less competitive; for instance, the SME firms may not be able to size business opportunities due to lack of technical skills, shortage of finance and limited administrative capacities. Local SMEs, on the other hand,lacked technology transfer to utilise the acquired expertise subsequently. Kayanula and Quartey (2000) emphasised that lacked entrepreneurial and business management skills as well as managerial know-how, places significant constraints on SMEs development in Ghana. Similarly, Mofokeng (2012) stressed on some related weaknesses and challenges to growth and performance of SMEs in Ghana, which includes deficiencies in technical and managerial expertise, poorly developed infrastructure, poor business environment and lack of access to credit.

3. Implications of the Study

The implication of this study to the SME sector in the Ghanaian economy is to establish detailed insight of firm's growth. Enough evidence from the study indicates the significance of SME's growth in the most economies including Ghana as captured in literature. This makes the study prudent to be embarked. The growth of firm has also been recognised to have lots of merits both on the macro and micro-economic levels. Every firm is unique and therefore has its constraints in achieving its goals. Therefore, when the strength and weakness of enhancing the growth of a firm are recognised, it will enable achievable and

realistic strategies to be adopted as a guide to increase growth among small and medium-sized construction firms in Ghana.

4. Conclusions

The study explored the strength and weakness of firm's growth among small and medium-sized construction firms in Ghana, by seeking to establish ideas that will facilitate growth among these SMEs. It is clear from the study that literature on SMEs has confirmed that SMEs are considered as the engine of growth for lots of developed and developing countries. This implies that the well-being of most economies in terms of socio-economic development both at macro and micro levels are dependent on SMEs. It was also apparent from the study that the construction sector is characterised globally to be a labour intensive and particularly in Ghana, the industry is notable for having a low level of entry barriers. This has brought about the ease of springing-up of SMEs and had resulted in the dominance of small and medium-sized construction firms with a low level of managerial structures. Vivid appraisal of literature on the small and medium -sized construction firm was made from existing models on the growth of SMEs in order to ascertain clarity in strength and weakness. The study discovered that the term small and medium-sized firms (SMEs) cover a broad spectrum of definitions and that till date literature has not established any universal definition for SME's. According to Eyiah and Cook (2003), however, some of the common features used to describe SMEs in Ghana are the number of employees, values of sales and size of the capital. As a result, different countries set their guide for SME definition. Growth in firmshas however been recognised as a complex process through studies (Baum *et al.*, 2001).The study demonstrated that according to Miriam (2006), firms grow in two ways; by internal expansion (organically) and through integration (inorganic). In addition conclusions from the study provided an explanatory view of firm's growth in terms of the strength and weakness of small and medium-sized constructionfirms in Ghana. The strength of firm's growth in the context of this study refers to the firm's competitive advantage and distinctive competencies this includes strong customer service, positive employees attitudes, excellent stakeholders relations, lower cost in production and high integrity of the staff. Also, strengths of firm's growth are prudent to be explored in order to aid the firm in matching their competencies in the market of jurisdiction.The weakness of firm's growth refers to the constraints that impede a firm to growth or what the firm does not do well. The further conclusion to the study emphasised that in growth among SMEs include: weak organisational structure, inadequate training of staff, lack of clear corporate goals, complex levels of reporting system of firm among others. Kayanula and Quartey (2000) emphasised that lacked entrepreneurial and business management skills as well as managerial know-how, places significant constraints on SMEs development in Ghana. Similarly,Mofokeng (2012) stressed on some related weaknesses and challenges to growth and performance of SMEs in Ghana, which includes deficiencies in technical and managerial expertise, poorly developed infrastructure, poor business environment and lack of access to credit.

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Sustainable Water Provision for the Urban Poor: Rights-based or Commodity-based Approach?

Busiku Sharlyn Kaunda¹, Priscilla Kachapulula-Mudenda²

Abstract

Water continues to be an increasingly scarce resource in most parts of the developing world; the UN's FAO estimates that by 2025 some 1800 million people will be living in countries/regions with absolute water scarcity. The discussion surrounding water provision as a human right arose from the 1948 Universal Declaration of human rights which brought human rights into the global development discourse. This rights-based approach has been promoted by many NGOs (such as CARE, OXFAM), UN agencies such as UNICEF and donor agencies like CIDA and DFID who acknowledge the important role that access to clean, drinking water plays in the significant reduction in mortalities caused by water-borne diseases. On the other hand, discussion around the commoditization of water stems from the perceived need for water utility companies to function as corporate bodies and thus, employ management systems that incorporate cost-recovery. The adoption of the business management approach by any water utility company changes the water from being regarded as a public good to a market good, accessible to only those who can afford it. This poses a huge problem for the urban poor, who are the majority of the urban population in Zambia. The question that arises then is *how do we ensure sustainable and equitable access to freshwater by the urban poor?* This paper's methodology took a 2-tiered approach of reviewing secondary peer-reviewed literature and undertaking in-depth interviews with key informants in the water sector. It includes the Zambian institutional setup in its analysis. Key observations are that, either approach cannot be implemented in isolation of the other. While countries like Bolivia, Ghana and selected areas in South Africa may have made progressive strides in striking the balance between the two approaches, institutional and socio-economic factors need to be thoroughly understood before policy adaptation. It is recommended that, among others, legal instruments supporting water access for the urban poor must be in harmony with actual strategies employed in order to meaningfully address water access issues among vulnerable communities.

Keywords: commodity-based, human rights, sustainability, urban poor, water provision

1. Introduction

The role of cities in meeting some of the basic needs of humanity is increasingly taking centre-stage in nearly every sphere of the development discourse. This is due to the high population density which is characteristic of these areas. The World Cities Report (2016) notes that urban areas are the habitation of about 4 billion people - over half of the world's population. Although the rates of urbanisation vary across

¹Department of Real Estate Studies, Copperbelt University; P. O. Box 21692, Kitwe, Zambia; busikuk@yahoo.com

regions and across continents, trends show that Sub-Saharan Africa (SSA)'s urbanisation rates have risen from an estimated 10 – 15% of the total population in 1950, which translated to about 20 million people then (Hove *et al*, 2013) to nearly 40%, a rate representative of about 346 million people currently living in urban areas (UN-Habitat, 2012). Furthermore, Karekezi and Majoro (2002) contend that urbanisation rates for most countries in SSA are almost twice the national population growth rates - with large urban centres which play a significant role in churning the economic wheels of respective national economies.

While the high population density in urban areas may offer a conducive environment for employment and innovation (Hove *et al*, 2013), literature indicates that rapid urbanisation in developing countries has had adverse repercussions on the provision of major urban services (UN-Habitat, 2006; Bakker *et al*, 2007; Hove *et al*, 2013; Chidya *et al*, 2016; WCR, 2016). Oftentimes this rapid urban growth occurs faster than the response of institutions and laid-out planning procedures aimed at addressing the growth; this, coupled with other socioeconomic issues are what Luhar (2014) argues to be the driving factors towards the development of slums – typically low-income in nature (UN-Habitat, 2003; Huysman, 2009), often peri-urban (Norström, 2007) and without access to services such as water and sanitation reticulation, housing, transport networks and solid waste management (WCR, 2016). However, this assertion does not overlook the water access challenges experienced by residents in formal, low-income urban areas - problems such as erratic water supply and poorly maintained infrastructure (Chitonge, 2011).

Furthermore, the UN's (2012) assertion that about 40% of all people on the globe without access to potable drinking water live in SSA presents a reasonable correlation between rate of residence in slums and inadequate access to improved drinking water in the SSA region. However, with respect to access to water, the World Cities Report (2016) excludes South Africa from the rest of SSA and notes that it is one of the regions of the world, including North Africa and Latin America that have made progress towards increasing the proportion of urban residents' access to drinking water. Some authors also argue that the statistical data presented above may be underestimated due to the challenges of collecting reliable data in informal settlements (Bakker *et al*, 2007) coupled with the rapid rate of urbanization of most developing countries (UN-Habitat, 2006). It is important to recognize that the current discourse for development has changed since 2000, towards climate change and urbanization which both present growing challenges and risks (WaterAid, 2013) that need urgent attention from the public, private and civil society.

Access to safe drinking water is an essential element of people's survival and development and yet the difficulties associated with accessing it in low-income areas of developing countries increase residents' likelihood of suffering from water-borne diseases, a cause of death for millions (Norström, 2007; Galiani *et al*, 2005; Bond, undated) Zambia is no exception to this. The roots of the current water and sanitation crisis in Zambia can be attributed to poverty, inadequate government funding, inequality and unequal power relationships, and it is exacerbated by social and environmental challenges: accelerating urbanization, climate change, increased pollution and depletion of water resources. In order to address this crisis, the international community has increasingly recognized that access to safe drinking water must be considered within a human rights framework. Galiani *et al* (2005) point out that, while most countries and concerned stakeholders are committed to the provision of safe water to the general public, there is modest consensus among them on how to actually improve water services. The other borne of contention is whether water provision to the urban poor should be subjected to commodification instruments despite the

affordability challenges they may be facing (Bakker, 2007; Harris *et al*, 2013) or be guided and supported by equity measures effected by the government and service providers (WaterAid, 2011).

2. Conceptualisation of Sustainable Water Provision

The World Bank (1996: ix) comprehensively defines water as "...a scarce good with dimensions of economic efficiency, social equity and environmental sustainability", whose parameters are likely to have been adapted from the popular three pillars of sustainable development. Although a discussion on water scarcity is not one of the key issues requiring analysis in this paper, Alatout (2013) presents an in depth debate on the theories and realities of water as a scarce resource and how these perspectives influence water governance nearly everywhere in the world. Bakker (2007) acknowledges the social, economic and ecological facets of water but also asserts that it is also a human right which should be accessed by every person regardless of affordability. This is a crucial factor that has been the subject of debate among many scholars. All societies are dependent on water for survival and thus, its supply must be continual. In view of this, Carter *et al* (1999) contextualize the sustainability of water provision as the continual delivery and consumption of services and the continual servicing of infrastructure and other cost-related matters associated with service-provision. They argue that, in principle, the water service established must continue to adequately function with time through the use of progressive and adaptive delivery methods and further illustrate what they term as the Sustainability Chain. This chain is characterized by four elements which are co-dependent in ensuring water provision sustainability. Firstly, a community which receives a new and safe water source needs to be motivated to continue using it due to perceived benefits such as water-safety, constant supply and ease of accessibility. In addition to motivation, a clearly structured, resource-equipped and trained maintenance organization is an essential factor of water-provision sustainability. The third component of sustainability is ensuring that the established system (whether subsidized or not) is able to recover costs associated with water-provision. Lastly, continuing support has to be provided by concerned stakeholders for water-provision to be sustainable.

Banda (2013) describes water provision as the delivery of water services to urban neighborhoods by an authorized water service-provider. Wena (2000; cited by Abubakar, 2016) further adds that, not only should the water service be guaranteed, but service delivery must include decisions about the water quality and quantity to be delivered to the consumer. With respect to quantities, source, cost and the acceptable duration for the water-service acquisition; the UN-Water Decade Programme on Advocacy and Communication outlined the following service specifications that are now widely accepted.

Table 1: Water Provision Parameters

Service Factor	Specification
Quantity	Between 50 and 100 litres per day per person
Source	The water source has to be within 1000 metres from home
Cost	Water cost should not exceed 3-5% of household income
Duration of service-acquisition	Collection time should not exceed 30 minutes

Source: UNW-DPAC, undated; WaterAid, 2011

Abubakar (2016:44) sheds more light to the service-delivery component of water supply by outlining the critical institutional and infrastructural components of water provision, which are "...infrastructure financing and development, system operation, billing and tariff collection, and system management and maintenance". Water providers in low-income areas in some Sub-Saharan countries including Zambia, comprise commercial utilities (CUs), Local Authorities and Small-Scale Independent Providers (SSIPs) such as NGOs, CBOs, FBOs and small-scale private operators (Chidya *et al.*, 2016). While the infrastructural components of water provision would offer hope to poor households seeking to access it, Bond (undated) points out that 'access' should go beyond the provision of household/communal taps to addressing the actual realities associated with having water continuously flowing through taps to service the urban poor's needs.

2.1 Challenges associated with sustainable water provision to the urban poor

There are a myriad of reasons why providing water to the low-income segments of urban areas has proved to be a challenge. Bakker *et al* (2008) present a concept they refer to as "governance failure", a situation where failure to improve water supply to poor households is attributed not only to national institutions and actual water providers, but also to the urban poor as well, whose means to access potable water may be hampered by economic and socio-cultural factors. Currently, CUs have no deliberate measures aimed at providing water to vulnerable groups in low-income communities such as orphans or child-headed homes, widows, the elderly and physically disabled people (Chitonge, 2011). Furthermore Carter *et al* (1999) and Phiri (2000) document important water supply constraints, summarized in figure 1.

Box 1: Why water supply is not sustained

- Poor households or communities may not be convinced of the need to explore the new, improved water sources.
- The financial obligations which communities are expected to contribute to the initial capital or recurring expenses may be unaffordable, unacceptable or impracticable (for example, monthly cash contributions may be impossible for households whose income flows are unsteady).
- Communities may not feel they "own" the new water infrastructure introduced.
- Misconception that water is a free gift from God and, therefore, ought to be provided without cost.
- Institutions responsible for water provision may be under-resourced and over-stretched, resulting in delayed repairs and maintenance;
- Benefits promised at the commencement of projects may have failed to materialize;
- Relying on voluntary efforts of community members in managing the established system may be risky if commitment wanes.

Source: Carter *et al*, 1999; Phiri, 2000

Figure 1: Reasons for unsustainable water supply

Maryati and Humaira (2015) also note the engineering difficulties of providing water to developing-country peri-urban areas, whose disorderly development makes provision of piped water or the sinking of boreholes a challenge. Affordability is one of the core issues which frustrate most low-income households' ability to acquire water. Dagdeviren (2008) ascertained that about 40% of the total urban population in Zambia would experience affordability problems if the water consumption charge is pegged at 5% of

household incomes. This is a worrisome statistic, particularly if it is associated with Bakker *et al.* (2008) and Chitonge's (2011) disclosures that certain water sources used by the poor such as vendor water and water sourced from neighbours with individual connections are several times more expensive than the CU service charges. Affordability issues are also noted in Chitonge's (2011) study of "low-income households' practices of alternating between safe sources of water when they have money to buy water and unsafe sources, such as wells and rivers, when they do not have the money" (p.15). Other challenges associated with water provision to low-income areas include:

- Cost-recovery challenges; reluctance by CUs to provide water to low-income areas due to low levels of profit anticipated
- Meter mis-readings which may go unqueried
- The requirement to produce security of tenure for peri-urban residents who desire to apply to the CU for installation of an individual household connection
- Low rates of infrastructural financing and development
- Slow progress towards service coverage in low-income areas
- Rising demand for domestic water supply in urban areas
- Erratic water supply

(Chidya *et al.*, 2016; Chitonge, 2011; Bakker *et al.*, 2008)

Bond (undated) notes that although NGOs may supplement developing-country governments' efforts of providing water to the poor, their efforts are flawed with lower standards of service-delivery; poor maintenance of infrastructure; frequent disconnections and; accountability distortions. The next two sections will discuss water provision within a rights based approach and subsequently within the commodity based approach.

3. Rights-Based Approach to Water Provision

The rights-based approach (RBA) involves the general perception that access to water is a human right. It constitutes; access as a legal entitlement of people rather than purely as an economic good; speeding up the achievement of access to basic and improved water sources; reducing inequalities in water provision; empowering vulnerable groups and communities to take part in decision-making processes and lastly monitoring advancement of countries in the fulfillment of this right and holding governments accountable (WaterAid, 2011). In short, the RBA is a progressive realizable framework which gives it an advocacy dimension where the primary focus is on states to fulfil their obligation towards water provision (WaterAid, 2011) by influencing policy formulation in favour of the vulnerable and excluded. However it means that governments should have a vision of how they can fully attain these rights for all and have elaborate national strategies and action plans for implementation (WaterAid, 2011). Viewed differently, it involves translating international standards of water rights into locally established benchmarks to assess gradual improvement and enhance liability. But perhaps the question that arises is what constitutes the government's fulfillment in securing these rights to all? Comment No. 15 of the UN Committee on Economic, Social and Cultural Rights (2002) provides clarity on this matter that ensuring water rights involves making sure that everyone has *sufficient, safe, acceptable, accessible and affordable water for personal and domestic uses*.

Zambia has made efforts towards recognizing water as a human right by becoming a signatory to key international instruments as seen in table 2, and developing localized programmes such as The National Urban water Supply and Sanitation Programme (2011-2030) (VAREN, 2015). This has incrementally increased access to improved water to an estimate of 65% of the population and contributed to the achievement of the MDG target of halving the proportion of people without access to safe drinking water as at 2015 (VAREN, 2015). Also an attempt was made to include the explicit right to water in the constitution through a referendum process on the 11th of August, 2016, however was not successful. This would have given people the constitutional right to demand sufficient, adequate and safe water and ability to hold government liable.

Table 2: Key water-related international declarations/treaties signed by Zambia

Declarations /Treaties	Year
- Zambia signed the UN Programme of Action at the Cairo International Conference on Population and Development which tried to address issues such as infant and maternal mortality.	1994
- Signed the Habitat Agenda of the Second UN Conference on Human Settlements to address sustainable human settlements within an urbanization context.	1996
- As member of the Human Rights Council Adopted Resolution 15/9. A legally binding commitment to the human right to water and sanitation.	2010
- Adopted resolution 16/2, reaffirming the right to safe drinking water and sanitation.	2011
- Zambia co-sponsored General Assembly resolution 68/157 which was the first resolution where all UN Member States affirmed that the human right to safe water and sanitation should be a legally binding International Law.	2013

Source: Varen et al., 2015

The RBA has been open to several interpretations by different international agencies working in the water sector resulting in varying methodologies and practices .An interesting case is the World Bank's claim of championing a RBA through its work on good governance, anti-corruption and privatization in the water sector. But what the bank describes as a RBA is actually a system of tradable permits in water which emphasize profitable use rather than adequate supply for all and this usually favors the middle and high income users (Cornwall and Musembi, 2004).This contrasts with UNICEF's RBA which aims at guaranteeing basic levels of services to all and emphasizing regulation to achieve both efficiency and fairness which the market alone cannot be relied upon to provide. The varied interpretation of a RBA by SIDA, UNDP, DFID, CARE and Action Aid which Cornwall and Musembi (2004) have provided poses a challenge in localising these standards. Also, although this approach encourages empowerment and participation of the grassroots it is sometimes critiqued for being a top down approach as the geopolitical location of the actors spearheading this agenda is normally viewed as neo-colonial/ imperialist development. This rhetoric flirtation with rights in the international development community is seen as just a latest flurry of cosmetic rhetoric with which to sell the same old development.

A distinction is also sometimes drawn between a RBA to national public policy and a RBA to development co-operation and Cornwall and Musembi (2004) recommended that an end to social, economic and political oppression can only be sustainable if it is internally driven and not externally driven because it would be in line with local culture and values. In fact although the RBA is used in the context of development assistance it is not clear whether donor countries position themselves as duty

holders to the realization of water rights or accountable to any negative consequences that may arise. What is clear is that recipient countries should bear duties to its citizens. The Declarations are in harmony with the newly formulated global Sustainable Development Goals (SDGs), particularly Goal 6 which advocates for clean water for all by 2030.

4. Commodity-based Approach to Water Provision

According to Harris *et al* (2013: 112), commodification “...is the process of converting a good or service formerly subject to non-market social rules into one subjected to market rules”. They further state that, although commodification of water has often been associated with private companies’ role in water provision (also known as water privatisation), public entities also have the capability to ‘commodify’ water if they establish water markets or use pricing instruments and other mechanisms similar to those used by the private water sector. Grover (2010), on the other hand, argues that water would be regarded as a commodity if viewed as a good that one can only have if one can afford it. Furthermore, Walsh (2011) states that water commodification may imply three perspectives: the formulation and implementation of a pricing mechanism for municipal water or; the commercialization of water utilities that supply municipal water or; the formation of full-scale water markets where water is sold and bought by commercial entities. All commodification perspectives place significant emphasis on the costs associated with access to water, a matter that has triggered critical debates about the complex effects of attaching a fee to a resource which is a basic right.

Prior to the water reforms of the 1990s, water services in Zambia were largely provided by local authorities who, to a great extent, relied on government grants to sustain the water supply system. This is with the exception of mine townships on the Copperbelt province, which were benefiting from the water domestication efforts of the mining companies that commenced in the 1920s (Senkwe & Guy, 2007). In line with the latter aforementioned understanding of commodification, public water charges, though non-economic, were levied on consumers. Like the rest of the developing countries across the world, the water sector underwent commercialisation or corporatisation with the introduction of neo-liberal reforms from the late 80s. These were marked by strategies such as privatisation, fiscal liberalisation, decentralisation, reduced role of governments and an increased role of the market in service provision (Prasad, 2006; Senkwe & Guy, 2007). The key feature of Zambia’s reforms was the establishment of Commercial Utilities (CUs) whose mandate was to provide water and sewerage services to the urban areas of Zambia (NWASCO, 2015). Neoliberal proponents chiefly pointed to the perceived inefficiencies of public sector in water provision and argued that the introduction of market-based approaches to water supply would:

- Reduce political interference in the decision-making process of water service provision (Chitonge, 2011).
- Result in efficiency gains (Hall & Lobina, 2006; Bakker, 2007; Senkwe & Guy, 2007; Chitonge, 2011)
- Inject investment required for revamping the sector (Hall, Lobina & De la motte, 2005)
- Reduce the financial burden of the state (Chitonge, 2011)
- Minimise degradation and misuse of [water] resources (Anderson and Leal, 2001).

Water-commodification approaches treat water as an economic good (Garcia, 2005; World Bank, 1996, Bond, 2004, Galiani, 2005) and “according to this view, water... can only be properly provided by offering “consumers” services for which they are prepared to pay and by favouring subsidiarity in service organization”(Jaglin, 2002:231). One of the key points of emphasis under this approach is the realities associated with the cost of water provision to urban areas (Senkwe and Guy, 2007).

5. Country Case Studies

5.1 Bolivian case study

In 1997, the World Bank’s denial to renew \$600 million of debt relief unless the government agreed to privatize water led to the privatisation of water in Bolivia. Unfortunately the privatisation incited massive protests within the country because of the increase in tariffs by about 50%. This was seen as a violation of basic human rights as access to water was now conditional on wealth. This led the international community to force Bechtel to decrease its tariffs but eventually Bechtel cancelled its contract and water supply was returned to public control. These protests led to the ushering in of a new president Evo Morales in 2006 because of his advocacy for socialism. A new constitution was then enacted in 2009 under the Morales administration which banned water privatisation on grounds that access to water was a human right. Despite this activism, Bolivia still faces challenges in water provision but it is believed the intersection of civilian activism and government policy will finally produce essential reforms which will confirm water as a human right. Bolivia’s water wars symbolised that a denial of basic human rights such as the commodification of water can provoke mass mobilisation and dramatic social reform. (Achtenberg, 2013).

5.2 South Africa

At the end of the Apartheid era, the Republic of South Africa witnessed high rates of installation of water-taps in an attempt to service communities that had been historically marginalized by the socioeconomically segregative regime (Bond, undated). Since then, the extension of water services to the less-privileged communities has been a zealously debated topic, especially when premised within the right-based and commodity-based approaches to water-provision. Over the years, the country has witnessed high levels of activism in support of the poor in the area of water governance. Relative to other countries in the SSA region, there has been considerable government support towards the water sector, which has resulted in improved rates of water accessibility for the urban poor (World Cities report, 2016). While the human right to water (regardless of affordability) has since been incorporated in the nation’s constitution, several non-government stakeholders have, on different occasions labeled this positive measure as mere rhetoric due to attempts to commodify water through mechanisms such as water prepayment meters (Harvey, 2007). Furthermore, regardless of the right-based strategy of installing taps in less-privileged residential areas, thousands of poor households connected to the municipal water supply still encounter disconnections due to unaffordable service charges. The main lesson learnt from the aforementioned is that legal instruments supporting water access for the urban poor must be in harmony with actual strategies employed in order to meaningfully address water assess issues among vulnerable communities.

5.3 **Ghana**

The aforementioned West-African country has had its share of difficulties associated with water-provision to poor areas, with large rates of informality in cities exacerbating the matter. However, on a positive note, CIGI-AI (2013) observes that the city of Accra has successfully set up an institutional framework which facilitates between water-providers and residents of poor communities in decision-making in issues pertaining to water affordability and access. This is an essential matter to note, particularly due to the fact that access and affordability are the key distinguishing factors between the two approaches. Notwithstanding, there is no evidence which shows that this participatory approach being undertaken in Accra has been extended to other parts of the country. The key lesson learnt is that participation and dialogue are important in resolving stakeholder issues that may arise regardless of which approach is actively being pursued to achieve improved access to water for the urban poor.

6. **Methodology**

It is the aforementioned discourse that prompted an inquiry into the approaches which may be considered in improving the availability of clean drinking water, which would undoubtedly improve quality of life and equity in LIAs. This paper's methodology took a 2-tiered approach of reviewing secondary peer-reviewed literature and undertaking in-depth interviews with key informants in the water sector. Literature reviewed included reports published by different local and international agencies as well as journal articles and books. With respect to in-depth interviews conducted, two institutions were purposively sampled due to their knowledge and experience in water-provision matters in Kitwe district and these are Nkana Water and Sewerage Company (NWSC) and the Kitwe City Council respectively. A total of four interviews were conducted between the periods May – July, 2016. A total of four in-depth interviews with the Technical Manager – NWSC; Former Director – Department for Community, Environmental and Health Services – KCC, Director of Operations – NWSC and the Community Mobilisation Officer-NWSC were conducted between the periods May – July, 2016.

7. **Status of Urban Water Supply Sector in Zambia**

Zambia, like many countries, has endeavoured to adapt and implement programmes towards the achievement of sustainable water provision. This has meant developing laws, policies and instruments directed at sustainability. For instance, the 1990's water reforms that were undertaken led to the development of the 1994 National Water policy which separated WSS functions from water resources management. The Ministry of Energy and Water Development (MEWD) is the lead ministry in charge of the whole water sector and its functionality involves Water Resource Management (WRM) whereas The Ministry of Local Government and Housing (MLGH) is responsible for Water Supply and Sanitation (WSS) including the mobilization of resources to maintain and expand infrastructure and service provision. Under this ministry the National Urban Water Supply and Sanitation Programme (NUWSSP) was established in 2011 and provides government's long term vision for the supply of water to urban and peri-urban areas by 2030. The government department for Infrastructure and Support Services (DISS) is also in charge of co-ordinating and facilitating support for improved WSS service delivery. An independent sector

regulator established in 1997, known as National Water Supply and Sanitation Council (NWASCO) regulates all WSS services. The Devolution Trust Fund (DTF) under NWASCO specifically provides financial support to CUs to enable them reach out to a wider coverage of the vulnerable, poor and growing peri-urban areas. The Zambia Social Investment Fund (ZamSIF) was part of a two phase program that intended to support two objectives outlined in the National Poverty Reduction Strategic Framework & Action Plan (1999-2004) (World Bank, 2008). Apart from these national agencies, donor involvement in the water sector includes bilateral and multilateral donor partners such as; The World Bank, Africa Development Bank, Denmark, The Netherlands, Japan, Ireland, Germany and the United States- which recently contributed \$US 355 million towards the Millennium Challenge project whose aim is to improve water and sanitation infrastructure in Lusaka. These donors have helped to increase sector financing (NWASCO, 2015) as it was estimated that the NUWSSP will require an investment of about \$US 4 billion in order to meet the 2030 demand of achieving 100 % access of the population to clean water which is in line with sustainable water provision (MLGH, 2011).

Besides separating WSS and WRM functions, The 1994 National Water Policy also led to the subsequent enactment of the Water Supply and Sanitation Act of 1997 (USAID, 2015). Under these two instruments, implementation strategies for improving services in the urban WSS sub-sector have been prepared. The policy's overall objective is; '*To promote sustainable water resources development with a view of facilitating an equitable provision of an adequate quantity and quality of water for all competing users at acceptable cost and ensuring security of supply under varying conditions*' (Phiri, 2000). The Water Supply and Sanitation Act also provides for CUs to provide efficient and sustainable water services. The other major legislation that regulates urban water provision is the Water Act which regulates groundwater but is beyond the scope of this study. The National Water Policy (2010) pending adoption will also bring in a new water policy and subsequent regulations. This demonstrates government's political will to improve the quality of life and productivity of people through water provision.

In the process of Zambia trying to domesticate international water related treaties, a number of milestones have been achieved through its sector reforms for instance 11 CUs have been created to provide efficient, reliable and sustainable water services. This has improved water supply coverage to urban and peri urban areas from as low as 45 per cent in 2002 to 74 per cent in 2009 to 90 per cent in 2014 (Zambia Demographic and Health Survey, 2013-2014). CUs have also achieved more local control and improved the quality of services provided although financial viability remains low due to the low cost recovery as a result of the non-revenue water which stands at 50 per cent (USAID, 2015).

Despite the above achievements inadequate provision of investment funds has hampered further improvements as most of the water infrastructure dates back to the 60s and 70s and have since been inadequately maintained and developed resulting in dilapidation and inadequate UWS systems. The sector is heavily reliant on Cooperating Partners (CPs) for investments for instance out of a total \$US 242 million total investments needed for UWSS for the 2009-2010 period, 93% came from CPs against 7% from government (MLGH, 2011). In the period 1997-2007, out of the 2.4% of the total national budget authorized for UWSS expenditure only 0.3 % was spent (MLGH, 2011). According to the ZDHS 2013-2014, diarrhoea continues to be a major cause of death in Zambia especially amongst infants and children below the age of five. The infant mortality rate showed that 1 in every 22 Zambian children died before the

age of 1 whilst under-five mortality rate for the same period indicated 1 in every 13 children did not survive to their fifth birthday (ZDHS 2013-2014). Childhood mortality rates are a useful indicator in monitoring progress towards sustainable water provision and a country's socio-economic development.

Having discussed the above challenges, the water sources in Zambia for the low income and peri-urban areas include improved (piped water, public taps, boreholes, protected wells and springs, bottled water, rainwater) and non-improved sources (Unprotected dug wells and springs, tanker truck with small tank, surface water) (Phiri, 2000). Although there are affordability challenges amongst peri-urban consumers as households in peri-urban areas using public taps (Kiosks) pay substantially more per cubic metre than those with individual house connections, between 900-2,500 ZMK/cubic metres and 1,140-1,650 ZMK/cubic metres respectively (MLGH, 2011). With regards to the distributed water quality, it is still not satisfactory in accordance with the 2005 Water Quality Guidelines even though the Ministry of Health inspects this periodically (MLGH, 2011).

8. Discussion

Several arguments both in favour of and against the perceived benefits of water-commodification have been widely documented. Studies (Jaglin, 2002; Bond, undated) show that the democratic demand for water and the pricing mechanisms attached to institutional channels of service-provision are not always compatible, particularly in regions where the poverty index is high. This is because the issue of affordability seems to be a perpetual thorn in the flesh of the urban poor, whose ability to pay for water services may be below the set service charges.

Senkwe and Guy (2007) point out that, prior to the commercialization of the water sector in Zambia, political interference was rooted in the government's social vision of providing water to all citizens under unrealistic circumstances and by institutions which were vulnerable to political influences. Chitonge (2011) contends that, although political interference in the water sector has not been totally eliminated, the CUs and the country's sole regulator (NWASCO) have achieved credible levels of autonomy. However, the extreme consequence is that the government has almost totally withdrawn fiscal support to the sector, thereby incapacitating the CUs' efforts to provide water to low-income and peri-urban areas. This echoes Senkwe and Guy (2007)'s observation that the current situation in Zambia and many other developing countries is that of a weak political will to serve the water supply needs of the poor. Since the middle-income and high-income segments of society are largely unaffected by the water affordability issues experienced by the poor, Jaglin (2002) argues that one of the resultant effects of reforms and low levels of government participation in the water sector is increased inequalities evidenced by the polarization of urban communities and the worsening of living conditions among the urban poor.

With respect to efficiency gains highlighted above, Hall and Lobina (2006) demonstrate that commercialized water-provision entities are no more efficient in providing water to low-income communities than public entities, thus repudiating claims in favour of efficiency gains. They further argue that real efficiency gains are dependent on how well the water-provision system is structured and managed, not necessarily on who (public or private) provides the water. On a positive note, the establishment of CUs

and the DTF have resulted in significant infrastructural gains across the country (NWASCO, 2015), which would not otherwise have been possible if the water sector was exclusively run by the government. This is mainly attributed to the financial support which NWASCO has been receiving from cooperating partners since its establishment. Although Chitonge (2011) rightly observes the reduced burden of the state in water provision, this does not cancel out the government's basic function of ensuring that a basic need such as water is availed especially to low-income and peri-urban residents who often experience water accessibility challenges. From an environmental point of view, Anderson and Leal(2001)'s concern about degradation holds merit especially when one considers the poor sanitation practices in peri-urban areas which contaminate underground water resources. It is also important to point out that environmental degradation in urban areas would not occur if there was an efficient and effective water and sanitation service provision system in place.

Literature reviewed also demonstrates that Zambia's institutional framework for water provision to low-income and peri-urban sections of the country is only as effective as the technical and financial means available to actually provide water to these communities. There is a direct correlation between funding to the DTF and progressive efforts aimed at improving water accessibility to poor communities. Reforms to public services can prove futile in the absence of upfront resources for investment in the restoration and extension of the existing infrastructure (Dagdeviren, 2008: 101).

9. Conclusion

The focus of the paper was to compare the rights based approach to the commodity based approach to ascertain which approach is sustainable for water provision and assess to what extent Zambia has domesticated either approaches. The paper finds that there is a shortage of a developing country model of 'Best Practice' in water provision especially to low income and peri-urban areas and both approaches seem to be coexisting although applied differently in different countries. In places like Bolivia and South Africa unlike Zambia water rights are enshrined in the constitution which has given its citizens the legal right to demand for water services and demonstrated the political will, focus and sustained commitment by the government towards water provision. In Zambia, the bill of rights which included access to freshwater went through a referendum on the 11th of August 2016 however this was not successful. Zambia has made progressive efforts towards the domestication and application of both approaches by embarking on key sector reforms which have involved policy and institutional reforms directed towards sustainable water provision. Although rapid urbanization has outpaced public policy formulation, implementation, infrastructure development and water supply in peri urban and low income areas. An achievement worth noting is Zambia's effort to extend water services to low income and peri-urban areas through the National Urban Water Supply and Sanitation Programme 2011-2030. Although, there is strong evidence that Zambia has slackened in pursuing sustainability issues and the current structure has not been sufficiently mapped to facilitate effective and efficient implementation of water provision. The few strategic institutions to facilitate implementation of water provision are poorly funded and as a result have had minimal impact on the ground. There are still challenges faced in access to water by the urban poor who opt to use unsafe water sources due to affordability challenges and the belief that water is free which has resulted in the prevalence of water related illnesses such as diarrhoea. This implies that the government needs to improve access in marginalized communities such as the low income and peri-urban areas as a

key to addressing inequality, poverty and deprivation. This should be a central focus of development efforts especially with the adoption of the post 2015 MDGs development agenda of SDGs. The paper then concludes that Zambia is torn between the two approaches; ‘market driven’ versus ‘state driven within a human rights context’ as both approaches cannot work in isolation. The rights-based approach is seen to complement the inefficiencies of the commodity-based approach especially with regards to mobilization of funds from cooperating partners towards infrastructure which requires large capital investments and extending service coverage to the unserved and underserved who are usually left out by CUs.

10. Recommendations

The following are recommended:

- Legal instruments supporting water access for the urban poor must be in harmony with actual strategies employed in order to meaningfully address water access issues among vulnerable communities.
- The government’s responsibility to service the DTF should be more defined (either through setting and fulfilling financial targets or setting a public versus donor funding ratio and meeting the set ratio) in order to enhance service accountability to low-income areas, in line with rights-based approaches.
- Participation and dialogue are important in resolving stakeholder issues that may arise regardless of which approach is actively being pursued to achieve improved access to water for the urban poor
- As a way of broadening geographical service-coverage in low-income areas, innovative, contemporary approaches such as GIS-mapping of communities should be embarked on.
- Engage community organizations in sensitizing community-members about the necessity of using and paying for safe water.
- In order to set realistic water tariffs for residents in low-income areas, there is need to structure service fees according to the Ability To Pay (ATP) and Willingness To Pay (WTP) parameters.
- Embark on an evaluation of low-cost multi-stakeholder options of providing potable water to LIAs.

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Performance of Construction Projects in South Africa: Perceptions of Consultants and Contractors

Clinton Aigbavboa¹, Ayodeji Oke², Khosi Mohapeloa³

Abstract

Performance of construction projects is an issue of concern, not only to contractors and professionals, but other stakeholders including clients, project sponsors and end-users. This is due to complexity of construction process, innovation in the use of raw materials and machinery, new construction management techniques and more importantly, variation in requirement from clients. Thus, this research evaluates factors affecting performance of construction projects from the perspective of consultants and contractors, in order to enhance the quest of the construction industry in contributing positively to the growth of economies. Using quantitative approach, data were collected through close-ended questionnaires administered on a group of learned and experienced consultants and contractors who are based within the study area. From the analysed data, there is a significant difference in the perceptions of consultants and contractors regarding factors affecting performance of construction projects. To consultants, general time factors and conformance to specification are the most important performance indicator for project success while from contractors' view, cost factors including delay in payment from owner to contractor is a major critical success factor. The two groups unilaterally agreed that bringing about the best planning and scheduling technique before and during construction would assist in improving performance of construction projects in the country.

Keywords: construction, key performance indicators (KPIs), performance

1. Introduction

Infrastructural developments are becoming more complex due to increase in size, scope and technology requirement. However, if construction projects are accomplished within contract time, budget and quality to the satisfaction of stakeholders, then the project is considered successful. In their quest to produce projects to the satisfaction of clients, understanding factors to measure project success has been a major concern to construction practitioners, professionals and concerned stakeholders (Parmenter, 2010).

¹Associate Professor; Department of Construction Management and Quantity Surveying; University of Johannesburg; P. O. Box 17011, Doornfontein 2028, South Africa; caigbavboa@uj.co.za.

²Post-Doctoral Research Fellow; Department of Construction Management and Quantity Surveying; University of Johannesburg; P. O. Box 17011, Doornfontein 2028, South Africa; emayok@gmail.com.

³Graduate Student; Department of Construction Management and Quantity Surveying; University of Johannesburg; P. O. Box 17011, Doornfontein 2028, South Africa; kakanyof@gmail.com.

Organisations around the world are failing in their expected performance and project delivery, whether they are operating as multinationals, government parastatals or agencies, or small local entities.

Performance management is a complex holistic system that arose out of a combination of performance appraisals and measurement systems (Furnham, 2004). With this holistic approach, performance management enhances effective measurement systems that enable executives and stakeholders to take a comprehensive view of the entire system. More so, with the integrated perspective provided by strategic measurement, projects executives and administrators are positioned to understand and forecast how actions taken in one aspect of the system can affect performance of another system. According to Brown and Armstrong (1999), performance management are all the processes involved in a system to improve total performance of organisation or process and it can be measured using the tool called Key Performance Indicators (KPIs). Masilamani (2005) defined KPIs as a set of factors acting as relative measure of the performance of an organization or process. In view of the KPIs, Auma (2014) noted that the construction industry is have underperformed compared to other industries.

Performance of construction projects are affected by various internal and external factors that could lead to the success or failure of such project. However, there are different views to indices for measuring performance of project success depending on the interest of the party in consideration. There are numerous parties involved in construction of projects including clients, owners, sponsors, financiers, clients' representative also known as consultants, statutory bodies, etc. Hence, this study examines perception of two of the major stakeholders, that is, consultants and contractors to factors affecting performance of construction projects.

2. Literature review

Traditionally, performance or success of projects is measured in terms of cost, time and quality. Over the years, due to complexity and changing nature of the various industries and varying demands of clients, attention has shifted to such measures as energy efficiency, stakeholders' satisfaction, projects sustainability, etc.

2.1 Construction project performance

Performance is the degree of achievement of certain milestone, effort or undertaking depending on the prescribed and planned goals or objectives that formed the project parameters (Chitkara, 2005). In the current construction industry that is highly competitive and characterised by uncertain business environment, clients of construction projects, who are the major stakeholder, are demanding timely delivery of their project (Costa *et al.*, 2004). This is related to early confirmation of design, early start of construction projects, certainty of performance in terms of acceptable delivery indices specific to the project, value for money for their capital and investment as well as minimal exposure to risk.

Performance of construction projects affects economic development of every countries especially the developing ones (Olatunji, *et al.* 2016). This is as a result of the contribution of construction industry to the economy of a country. Success of any construction project depends mainly on success of approved and acceptable performance indicators for such project. This implies that success or delivery indices to

measure performance vary from one project to the other. Reichelt and Lyneis (1999) remarked that the important structures underlying the dynamics of project performance are work accomplishment structure, effects of feedback on productivity and work quality as well as effects from upstream to downstream phases. More so, Ugwu and Haupt (2007) stated that an adequate awareness and ample knowledge of performance indicators are required for archiving managerial goals of an organisation.

2.2 Factors affecting performance of construction projects

Construction project development may be impaired without a good knowledge and management of the factors influencing the performance of such projects (Akanni, Oke and Akpomiemie, 2015). Dissanayaka and Kumaraswamy (1999) concluded that one of the principal factors for construction industry's poor performance is the inappropriateness of adopted or chosen procurement system. Furthermore, Thomas, Palaneeswaran and Kumaraswamy (2002) identified the main performance criteria of construction projects as financial stability, standard of quality; project duration; health and safety; relationship among clients, consultants, contractors, sub-contractors and other stakeholders; amount of subcontracting; claim and contractual disputes; and management capabilities. In addition, Akogbe, Feng and Zhou (2015) identified project size as a key project performance factor.

2.2.1 Cost performance

According to Mbamali, Aiyetan and Kehinde (2005) a project is successful when it is completed within budgeted and planned cost, specified quality, stipulated time and delivered safely to the satisfaction of clients and other stakeholders. Msani (2011) stated that setting up cost objectives and indicators is driven mainly by the process and individuals involved in the process. The level of experience, skills, training, knowledge and expertise possessed by project team members shouldered with the responsibility of costing is a major factor for the process. The cost also depends on the process adopted at arriving at the cost and procedure that will be used to execute the project. For instance, transporting raw materials from source by railway carriages or trucks would influence the cost of such materials, and thereby, affect overall cost of the project.

2.2.2 Time performance

Jouini *et al.* (2004) stated that managing time in the procurement, engineering and construction of projects is a key competing factor among innovative firms. It is believed that customers who consider time as a valuable performance indicator and resource will be keen on timely delivery of their projects and sometimes, their demand influence contractors to improve their time performance. Walker and Shen (2002) found that time performance of construction projects is directly proportional to design team performance. Moreso, Aiyetan (2010) emphasized that where there are challenges in getting to the site, as a result of bad roads, narrowness of the road or long distances between the storage and usage point, construction speed are likely be negatively affected. According to Toor and Ogunlana (2008), this eventually causes delays in completion of construction projects.

According to Yakubu and Sun (2009), change in design at various times is the most influential factor inhibiting timely delivery of construction projects in the United Kingdom. Proverb and Holt (2000) observed that construction methods adopted for the procurement of a project significantly affect construction time performance. More so, Koushki and Kartam (2004) concluded that projects experience

delays due to late delivery of materials, late selection and approval, type of construction materials and their availability at either local or international market.

2.2.3 Quality performance

Quality of a project is influenced by general project characteristics, project participants, contractual arrangements and interactive processes among the participants (Iyer and Jha, 2006). Chan, Scott and Chan (2004) stated that factors affecting quality performance of construction projects are: effectiveness of design team leader and project manager; project complexity, size and scope; nature and competency of client; environmental factor; client's requirement and emphasis on quality, cost and time; project management actions; procurement and contractual method and nature of project.

Ling *et al* (2009) submitted that important practices for quality management are to control the quality of contract document, quality of response to perceived variations and extent of changes to signed contract. According to Aiyetan (2010), planning factors to be considered for project quality management are analysis of construction methods; analysis of materials and general resource movement to and within site; analysis of work and activities sequencing to achieve and maintain workflow; monitoring and updating of plans to reflect work status; responding to problems and taking advantage of present opportunities; effective coordination of project resources, and development of appropriate and effective organisational structure to maintain workflow.

2.2.4 Health and safety performance

Most of the factors affecting cost, time and quality performance of projects were found to affect other measures of performance such as sustainability, health and safety, satisfaction, etc. Mc Donald and Hrymak (2002) investigated the factors that influence safety behaviour and compliance with safety requirements on construction sites. It was revealed that the most significant safety compliance factor is the presence or absence of a safety representative for the project. The presence of this representative is strongly related to the effectiveness of response to audits and reported hazards on construction sites. This pattern of relationships suggests that presence of safety representatives affect project health and safety performance.

3. Research Methodology

Qualitative research approach was adopted for the study due to the nature of the research. Survey method was adopted to collect information from respondents through distribution of close-ended questionnaires. The target population was contractors and professionals acting as consultants or clients' representatives. These include architects, quantity surveyors, civil engineers, project managers, construction managers and construction project managers. Using convenient sampling method, questionnaire were designed and administered on 60 of these respondents to gather information about factors affecting the performance of construction projects. Prior to the actual data collection, pilot test was conducted on selected professionals in the construction industry. Base on their comments and observations, adjustments were made to the questionnaire before the final distribution.

Information relevant to the study was provided on the cover letter attached to the questionnaire. It was stated that data supplied will strictly be used for academic purpose. More so, respondents can

complete the instrument at their convenience and also withdraw from the survey at any time. Confidentiality of the respondents was ensured by excluding questions that may reveal their identity. The major questions relating to the study were asked using 5-point Likert scale (5=strongly agree; 4=agree; 3=average/neutral; 2=disagree; and 1=strongly disagree) from which Mean Item Score (MIS) for individual factors for both consultants and contractors were computed. The data were coded and analysed using Statistical Package for Social Science (SPSS 21) software. The MIS was used to evaluate and rank the identified variables in descending order. More so, Spearman' rho was employed to examine significant relationship between the opinions of contractors and consultants concerning factors affecting project performance using SPSS software.

4. Findings

4.1 Background information

Forty-Four questionnaires were retrieved and found worthy of further analysis. For years of experience, 34% reported to have experiences varying between 1 and 5 years, 27% are between 6 and 10 years, 11% are between 16 and 20 years and 9% are 20years and above. On the number of projects respondents have executed in the last five years, 25% executed 1 to 5 projects, 19% executed 6 to 10 projects, 27% executed 11 to 20 projects, 9% executed 21 to 30 projects while 20% executed more than 30 projects. On the worth of projects executed in the last 5 years, none of the respondents were involved in project worth less than R 13million. 36% have executed projects worth between R 13million and R 130 million while the remaining 59% have executed projects worth more than R 130million. Currently, 34% of the professionals are involved in 1 to 5 projects, while 27%, 11%, 14% and 14% are involved in 3 to 4, 5 to 6, 7 to 8 and more than 8 projects respectively. This indicates that the respondents have the necessary knowledge and experience to supply adequate information require for this study.

4.2 Project performance factors

Overall, the general opinions of contractors and consultants in Table 1, indicates that conformance to specification, cash flow of project and planned time for construction projects are the most important factors to measure project performance. Using a benchmark of 4.00 mean score, other important factor are quality assessment system in organization, percentage of orders delivered late, availability of personals with high experience and qualification, delay because of closures and materials shortage and availability of resources as planned through project duration. All the factors have MIS score of above 3.50 indicating that they are all important performance indicators. However, the least important factors were found to be medical fitness, project overtime cost and project design cost.

In order to examine the relationship in the opinions of the two groups of respondents, Spearman' rho was employed. The analysis revealed a correlation coefficient of -0.21 and significance (2-tailed) value of 0.903 indicating that the relationship is not significant at both 5% and 10% level. This implies that there is difference in the opinion of contractors and consultants concerning factors affecting project performance. The general opinions of the two groups are closely related to the opinions of consultants. However, contractors were of the opinion that delays in payment from owner to contractors and delays in claim

approval are the important performance factors with MIS value of above 4.00. The least important factor is project design cost with MIS of 2.80.

Table 1: Performance indicators for construction project performance

Factors	Contractors			Consultants			Average		
	MIS	SD	Rank	MIS	SD	Rank	MIS	SD	Rank
Conformance to specification	3.60	0.71	18	4.46	7.56	1	4.36	8.35	1
Cash flow of project	3.40	0.71	23	4.28	8.26	2	4.18	8.67	2
Planned time for project construction	3.80	1.22	14	4.21	9.93	3	4.16	10.30	3
Quality assessment system in organization	3.20	1.73	30	4.15	10.03	4	4.05	8.04	4
Percentage of orders delivered late	3.60	0.71	17	4.10	7.60	5	4.05	8.67	5
Availability of personals with high experience and qualification	4.00	1.00	6	4.05	8.17	7	4.05	9.73	6
Delay because of closures and materials shortage	3.80	1.22	12	4.05	7.69	6	4.02	7.40	7
Availability of resources as planned through project duration	4.00	1.00	5	4.03	6.65	8	4.02	9.23	8
Time needed to rectify defects variation orders	3.80	1.22	11	4.00	6.38	9	3.98	6.69	9
Material and equipment cost	3.80	1.22	9	4.00	8.47	11	3.98	9.50	10
Project labour cost	3.80	1.22	10	3.97	7.16	14	3.95	7.26	11
Profit rate of project	3.60	1.41	20	3.97	6.06	12	3.93	7.26	12
Escalation of material prices	4.00	1.22	8	3.92	8.11	19	3.93	7.56	13
Liquidity of organization	3.60	1.22	19	3.97	6.76	13	3.93	7.79	14
Cost control system	3.60	1.73	21	3.95	6.72	16	3.91	6.57	15
Quality training/meeting	4.00	1.22	7	3.90	6.38	21	3.91	7.73	16
Quality of equipments	3.00	1.00	34	4.00	7.46	10	3.89	7.01	17
Participation of managerial levels with decision making	3.60	1.73	22	3.90	5.89	20	3.86	6.61	18
Waste rate of materials	3.60	0.71	16	3.90	6.87	22	3.86	7.46	19
Training and development	3.40	0.71	25	3.92	8.02	18	3.84	6.42	20
Market share of organization	3.20	0.71	27	3.92	6.14	17	3.84	8.04	21
Time needed to implement variation orders	4.00	1.00	4	3.82	7.22	26	3.84	8.47	22
Delay in claim approval	4.20	1.73	2	3.79	5.89	28	3.84	8.67	23
Delay in payment from owner to contractor	4.20	1.00	1	3.71	6.10	33	3.82	6.42	24
Site preparation time	3.00	0.00	31	3.87	6.26	23	3.77	6.76	25
Appointment of health and safety officers or managers	3.00	1.00	33	3.95	6.69	15	3.77	7.50	26
Regular project budget update	3.20	1.73	29	3.82	6.87	24	3.75	6.30	27
Regular visits of the Health and Safety officer	3.40	1.00	26	3.79	5.85	27	3.75	6.69	28
Cost of rework	4.00	1.00	3	3.72	5.50	32	3.75	7.98	29
Cost of variation orders	3.40	0.71	24	3.79	6.94	29	3.75	8.79	30
Regular toolbox talk meetings onsite	3.00	1.00	32	3.82	7.22	25	3.73	7.46	31
Overhead percentage of project	3.20	1.00	28	3.77	5.36	30	3.70	8.59	32
Project design cost	2.80	1.73	35	3.77	7.26	31	3.66	6.14	33
Project overtime cost	3.80	1.22	13	3.62	5.40	34	3.64	6.38	34
Medical fitness	3.80	1.22	15	3.59	7.85	35	3.61	8.17	35

4.3 Performance improvement strategies

For improvement in the performance of construction projects, several measures were analysed. These measures include project planning and scheduling; meeting for monitoring, updating and controlling of project progress; request for sub-contractors to submit activity schedule; provision of incentives for workers' motivation; presence of quantity surveyors in project team; safety meetings; and site visit by safety officers.

As for project planning and scheduling, 64% use the bar or Gantt chart, 16% use the line of balance method, 18% use the network method and 2% use other methods. However, on frequency of project team meeting for discussion of monitoring, updating and controlling progress of work, 86% meet weekly, 11% daily and only 2% meet monthly, this shows that most meetings to monitor progress and implement necessary measures to enhance performance are undertaken weekly. Most construction firms require sub-contractors or suppliers to submit their detail activity schedule in advance in order to adjust their actual schedule weekly (82%), 9% require it daily while the remaining 9% never ask for it. This indicates that most respondents require their sub-contractors or suppliers to submit their activity schedule weekly but the challenge lies with the 9% that never request for the document.

The most adopted incentives and reward packages to motivate personnel in the quest to enhance project performance are through bonuses (39%), 37% increase salaries while 23% reduce the knock-off time. 80% of project teams organises meetings for safety issues weekly, 11% organise the meeting monthly while 9% organise it daily. More so, 80% of the projects are always visited by safety officer while 18% and 2% are visited often and sometimes. About 75% of project team always have a quantity surveyor who is responsible for dealing with cost control of construction projects. However, 14%, 5%, 5% and 2% often, sometimes, rarely and never observes this practice respectively.

5. Discussion of Findings

Conformance to specification is the most important factor for measuring performance of construction projects followed by cash flow of the project. This is supported by Shaban (2008) where it was stated that construction professionals such as contractors and consultants are averagely satisfied with performance of their project due mainly to non-conformance to specification. It is therefore necessary for construction professionals to devote more attention to enforcement of specification for construction projects in their quest for improved performance of construction projects. Another factor affecting project performance of construction projects is cashflow, which is related to cost planning, control and management. Oladinnrin, *et al* (2016) noted that healthcare projects are abandoned due to lack of proper cost planning by contractors.

Planned time for construction projects and quality assessment system were also indicated as important factors. In support, Shaban (2008) observed that if planned time is not implemented appropriately, the project will suffer from delays and disputes between the owner and other parties. More so, Akogbe, *et al.* (2015) noted that most of the problems in construction are related to planning issues. From contractors view, financial issues relating to payment and claims are major factors. In agreement, Sweis *et al.* (2014) noted that contractors' top three project performance indicators are too many change orders from owners, contractors' financial difficulties and owners' financial constraints

For performance improvement, majority of construction firms adopt Bar Chart for project planning and scheduling. This, according to Alaskini, Wikstrum and Kiiras (2004), is because it is quicker to design and easier to understand. Moreso, formal meeting for monitoring, updating and controlling project progress are mostly done weekly. Navon (2005) noted that such issues are usually discussed at site meetings which are usually organised weekly for most construction projects. About 9% of construction firms rarely require subcontractors to submit detail activity schedule. Against this practice, Thomas and Wentao (2006) noted that reports from sub-contractors and suppliers for the provision of various construction services and materials are necessary to monitor their progress and identify areas for immediate attention or improvement. This will also help the subcontractors and suppliers as Errasti *et al.* (2007) stated that, subcontractors in the infrastructure sector undergo tremendous difficulty in delivering their services to time and cost.

Most of the construction firms supply bonuses and increase salaries to motivate their employees. However, Chan and Kumaraswamy (2002) noted that better training and motivation are major requirements to improve performance of construction projects. Majority of the firms engage the service of quantity surveyors in dealing with cost control. Chan (2009) stated that quantity surveyors can control the cost of projects to stay within the budget and help to achieve the objective of the project. Safety meetings are usually organised monthly and safety officers always visit most construction sites. McDonald & Hrymak (2002) observed that the presence of a site safety representative enhances a higher level of compliance with safety. It was recommended that all sites should have a safety representative and their role and functions should be reinforced as part of the safety management system. In support, El-Nagari, Hosny and Askari (2015) noted that safety training and planning is one the necessary but less utilised factors by contractors.

6. Conclusion and Recommendation

Factors affecting the performance of construction projects are conformance to specification, cash flow of project, planned time for project construction and quality assessment system in organization. Compliance is the most crucial thing in construction and this is where consultants and contractors both need to comprehend original intention of their clients. For contractors, delays in payment and claim approval are basic. It is therefore essential that professionals shouldered with the responsibilities of processing contractors' payment, that is architect and quantity surveyors, improve on document preparation and approval process for prompt payment of contractors. In order to provide value for money for construction clients, owners and financiers, stakeholders in the industry must ensure and improve on the following performance improvement measures: project planning and scheduling; formal meeting of project team to monitor, update and control progress; submission of detail activity schedule by sub-contractors or suppliers; and provision of necessary incentives to motivate workers and thereby improve project performance.

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The Utility of the ‘Step-In’ Clause in the South African Prison Public Private Partnerships

Nthatisi Khatleli¹

Abstract

The recent instability in one of the prisons procured through a Public Private Partnerships (PPP) brought to the spotlight the sustainability of the PPP prisons in South Africa. The sustainability came to the fore because there has always been an opposition to the privatization of such facilities, in a country plagued by high crime rates such as South Africa. This study sought to elicit information from the participants about their experience on the effectiveness of private players in operational management of prisons and whether the existence and invocation of a ‘step-in’ clause is a necessary cushionary intervention in cases of lackadaisical adhesion to contractual stipulations. The contract documents dealing with the intentions of the ‘step-in’ clause in South Africa were perused through. Interviews were held with all major stakeholders and experts in prison PPPs and Mangaung Maximum prison was used as a case study. Since PPPs do not have a long history in the country this case study will provide relevant data for comparative studies and it has a wider application in other sectors as well. The emerging transformational economies which are contemplative about adopting this method will glean a lot of valuable instructive lessons.

Keywords: contractual stipulations, prison PPPs, step-in clause, sustainability, transformational economy

1. Introduction

Although Public Private Partnerships (PPPs) have been utilized for the last fifteen years in South Africa, their adoption in the correctional services was vehemently resisted by some key players both within and without the government. With one of the highest crime rates in the world, and where violent crime is prevalent it was argued that private management of these facilities was bordering on compromising national security. The two pilot projects were procured using design, construct, finance, operate and maintain method. When the government invoked a “step-in” clause in one of the facilities the sustainability of these facilities was brought in the spot light. The Step-in Right is defined as the right of the customer, where the supplier defaults, to intervene in one or more of the supplier’s areas of responsibility (Scottish Government, 2013).

¹Senior Lecturer, Department of Construction Economics and Management, University of the Witwatersrand, Nthatisi.Khatleli@wits.ac.za, Tel No. +27 11 717 7651.

2. Literature Review

Since the introduction of Public Private Partnerships (PPPs) in South Africa in 1997, intensive work has been done to refine and improve PPP legislation so as to promulgate a well-developed and clear procurement model. To a large extent the successful implementation of PPPs depends on the development of sound legislative frameworks, agreements and contracts that clearly define the relationship between government agencies and private parties (Pongsiri, 2002). In South Africa prisons are called Correctional Centres, and the introduction of PPPs in this sector was to overcome overcrowding and funding challenges faced by the Department of Correctional Services (Goyer, 2001). According to Brinkerhoff (2011) the prospective benefits associated with the use of the PPPs in achieving better service delivery than traditional procurement methods continues to seize the attention of policy makers and public administrators within governments. Although PPPs entrust the delivery of certain government services and administrative functions to the private party, the final accountability for efficient management of PPP facilities still resides with the government. Brinkerhoff (2011) argues that government's capacity to successfully participate and oversee the PPP arrangement can be significantly reduced with these arrangements. However, outsourcing the core functions of government facilities according to Tanner (2013) could prove to be problematic.

PPP Correctional Centres in South Africa were implemented 14 years ago prior to the promulgation of PPP legislation. The two pilot Correctional Centres (Mangaung Maximum Prison and KutamaSinthumule) were not based on the proper legislative framework (PPP Unit, 2009). Their implementation was aimed at “alleviating prison overcrowding”, capital costs, rehabilitation and associated risks were to be borne by the private sector (Ramagaga, 2011). Several other governments around the world had implemented this strategy as a way of reacting to the increasing number of offenders and the lack of funding available for new Centres (Goyer, 2001). The former minister of correctional services Ndebele (2013) stated that the inception of PPP Correctional Centres was based on good intentions, however the experiment is failing to meet its desired objectives at the Mangaung Correctional Centre specifically, and this happens when other countries that had initiated similar facilities are beginning to realize that its implementation is flawed.

Although it is indisputable that the management of a PPP Correctional Centre is governed by sound regulatory frameworks, the events around the Mangaung Correctional Centre gave rise to concerns about the ability of a private party to manage a Correctional facility after the invocation of the “step-in” clause” at the facility. The government specifically had to intervene following reports of forcible injection of inmates with antipsychotic medication and using electroshocks to subdue and control them (Hopkins, 2013).The National Treasury (2008) PPP standardized provisions states that a “step-in” by the institution can occur where there is a breach by the private party or when there is no breach by the private party. The ‘step-in’ without breach can be a case where the private party requests the institution to take over the facility temporarily due to difficulty in meeting certain service level outcomes (*ibid*). This “step-in” clause” states, according to Section 112 of the Correctional Services Act Section that (a) “If in the opinion of the National Commissioner in consultation with the Minister:

- The Director (the director referred to is a custodial official appointed by the Contractor, to serve as the head of the PPP Correctional Center) has lost, or is likely to lose, effective control of a public-private partnership Correctional Centre or any part of it and

- If it is necessary, in the interest of safety & security to take control of such Correctional Centre or part of it. He or she may appoint a Temporary Manager to act as the head of that Correctional Centre and may replace custody officials with correctional officials to the extent necessary.”

Although the initial PPP contracts were signed and implemented outside the current legislative frameworks (Sekhonyane, 2003), intensive work has been done to refine and promulgate sound legislation frameworks, however the level of enforcement and effectiveness of monitoring mechanisms to ensure compliance of these frameworks is still ambiguous and unclear. The idea of PPP Correctional Centres in SA has received great skepticism from various stakeholders in the early stages of its conception, due to the financial burden on government funds and signing of the initial contracts without clear knowledge and research of the PPP process, however these concerns remained sidelined in over-optimism of the prospective benefits that would be retrieved from such a project (Nathan, 2003). This research aimed to unearth the substantiveness of these concerns following Mangaung prison debacle.

3. Methodology

The philosophical grounding for this study was based on the interpretivist paradigm, which simply seeks to determine how people make sense of the world they live in and the events that unfold in it. The interpretivist approach implies that reality is multiple and relative. In the sense that there is more than one reality and there are various ways of analysing that reality Carson *et al*, (2001). According to Saunders, Lewis & Thornhill (2003) instead of generalizing and making predictions of causes and effects an interpretivist researcher intends to understand and interpret the motives, implications and reasoning behind the occurrence of a phenomenon within a particular time and context. An exploratory approach, used under qualitative methodology was used to assess the legislative frameworks and monitoring mechanisms within PPP Correctional Centres. One of the main objectives of the study was to determine the significant role played by regulatory frameworks in influencing adherence to monitoring and evaluation procedures stipulated by legislations. Undertaking this research using this approach assisted in identifying other structural deficiencies that hinder the effective implementation of PPP Centres and that of monitoring and evaluation procedures.

Interviews were conducted as with them, the researcher has a certain level of control regarding the question addressed (Creswell, 2003). The limitation of this method is that the respondent may be biased when divulging the information due to the presence of the researcher. Open-ended questions were used to give full understanding of the respondent's impression or experience, also allowing for a degree of flexibility and probing of new issues that may unveil (Knight & Ruddock, 2008). The Thematic Analysis method was used to identify, analyse and report on patterns (themes) within data (Braun & Clarke, 2006). The coded data was then subjected to detailed analysis using a code process, coding refers to organizing data into “chunks” prior to articulating meaning (Rossman& Rallis, 1998, p. 171). The main interviewees constituted individuals responsible for the legislative and monitoring systems for Correctional Centres such as the PPP Unit and civil societies. Perceptions were also obtained from people that have experience in the implementation of PPP contracts in the context of Correctional Centres. The targeted sample for the study was 15 respondents which were divided into 3 categories, namely the authorities responsible for

monitoring and evaluation JICS, National treasury PPP Unit as the regulatory body, and companies that have experience in the implementation of PPP agreements.

4. Findings

Although fifteen people were targeted only 5 interviewees were available for this study. However these are very respectable people in the PPP arena in South Africa. An analysis of the findings for embarking on this approach to correctional services management is given in Table 1.

Table 1: Reasons for Selecting PPP Procurement Method for Correctional Centre

Theme	Findings/Results	Respondents
Reasoning behind PPPs CC in SA	Overcrowding	3
	Budget constraints on the government	3
	Private Sectors has more to offer in terms of risk transfer than the public sector	2
	Political Agenda	2
	PPP procurement process in quicker than the traditional method	1

Although the problem of overcrowding within correctional centres and budgetary constraints necessitated the rollout of new facilities few people appeared to be convinced on whether the private sector could actually deliver. Although the procurement process could drag on sometimes, the construction phase is quicker and could make a very good PR tool, which could be exploited politically. Table 2 below actually demonstrates the issues that were considered to have led to the management challenges during the operation of this facility.

Table 2: Implementation and management of PPP Correctional Centres

Themes	Findings/Results	Respondents
Implementation and management challenges	Weak PPP regulations at the time of implementation	5
	Service Level Specification in place, hence management is contractually driven	3
	No challenges in implementation due to specifications being of high quality	3
	Human relational and communication issues	3
	Challenges not contract related	3
	Lack of understanding of PPP process	2
	Lack of active participation from stakeholders	2
	Change of leadership may have had an effect on management	1

Most of the respondents confirmed that within the contract there was a Service Level Agreement between the public institution and private party, where the private party commits to a certain quality of service and failure to do so may result in penalties which vary in severity depending on the breach. When asked about the challenges in implementing PPP contracts, three respondents agreed that there were no major issues in the implementation of the contract as the specifications were of very high standard, ‘top-quality’ as one respondent described. Even though all the respondents agreed that the PPP regulations were weak at that time of contract signature, this did not have a major impact on the implementation of the contract. Most of the respondents perceived current challenges to be residing with the management of the facilities, mainly due to over-subcontracting of the major responsibilities. Another important issue raised is the poor communication which led to the late reporting of challenges by the consortium to the government. The fact that most consortium members were not operationally involved or updated regularly compromised a robust approach to challenges. So in the absence of all the relevant information and the mounting public pressure most reasonable thing was for the government to invoke the ‘step-in’ clause. However, most of the respondents agreed that terminating the contract is not in the interest of both parties when challenges are encountered in a PPP, as this would imply that the government would still be liable to pay off the bond to the lenders as agreed in the contract. Most of the respondents suggested that the DCS should have control of correctional/custodial services. The other aspects of the service quality were of a high quality that some felt might not be easily emulated by the DCS. The government however argues that the newest government-run facilities are at par with the PPP centres. It was also noted that there is commonality in the operational challenges faced by PPP Correctional Centres and conventional Correctional Centres. The problem with Mangaung was the inexperience of the management level staff, as the turnover was too high.

5. Conclusion

Although there is a general consensus that the private players are delivering consistently better quality in prison management their service comes at a high cost. This makes the pursuance of this approach debatable in a developing country. Although study is continuing the evidence so far demonstrates that the political ramifications of any failure at a correctional facility are high. The following lessons were garnered:

- A “step-in clause” is a very useful mechanism and it was rightly deployed in the case study used for this study.
- Contextual exigencies call for governmental involvement in the custodial management of inmates although other duties could be delivered through the PPP. Thus militating for a tailor-made mix of responsibilities.
- The high cost with administering a correctional PPP facility might not be cost effective in the long run for most jurisdictions.

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Development of a Conceptual Main Contractor-Subcontractor Partnering Model

Tafadzwa Mudzvokorwa¹, Balimu Mwiya², Erastus Mwanaumo³

Abstract

In recent years there has been a substantial number of projects conducted in the Zambian construction industry. Due to the magnitude and complexity of many of these projects, contractors have resorted to subcontracting to share responsibilities and mitigate project risks. The Zambian government has also invigorated the practice of subcontracting in the construction industry as it plays an imperative role in increasing economy viability and development of local contractors. Instead of improving project success, subcontracting can act as a catalyst for poor project outcomes. Though there are many reasons that contribute to problems from subcontracting, a strained relationship between main contractors and subcontractors can be seen as a notorious contributor to poor project outcome. The study aimed at investigating the relationship between main contractors and subcontractors in Zambia and providing a means to improve the relationship. To investigate the relationship, data collection techniques utilised included, literature review and questionnaire surveys. The study established that the relationship between main contractors and subcontractors on most projects in Zambia is poor therefore needing attention. Projects with the strained relationship were experiencing project delays. With the aim of improving the main contractor-subcontractor relationship a non-contractual project partnering model was developed.

Keywords: construction industry, main contractor, subcontractor, partnering, Zambia

1. Introduction

The construction industry contributes significantly towards the economic output of a country (Mirawati *et al.*, 2015). The construction industry in the United Kingdom (UK) contributed £103 billion in economic output which is 6.5 percent of the total output in 2014. It also created 2.1 million jobs which was 6.3 percent of the UK total employment (Rhodes, 2015). In Zambia, the construction industry comprised 9.9 percent of the national Gross Domestic Product (GDP), with a growth rate of 8.9 percent from 2013 (CSO, 2016). A major aspect of projects in the construction industry is subcontracting (Ujene *et al*, 2011). Research has shown that currently up to 90 percent of the work on a construction project is performed by subcontractors (Rajput and Agarwal, 2015). Assigning work to a subcontractor reduces work load and

¹Student, Department of Civil & Environmental Engineering, University of Zambia, Lusaka, Zambia, 10101, PH (+260) 973 688195, Email: tafmud@gmail.com

²Lecturer, Department of Civil & Environmental Engineering, University of Zambia, Lusaka, Zambia, 10101, PH (+260) 965 837400, FAX (+260) 211 290962, Email: balimu.mwiya@unza.zm

³Lecturer, Department of Civil & Environmental Engineering, University of Zambia, Lusaka, Zambia, 10101, PH (+260) 969 561353, FAX (+260) 211 293-792, Email: erastus.mwanaumo@unza.zm

limits the contractors risk exposure (Abdullahi, 2014). Manu *et al.*, (2013) indicated that subcontracting is a means of bargaining down labour cost, encourage quicker completion of tasks, externalise less rewarding and dangerous activities and rapidly meet changing product market demands.

However, with all its benefits, subcontracting can be a risk to construction projects (Yoke-Lian *et al.*, 2013). Kaliba, (2010) identified that subcontracting was causing project schedule overruns in Zambia. A major aspect that contributes to the degree of success or failure of projects which are subcontracted is the relationship between main contractors and subcontractors (Jin *et al.*, 2013; Okunlola, 2015; White & Marasini, 2014). When utilising subcontracting, interface problems can emanate. These problems include the lack of cooperation, limited trust, and ineffective communication leading to an adversarial relationship between the main contractor and subcontractor (Mirawati *et al.*, 2015). However, a better interface between project parties encourages project success or even improves project performance (Vilasini *et al.*, 2012). A good relationship between main and subcontractors is also pivotal to skills transfer from bigger well-established main contractors to transfer knowledge to small local subcontractors (CIBD, 2013).

Partnering is recognised by many researchers as a means to foster the collaborative relationship between parties and improve project performance (Meng, 2012; Hong Kong CIC, 2012). Partnering is a voluntary process by which two or more organizations act as a team to achieve mutually beneficial goals (Nevada Department of Transportation, 2010). However, the integration and building close relationships in construction projects has not been taken seriously (Meng, 2012). In Zambia virtually no literature is available on relationships and partnering in the construction industry. Therefore, this paper addresses this, and contributes to the body of subcontracting knowledge in Zambia by detailing a partnering approach for main contractors and subcontractors. This paper provides a brief literature review on partnering, reports on a study done to confirm the need for a better relationship in the Zambian contraction industry and lastly provides a partnering approach that can be followed in the construction industry.

2. Partnering

There is no definite definition of partnering as it differs from project to project, consisting diverse processes and strategies (Widen *et al.*, 2014). Partnering is generally understood as a commitment by parties involved in a project to work closely or cooperatively, instead of competitively and adversarial (Meng, 2012). It is a long term commitment between two or more organisations to implement a structured collaborative approach that facilitates team work across contractual boundaries for the purposes of achieving specific business objectives (California Department of Transportation Division of Construction, 2013). It involves the building of harmonious working relationships between stakeholders by aligning of shared goals and objectives (Crespin-Mazet *et al.*, 2015). Through this the development of trust and shared goal there is an increase in the likelihood of project success (Skeggs, 2003).

2.1 Types of partnering

Partnering has been categorised in different ways by various researchers. The categorising employed is usually based on the duration of the partnering arrangement. Here partnering can be either project partnering or strategic partnering, where project partnering is based on a single project whilst strategic

partnering is based on a long term commitment (Meng, 2012). However, for this research partnering methods are classified using Hong Kong Construction Industry Council (Hong Kong CIC, 2012) method, where partnering arrangements are categorised based on contractual status. The categories are:

- non-contractual partnering, where the partnering arrangement is not legally binding meaning it does not change the terms of contract or the contractual relationships that exist between the parties. Here the contract can act as an insurance policy should the parties retreat from their roles and responsibilities under the partnering agreement (Skeggs, 2003); and
- contractual partnering, where partnering principles are incorporated into the construction contract. This is done by either amending the existing traditional contract to make it more partnering friendly or adopting a full standard partnering contract (Hong Kong CIC, 2012).

2.2 Benefits of partnering

Previous studies on main contractor-subcontractor relationships, indicates that partnering has a positive impact on project performance, not only with regard to time, cost and quality, but also improvement in profit margins and reducing litigations (Mirawati *et al.*, 2015). Ohio Department of Transportation (2013) noted that partnered are more likely to meet safety, cost, schedule, and quality goals. Research conducted by Du *et al.* (2016) revealed that partnering can directly facilitate organisational capability and risk management, thereby improving project performance.

3. Research Methodology

Literature review was carried out to inform the development of research tools for primary data collection and also to develop the partnering model. The questionnaire survey was used as the principal method to gather information and gain insights into the research area. This is because questionnaires allow the collection of large amounts of data from many respondents in a short period of time and in a relatively cost effective way (Kothari, 2004). The questionnaires were distributed to contractors, subcontractors, clients and clients who are directly involved in the execution of construction projects in Zambia. A total of 80 questionnaires were distributed. Out of the targeted 80 respondents 56 responded, giving a response rate of 70 percent. Data collected were then analysed statistically using Microsoft Excel software in order to execute calculations and provide figures that will clearly portray research results.

4. Findings

The survey focused on determining the nature of the relationship between main contractors and subcontractors in the Zambian construction industry. Figure 1 illustrates the results on how the respondents perceived this relationship. Among all the respondents 7 percent indicated that the relationship was very poor, 34 percent indicated that it was poor, 29 percent indicated that they were not sure, 23 percent indicated that the relationship was good and 7 percent thought it was very good. This indicates that the overall sentiment among the total respondents is that the relationship between main contractors and subcontractors was poor, therefore needing attention.

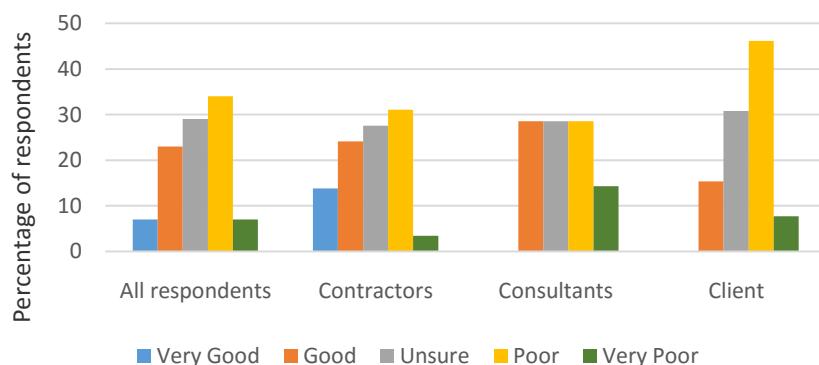


Figure 1: The relationships between main contractors and subcontractors

A question was included in questionnaire to determine the effects of a poor relationship between main contractors and subcontractors on a project. Figure 2 shows the impacts of a poor relationship. The figure indicated that project time overruns in terms of delays, are likely to occur if there are problems in the relationship. These results concur with results adduced by Okunlola, (2015) demonstrating that, projects with interface problems are prone to project time overruns.

The results obtained in this research confirmed the existence of a poor relationship between main contractors and subcontractors in the Zambian construction industry. With the knowledge that this relationship affects project success there is a need of providing a solution. Nevada Department of Transportation (2010) highlighted that partnering provides better risk management that enables an improved ability to look forward, anticipate and avoid problems. Meng, (2012) noted that, partnering increases project performance, reducing the likelihood of project time overruns. As a result, partnering was preferred as a framework that can be utilised in order to enhance the main contractor-subcontractor relationship and improve project success.

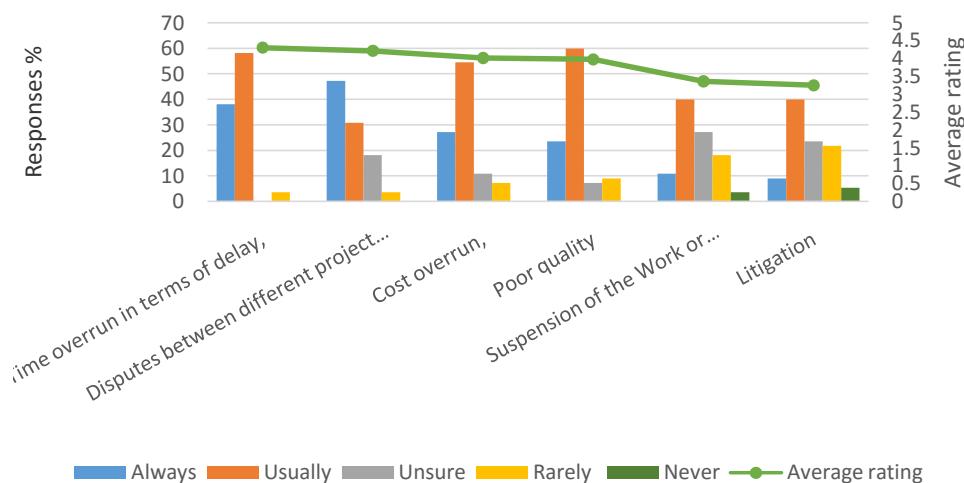


Figure 2: Impact of a poor relationship between main contractors and subcontractors

5. The Non-Contractual Project Partnering Model

For the model developed in this study, a non-contractual project partnering approach was adopted. Non-contractual partnering was selected because partnering is not yet extensively practiced in the Zambia construction industry therefore, project parties are deemed to be unwilling to abandon the usual traditional contract and embark on full partnering contract. Project partnering was chosen because it allows main contractors to partner with different subcontractors in different projects allowing subcontractors to experience and learn partnering from experience.

The non-contractual project partnering approach was adopted with guidelines from The Hong Kong Construction Industry Council, (2012) partnering framework. The Hong Kong Construction Industry Council, (2012) highlighted that following the partnering framework can foster open communication, timely escalation of critical issues for resolution, early involvement, trust and honesty between project parties and lastly help improve project performance. However, additional processes that are recommended in literature were added to the framework. These processes are self-assessment, making the offer to partner and facilitated dispute resolution. The Non-contractual project partnering model is shown in Figure 3.

5.1 Decision to adopt partnering

The first step of the partnering process is the decision to adopt partnering (Hong Kong CIC, 2012). The decision must be backed by commitment from the highest level of the organisation management and is continually communicated and reinforced throughout the organisation. The organisation must be willing and prepared to adopt a culture change from the usual way of conducting work to a more collaborative approach.

5.2 Self-assessment

Before embarking on the search for a facilitator and partners, the organisation needs to assess themselves. This means understanding if the organisation is sufficiently flexible and prepared to respond to a cultural change; if the decision to partner was backed by a satisfactory reason that will not become irrelevant as the project progresses; and if people in the organisation are knowledgeable about partnering. Construction Excellence UK, (2004) advocated the importance of self-assessment in the partnering process as it enables an organisation to understand their readiness for the partnering journey.

5.3 Engagement of facilitator

A partnering facilitator is an independent professional trained to assist in developing an effective partnering process and partnering workshops for the project (Hong Kong CIC, 2012). However, the facilitator is not the leader of the partnering effort. The parties should engage a partnering facilitator that is experienced in partnering and understand the various aspects of partnering, including its potential benefits, requirements and process of partnering. If the project is small and not complex the project can be internally facilitated meaning the facilitator is not used. Here, the facilitation responsibilities are jointly shared by the parties.

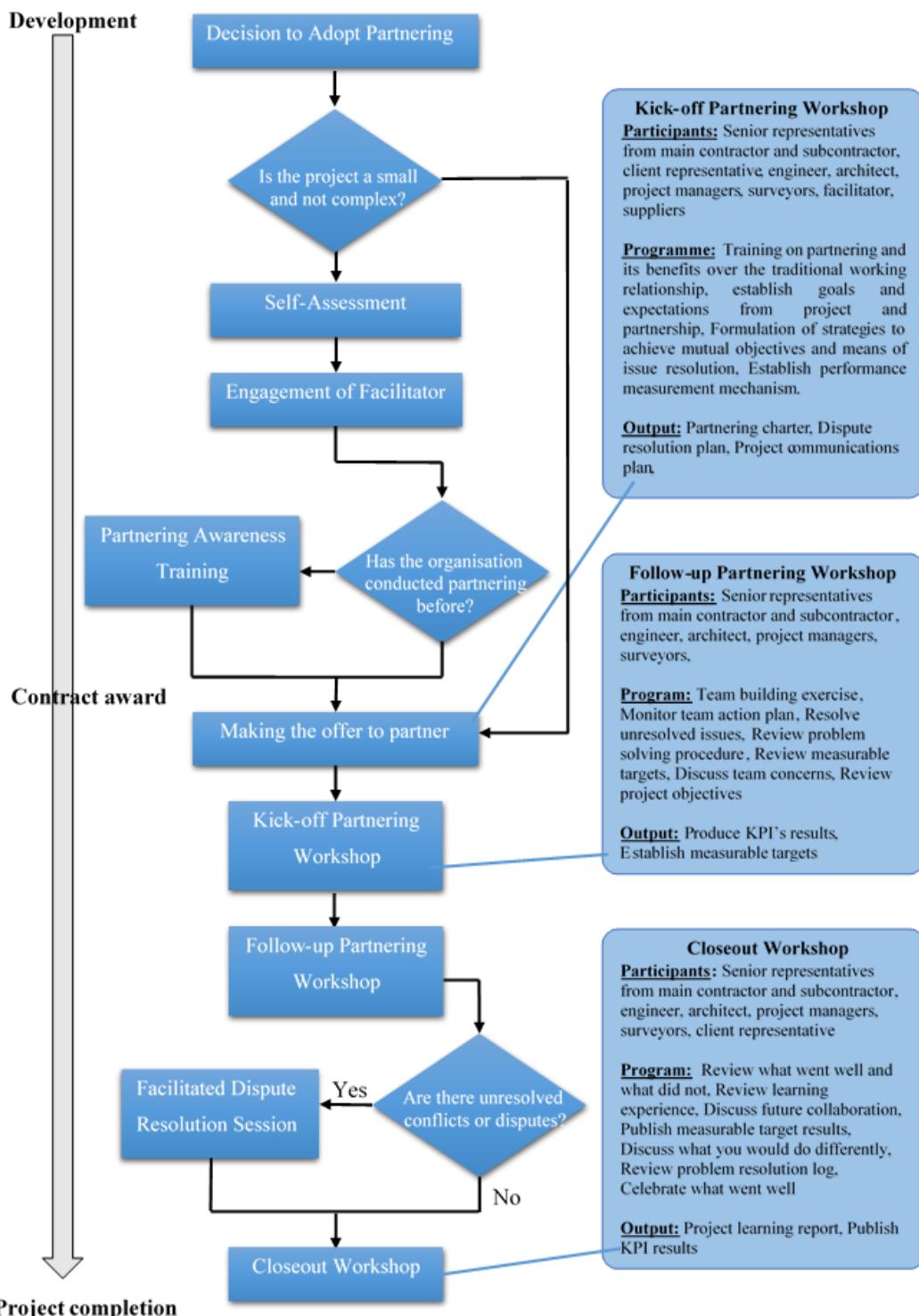


Figure 3: Non-contractual project partnering model

(Developed from partnering Hong Kong CIC, 2012)

5.4 Partnering awareness training

If an organisation is going to embark on a partnering relationship it is important that the staff of that organisation understands what they will be involved in and how to make it successful. An internal training session can be conducted as per organisational requirements. The internal staff should understand the potential benefits of partnering to the project and the organisation and how to practice partnering (Ohio Department of Transportation, 2013). Key project staff including engineers, architects and surveyors should be present. If the organisation has conducted partnering before this will not be necessary since the kick-off partnering workshop will provide an opportunity a brief training.

5.5 Making the offer to partner

This offer will be in the form of a letter of invitation. Before the party can make an offer it is important that they possess important information and understand about the other party's work culture (California Department of Transportation Division of Construction, 2013). Knowing this attributes can help decide if a party is ready for partnering.

5.6 Kick-off partnering workshop

The kick-off workshop is an important step in creating the partnering relationship as it is the first formal step towards partnering. This is where a party officially signals their intention to adopt a partnering approach. The workshop is a platform where parties can know each other, identify project challenges and create ways to overcome them (Washington Department of Transport, 2009). The workshop enables the partnering parties to set expectations, roles, and develop team processes that support the oncoming project. The team processes to be established include: mitigation strategies for project challenges; communication protocols; procedure for decision making and issue resolution; and establish the partnering plan for the project.

5.7 Follow-up partnering workshops

Follow-up partnering workshops are held at various intervals throughout the project life cycle. Follow-up partnering workshops are short hence they can easily be handled in a few hours. These workshops allow the partnering teams to monitor the success of their partnering efforts and also integrate new members (Hong Kong CIC, 2012). Since subcontracting is Zambia is also conducted with the aim of assisting small subcontractors to learn and develop, these sessions provide the opportunity for subcontractors to gain knowledge from main contractors. The frequency of these workshops depends on the size and complexity of the project. However, it is essential that the parties conduct the follow-up workshops at least twice on a project.

5.8 Facilitated dispute resolution session

Facilitated dispute resolution session is conducted with the sole purpose of team repairing when there is a dispute between the partnering parties. During the kick-off partnering workshop a dispute resolution plan is devised to deal with disputes. The plan contains a dispute resolution ladder, where a dispute if unresolved can be raised from one level to another. At the top of the ladder are the two primary parties to the contract, and behind these two are all of the other project stakeholders. When an issue is elevated, a meeting between parties at that level is held to discuss the dispute at hand. However, if the issue cannot be resolved through this method, the issue is scheduled to be discussed when all the parties meet during the follow-up partnering workshop. If the issue is not solved during the workshop a facilitated dispute resolution session is scheduled where a discussion is done with all the parties and a neutral facilitator present (Nevada Department of Transportation, 2010).

5.9 Closeout workshop

The closeout workshop is the final workshop held at the end of the project. It is not a requirement for a professional facilitator to be present for this meeting. The closeout workshop is primarily structured as a means of reflecting and learning (California Department of Transportation Division of Construction, 2013). Therefore, this workshop should create a “lessons learned” and means on how to implement those lessons in future projects. The closeout workshop shop is also conducted to celebrate project successes and completion of the project.

5.10 Continuous improvement

Partnering is not a onetime event however it's a cycle that continues throughout the project (Nevada Department of Transportation, 2010). Procedures should be formulated to continuously assess the performance of the partnership. This can be done using relevant internal or external indicators. In addition, not all stakeholders will participate in the initial workshop for example subcontractors that are contracted after the project commences. Continuous improvement can allow such stakeholders to be identified and progressively integrated into the partnering process, this can be done during the review workshop.

6. Conclusion

Subcontracting has become a major part of construction projects. As a result, the relationship between main contractors and subcontractors now plays a vital role in project success. Strain in this relationship has been a source of disputes and projects not attaining their goals, hence the study was conducted to understand and help improve this relationship. The study found that the relationship between main contractors and subcontractors in the Zambian construction industry is poor on many projects. It was revealed that a bad interface between main contractors and subcontractors was causing project delays.

In order to address the relational problems between main contractors and subcontractors in the construction sector partnering was suggested and a model of processes to be followed was developed. The non-contractual project partnering approach comprised of 10 critical processes. The first step is the company

making an informed decision to adopt partnering. Second process is self-assessment where an organisation assesses its readiness for partnering. Third process is the engagement of a facilitator to facilitate the partnering process. The fourth step is conducting partnering awareness training. The fifth step is making a partnering offer to the partner. The seventh step is conducting a kick-off partnering workshop. The eighth process is conducting follow-up partnering workshops. The last step is conducting the closeout workshop.

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Developing Alternative Roof Tiles from Plastic Waste and Copper Tailings

Happyson Siluonde¹, Franco Muleya²

Abstract

The purpose of this study was to investigate the feasibility of developing a low cost alternative roof tile from a combination of plastic waste and copper tailings. The motivation of this study came from the high cost of roof covering materials that significantly contribute to the high cost of construction. This led to the identification of waste materials in the environment that were widely and readily available for recycling. Plastic waste and tailings (mining waste) were identified as waste materials that could be used in combination to produce roof tiles. The tailings were added to molten plastic and mixed in volumetric ratios of 50%-50%, 65%-35% and 75%-25% plastic to tailings respectively. Plastic types used were High Density Polyethylene (HDP), Low Density Polyethylene (LDP) and Polypropylene (PP) due to their good workability property and availability. The roof tile specimen of 900cm² surface area and 8mm thickness were moulded and tested for water absorption and permeability, compression and flexural strength, impact and fire resistance. All specimens performed well in all tests except for the fire and impact tests. For fire test, flame spread and ignition time was found to be short as no fire resistant additives were added to the mix. The study established that it was feasible to develop a roof covering tile from a combination of plastic waste and copper tailings. An estimate of the probable cost of the developed tiles was made and found to represent up to 81% and 41% cost savings when compared to concrete and steel roof tiles respectively on the market. In addition, the combination of the two waste materials provided a sustainable solution to the disposal of plastic waste and tailings. It was further established that at an estimated that production of 2 million tiles/year, up to 1.2 million tonnes of plastic and 1.4 million tonnes of tailings would be kept out of the waste stream and landfills every year. The findings of this study will contribute to significant savings in costs of roof materials.

Keywords: roof tiles, plastic waste, copper tailings, waste recycling, cost reduction

1. Introduction

Building materials are known to constitute 65-70% of the total building cost according to Ashworth (2004) and Yalley and Kwan (2008), making it an important factor in determining the final building cost. The

¹Graduating student, The Copperbelt University, School of Built Environment, P.O. Box 21692, Kitwe, E mail: www.happysons@yahoo.com

²(Corresponding author): Lecturer, The Copperbelt University, School of Built Environment, P.O. Box 21692, Kitwe. Phone: +260 953815747, E mail: muleyaf@yahoo.co.uk

view of Arvanitis (2013) that the construction market needs more alternative cost effective building solutions cannot be over emphasised if the building costs are to be kept as low as possible. One of the many reasons building materials are expensive in Zambia can be traced to the high importation of both raw materials and products. Those that are manufactured locally still have their raw materials imported at a high cost. This view is also supported by Danso (2013). In addition there is over dependency on traditional building materials by the construction industry which makes it difficult to adopt alternative materials Taiwo and Adeboye (2015).

The aim of this research was to establish if a cheaper alternative roof covering tile based on the concept of appropriate technology could be developed. Plastic waste and copper tailings provided the local and low cost materials that were used to develop an alternative low cost roof tile. It was envisaged that development of the tile would contribute to reducing cost of roof covering material once developed to commercially and technically acceptable levels.

1.1 Problem discussion

The ideal scenario for the building industry would be to have low cost building materials so that the resulting final building cost is subsequently low. In Zambia however, this is not the case. As an example roof covering materialssuch as steel roofing sheets and tiles cost an average K 32/m² (Sun Share, 2015), Concrete tiles cost as much as K75.76/m² (Milan Engineering Construction Company, 2015) whilst synthetic sand coated tiles cost up to K212/m²(Colosui Industries Ltd (2016). This represents considerable large sums of money notwithstanding that associated material cost, transportation costs, which are high due to weight of some of the materials. .Although there are a number of roof covering materials available on the market, they remain largely expensive. Efforts have been made to adopt the concept of appropriate technology in an effort to develop alternative low cost building materials, howeverlittle record can be found of local works relating to alternative roof covering materials. As such the Zambian construction industry lacks low cost alternative roof covering materials which could bring down the cost of building materials.

1.2 Justification of the study

The justification of carrying out a research to develop a local roof covering tile from plastic waste and copper tailings was the significance of the prospect that such a material could provide.Creating such a material could alternatively lower the cost of roof covering materials that in would in turn contribute to lowering the overall cost of building. The need to find cheaper ways of dealing with copper tailing dumps as reported by Piesold (2009) and the need to deal with plastic waste in the environment)was additional justification for carrying out the study. (Zambia Environmental Agency, 2011

1.3 Objectives

The objectives of the study were to:

- a. Develop a roof tile from a combination of plastic waste and copper tailings

- b. Carry out laboratory tests to establish physical and structural properties of the developed tile and compare with existing ones on the market.
- c. Establish a probable cost for the developed tile and compare with existing tiles on the market.

2. Methodology

The study was semi-experimental and quantitative in nature. The non-experimental part involved identification of all necessary materials and ingredients required to develop the roof tile. It was further used for collection of data on cost and properties for selected roof covering materials. The experimental part of the research involved development the roof tiles and carrying out physical and structural tests to determine the properties of the developed tiles. The results were then reported and analysed.

2.1 Experimental procedure

The experimental part of this study involved developing the plastic and copper tailing tile in three sets of volume metric mixes. Tests were carried out to establish the structural and physical characteristics of the developed tiles. The mixes were in the following proportions of volume of mould; mix one (1) 50%-50%, mix two (2) 65%-35%, and mix three (3) 75% - 25% plastic to tailings respectively.

2.2 Preparation of specimen

The following procedure was followed in preparing the tile specimen to be tested: Polypropylene and polyethylene plastic waste were collected from garbage collectors at cost of K0.50/kg. Tailings were collected from tailing dump (TD) 25 Nkana East Kitwe. Plastic waste was shredded into smaller pieces to allow for enable easy melting and washing. The shredded pieces were washed in household detergent and dried at room temperature. Sieve analysis of copper tailings was also done for the purpose of classification according to Laboratory Testing Manual (2000). The density of the aggregates was determined for the purpose of accurate determination of mix volumes. The plastic and copper tailing mix in the appropriate mix proportions was then placed in a steel melting chamber on a locally made furnace at temperatures not less than 300°C to allow the plastic to fully melt. A thermocouple was used to record the temperatures. The mix was drained into the steel mould and left to cool for 10 to 15 minutes and then placed under a load not exceeding 60N for at least 2hrs in normal atmospheric conditions.

2.3 Types of tests done

For the purpose of this research six main tests were carried out on the developed tiles with three specimen tested from each mix proportion as described below:

- **Water absorption test** – This test was done to establish the amount of moisture or water that the tile was prone to absorb.
- **Flexural Strength test** – This test was done to measure the flexibility of the developed tile in all the three different compositions. The tests were done in accordance with **ASTM D 790 -02 (Standard Test for flexural test of concrete tiles)**

- **Compressive Strength Test**– Compressive strength tests were based on **BS1881: Part 116:1983.** This test was done to establish the compressive strength of the tile.
- **Permeability test**.-The test was meant to test if the tiles had permeabilityproperty.
- **Fire resistance test – ASTM Standard E 108-00**, standard test methods for fire tests of Roof coverings materials was used to establish the level of fire resistance.
- **Impact test**– This was done to test the effect of impact on the tiles

3. Literature Review

The problem of high cost of building materials is highlighted in the National Housing Policy of 1996 whose main goal is “to provide adequate affordable housing for all income groups in Zambia” Ministry Of Local Government And Housing (1996).The policy directly addresses the issue of building materials stating that one of the ways to attain the goal is “encouraging the production and use of local and affordable building materials”. This remains a very important objective to address the problem of high cost building materials. Building material cost constituting 65–70 % of total building costs (Yalley and Kwan, 2008). These costs are considered to be amongst the highest amongst most African countries (KPMG, 2013) and as suchthis greatly contribute to the high cost of construction.

On average the common roof covering materials available have both high cost and weight per square meter. Concrete tiles as an example costs as much as K102.00/m²with a weight of 55kg/m² according to Millan Engineering (2015).It can be argued that if a cheaper and lighter roof covering material is ideal for a good roof covering materials then it is essential to consider possible alternatives that strike a balance across the disadvantages and advantages as well as cost and weight of existing materials.Ideally, building materials should be produced from locally available raw materials if costs are to be lowered. Furthermore, raw materials must be abundantly available or renewable in nature, a view supported by the Royal Institute of Chartered Surveyors RICS (2008). It is therefore important to identify and use locally manufactured and available materials in providing building materials especially in the developing world (*ibid*).Low cost building materials for housing have not been sufficiently institutionalized, unlike conventional technology whose dissemination has largely been effected through commercial organizations and the profit mechanism (Magutu 2015).

Action Aid Kenya (AAK) has thus been actively involved in the training of the local communities in production of fibre concrete roofing tiles. Action Aid Kenya’s involvement in low-cost building materials and technologies has been noted as worthy, particularly with respect to the introduction and promotion of ‘Fibre Concrete Roofing’ tiles (FCR) as an alternative roofing material (*ibid*). According to Ugochukwu *et al.* (2014), in Nigeria, like many other African countries including Zambia, a non-harmonized system of construction material ordering and importation is experienced. Imported building materials lack control at the entry point and that they are expensive thereby raising housing cost, capital flight and undermining exchange rates. Insufficient locally produced building materials and lack of advanced materials technology in Nigeria has led to unbridled taste for imported materials. Table 1 shows efforts that have been made to develop alternative roof covering materials including a brief highlight of some advantages and disadvantages of the materials.

Table 1: Properties of alternative roof tiles

Alternative Material	Advantages	Disadvantages	Materials
Fiber and Recycled Plastic Roof Panels (America) (Pinchot, 2005)	Low production cost , Zero manufacturing waste, dimensional stability and Lightweight	High flammability and Source of one of the main materials is plants hence not environmentally sustainable	Natural fibers such as Knead or Jute and waste plastic
Limestone and Plastic Roof Shingle (America) (Bartel, 2012)	Durable, Good thermal properties, Long life cycle and Low production cost	Slightly Heavy 25:75% ratio plastic to limestone Extraction of Limestone not sustainable	Limestone and waste plastic
Bamboo Corrugated Roofing Sheet (India) (Taur and Devi, 2009).	Light weight, Cheap and Easy to install	Short life cycle, High maintenance and Low fire resistance	Bamboo, polymeric resin, and cashew nut shell liquid

4. Experiment Findings and Analysis

For the purpose of this experiment the plastics that were used were Polyethylene Terephthalate (PET), High Density Polyethylene (HDP), Low Density Polyethylene (LDP) and Polypropylene (figure 1). These plastics were found to be much easier to handle. These plastics further resulted in a product with the following combined properties namely; stiffness, strength/toughness, resistance to chemicals and moisture, impermeability to gas, ease of processing, ease of forming, flexibility and ease of sealing, resistance to heat, versatility, and resistance to grease/oil.



Figure 1: Development of tiles: Sampling and sorting, testing of specimen, final product

A total 39 specimen were made, translating into an estimated volume of 0.0042m^3 . This further translated in the use of 12.1kg and 13.2kg of plastics and tailings respectively. From the study alone 12 kilograms of plastic and 13 kilograms of tailings were removed from the waste stream. A roof with an area of 200m^2 using this type and size of tiles can therefore be responsible for keeping up to 700kg of plastic and tailings from the waste stream. Furthermore if production is taken to be at 2 million tiles per year, up to 1.2 tons of plastic and 1.4 metric tons of tailings would be taken out of the waste stream.

4.1 Experimental tests

The following tests were carried out in order to measure the suitability and quality of the developed tile as well as determine and classify the properties of the developed material.

4.1.1 Compression test

Compression tests were carried out for the purpose of classifying strength of the material developed in accordance with BS 881: Part 116 (1983). Mix 1 (50-50% plastic to tailings respectively) was found to have an average compressive strength of 17.6 MPa which represented the strongest mix. Mix 2 (65-35% plastic to tailings respectively) was found to have a strength of 15.3MPa representing the second strongest mix. Mix 3 (75-25% plastic to tailings respectively) exhibited the lowest compressive strength 15.0MPa which did not vary much from that of Mix 2. The amount of tailings in the mix had a bearing on the compressive strength. Specimen with higher quantity of tailings presented higher compressive strength.

4.1.2 Impact test

The impact test was carried out to determine if the produced tile was able to take the impact of a nail being hammered through it. This was done to assess suitability of fixing the tiles by using nails. All specimens presented high levels of brittleness and therefore could not withstand the impact of a nail. A cost effective way of mitigating the failure could be to redesign the mould by incorporating preformed holes in the tiles through which nails or screws could go through to secure the tiles without causing damage to them.

4.1.3 Flexural test

The flexural strength test was carried out to assess the carrying capacity of the tiles in an effort to identify the maximum load that the tile could carry before failure (test standard ASTM D 790-02). The results indicated that the specimen containing a higher percentage of plastic presented high flexural strength as opposed to those with the lesser percentage of plastic. This was because plastic is more flexible and elastic thereby withstanding greater loading reaching the breaking point.

4.1.4 Permeability test

The permeability test was very important to the experiment because it is one of the most important properties for a roof covering material. The tiles specimen were placed in the permeability apparatus and observed after 24hrs to determine if they was water seeping through ((TAS) No. 112-95). All specimens were found to be impermeable to water.

4.1.5 Water absorption test

Water absorption tests were carried out to establish the extent to which the tile specimen absorbed water. This was important to assess the change in weight of the developed tiles in wet conditions. The specimens were dried in an oven for 24 hrs at 40°C and their mass recorded. They were then placed in a water bath for 24hrs and their mass taken after. The readings indicated that the amount of water absorbed after 24hrs was negligible. The greatest change in mass was exhibited by the specimen from Mix 1. Generally, all mixes showed low water absorption rate and as such the mass of the tiles was expected to remain constant even after getting exposed to water.

4.1.6 Fire test

The specimens were tested for ignition and fire spread at temperature of 600°C, which is the average flame temperature for a normal household fire (ASTM E108-00). It was found that the specimen with the mix containing higher content of tailings had a longer ignition time and flame spread. These results were supported by Bartel (2012) who states that the presence of aggregate filler in plastic product helps improve fire resistance properties. It was found that the fire resistance properties of the developed tile were below the proposal to counteract this deficit by adding a tailing coat over the tiles as a way of protecting the tile.

4.2 Probable cost

After considerations of all material, equipment and maintenance the production cost of the tiles was found to be K0.99 which translated to K 15.84/m². The addition of Value Added Tax, profit and office overheads takes the cost to a market price of K19.26. This price represents significant differences when compared to other roof materials especially concrete roof tiles.

4.3 Comparing developed tile and existing concrete tiles

Figure 3 presents tile properties from different manufacturers of concrete roof tiles compared with the developed PT tile. Other roof tiles were generally costly in terms of the cost/m² which on average amounted to K94.50/m² based on the three manufacturers of roof tiles. The average weight per tile for existing roof tiles amounted to 4.4kg per single tile. The expected life span for most building materials including roof tiles is 50 years. Results for the developed Plastic/Tailings (PT) indicate a cost/m² at K19.26, weight/tile at 1.22kg and an expected life of up to 100 years. The plastic and tailing tiles (PT) provides an attractive and good alternative roof covering material that is more affordable in price, light weight and longer life span.

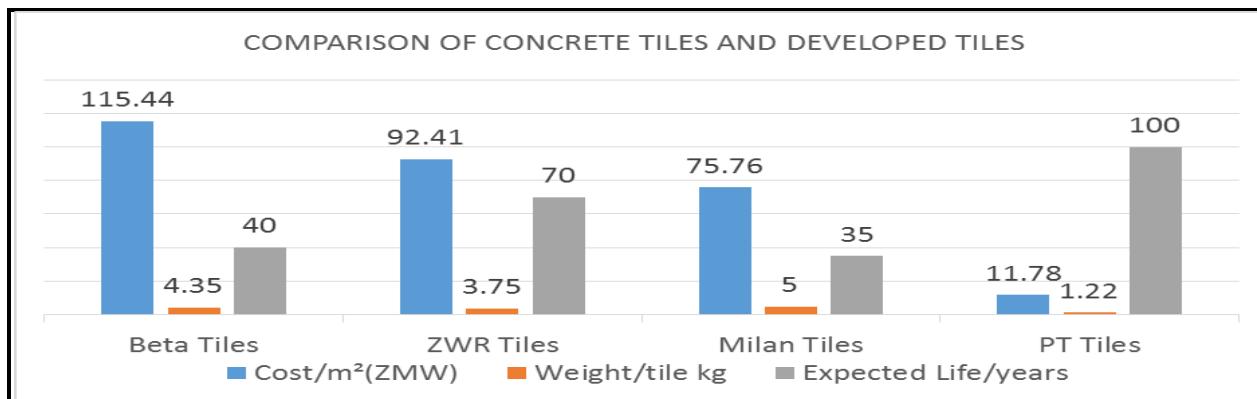


Figure 5: Plastic- Tailings (PT) developed roof tile properties vs other existing roof tiles

5. Conclusion

Following the successful development of the 30cm x30cm plastic and tailing roof tile, the following conclusions were drawn:

- The plastic-tailings roofing tile was successful developed with some key preliminary tests carried out.
- Physical and structural characteristics were established with averages for different mixes as followsFire had 2min ignition time and 1min flame spread. The impact test found the tile to be brittle and had exhibited permeability resistant properties.The water absorption test reflected a 0.01kg difference in dry and wet mass while compression strength was 16Mpa with flexural strength being established at 0.01Mpa.
- Out of the six tests conductedthe fire and impact tests were found to be unsatisfactory. The failure in impact test had a negative effect on the method of fixing the tiles to the structural roof. A proposal was made to modify the mould so that tiles could have pre made drilling holes as a means of securing them to the roof structure. The fire tests results presented a low degree of fire resistance for the developed tile and hence the proposal to have the tiles coated with a protective coating of tailings to increase fire resistance.
- The probable cost of the developed tile was established and found to beK19.26/m² .This cost made the developed tile was 81% cheaper than the concrete tiles and 41% cheaper than steel sheets which constitute the cheapest conventional roof covering material on the market. The unit cost could rise after improving the tile and commerciallyrunning it using more expensive equipment for commercial production.
- The weight, estimated cost, and life expectancy of the developed tile were found to be better than the existing concrete tiles on the market.
- Only steel sheets where found to be lighter (30%) than the developed.
- Lastly thePlastic Tailings (PT) tile is still at research and development stage. Further rigorous tests need to be done at a much larger and complex scale before they can be formally used and floated onto the market. This requires funding and consultation from stakeholders.

6. Recommendations

The following recommendations were drawn based on the conclusions:

- The National Housing Policy emphasises the need of using and developing local lowcost building materials as one of the means of delivering affordable housing. The recommendation therefore is for the National Housing Authority, who according to the National Housing Act of 1970, aresolely responsible for housing delivery, to adopt this product development, improve it and commercialise the plastic and tailing tiles to be used in construction especially for low and medium cost housing.
- ZCCM-IH been an institution seeking alternative ways of managing tailing dumps and therefore, the findings from this research could be of great interest and value.
- Zambia Environmental Management Agency (ZEMA) has reiterated the lack of recycling activity with regards to plastic waste and thus the findings of this research could be a means of having

alternative plastic waste disposal. This could be done in collaboration with local authorities who could recognise the material as acceptable for planning approvals.

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Investigations on Properties of Recycled Aggregate Concrete Made from Different Construction Debris Sources

Ruoyu Jin¹, Yung-Tsang Chen², Ahmed Elamin³, Dariusz Wanatowski⁴, Yun Yu⁵

Abstract

The urbanization movement in developing countries including China has resulted in tremendous construction wastes from building and infrastructure demolition. Construction debris in the form of old concrete, bricks, tiles, and other wastes are currently being handled in multiple ways, such as being sent to landfill, backfilled as road base, or recycled as new aggregate for concrete production. One uncertainty with recycling and reusing the construction debris in the new concrete mixing is the effects of unknown waste sources on concrete properties. This research started from collecting construction debris from several locations (e.g., suburban infrastructure site, urban demolished reinforced concrete buildings, and the newly damaged laboratory concrete specimens). These different debris types were crushed into particles and went through the sieve analysis for the collection of appropriate sizes of coarse aggregate. The properties of recycled aggregates in terms of density, water absorption, and Los Angeles abrasion were tested. The recycled coarse aggregate was used to replace 30% of the natural aggregate by weight as concrete materials. Through the experimental studies following ASTM standards, concrete properties in terms of slump, ultrasonic pulse velocity, and compressive strength were tested and compared among the batches using recycled aggregates from different waste sources. Similar slump and ultrasonic pulse velocity values were found among these batches. The compressive strength of recycled aggregate concrete turned lower in the early age, while the 28-day strength values were more comparable. The research provided insights of how recycled aggregates from various construction waste sources would affect concrete properties based on raw aggregate properties.

Keywords: concrete properties, construction wastes, recycled aggregate, sustainability

1. Introduction

Concrete is identified as one of the most widely consumed construction materials worldwide (Naik, 2008). The major constituents of concrete include cement, fine aggregate, coarse aggregate, and water. Coarse aggregate is a major part of concrete and China consumes 25% of the global construction aggregates exceeding 26 billion tons (Pandurangan *et al.*, 2016). It was estimated by Herrick (1994) that 87% of Portland cement concrete is composed of aggregates. The use of recycled aggregate (RA) could reduce the production of natural aggregate (NA) and decrease landfill disposals (De Brito *et al.*, 2016).

¹Assistant Professor in Building Physics, Department of Architecture and Built Environment, University of Nottingham, Ningbo China; ruoyu.jin@nottingham.edu.cn

Concrete was estimated to account for 50% to 70% of the total construction wastes worldwide (Oikonomou, 2005; Kim and Kim, 2007). The construction waste in China is counted towards 30% to 40% of the total urban waste partly due to short life spans and frequent repairs of buildings caused by poor construction (Kerckhove, 2012). A similar percentage was provided by the World Bank (2012) that construction and demolition waste (i.e., building rubble, concrete and masonry) represented 40% of the total municipal solid waste stream. Developing countries such as China are currently moving towards urbanization with tremendous amount of construction wastes generated every year. China Technological Innovation and Strategy Association on the Industrialization of Construction Waste Resource (2014) estimated that although over 95% of construction wastes could be reused in China, the current reuse rate was only 5%.

One major barrier of using non-conventional aggregate in the construction industry, as identified by Jin *et al.* (2015), was the resulted lower quality of concrete. For example, RA tends to have higher water absorption rates than NA (Rao *et al.*, 2007). Thereafter, RA would decrease concrete workability and demand more mixing water (Rahal, 2005). Recycled aggregate concrete (RAC) usage would result in lower compressive and flexural strengths as well as the modulus of elasticity (Limbachiya *et al.*, 2012). Concrete made with RA might require a higher amount of cement compared to conventional concrete, and therefore is not cost-effective (Etxeberria *et al.*, 2007). One concern from the previous RAC studies is that the sources of RA vary. For example, Çakır and Sofyanlı (2015) used RA of old concrete from building demolition. The RA in Sadati *et al.*'s (2016) study came from demolished pavement. Some other studies such as Limbachiya *et al.* (2012) recruited RA from multiple sources including demolished buildings, laboratory-cast concrete wastes, pavements, and concrete masonry blocks.

The source of old concrete is usually unknown and the suitability of RA for new concrete production needs to be tested (Oikonomou, 2005). The variety of RA from different sources may cause variations in concrete quality (Meyer, 2009). The question of whether different sources of RA would cause varied properties of RAC has not been thoroughly investigated. Specifically, whether single source of RA (e.g., demolished building) or mixed RA from unknown or multiple sources would affect concrete properties requires further studies. This research aims to explore whether different sources of construction wastes would have significantly varied effects on RAC properties. RAs from multiple sources including demolished reinforced concrete building, pavements, and laboratory wastes were collected from multiple locally rural and urban construction debris. Experimental tests were conducted to investigate how these different sources of RAs would affect concrete slump, ultrasonic pulse velocity (UPV) and strength. The test results provided initial insights on whether it would be necessary to categorize different sources of wastes in terms of producing RAC.

2. Methodology

The description of methodology covers three subsections: the production process of RA from different waste sources, the test methods of RA and concrete properties, and results of RA property tests including density, water absorption and Los Angeles (LA) abrasion.

2.1 Recycled aggregate production

Since November 2015, the research team of RAC from the University of Nottingham Ningbo China (UNNC) collected locally available construction debris from multiple sites including demolished masonry building (originally built from 1911 to 1949) in the rural village of Ningbo, demolished old pavement concrete (originally constructed from 1949 to 1980) surrounding the urban area, and demolished debris from reinforced concrete buildings (originally built in 1980s) in the city centre of Ningbo. Extra two sources of recycled debris were also recruited in this study for comparison purpose. They were the recycled construction debris from a local brick and masonry factory utilizing mixed construction wastes, and the laboratory wastes after destructive tests. These waste types were transported to the UNNC construction materials laboratory, initially crushed into smaller sizes before being sent to the jaw crusher to gain the desirable sizes to be used as RA. Finally the sieve shaker was used to divide the crushed RA into multiple standard size ranges (e.g., 4.75 mm to 9.5 mm, 9.5 mm to 12.5 mm, and 12.5 mm to 19 mm, etc). Different size ranges of RAs were stored separated. This study adopted the size range from 4.75 mm (No.4) to 9.5 mm (3/8 inch) as the coarse RA, which was consistent with the NA size. Figure 1 displays some examples of the RAs from different waste sources.



a) RA from laboratory waste b) RA from pavement c) RA from demolished urban buildings d) RA from demolished bricks

Figure 1: Various types of recycled aggregates analysed in this study

2.2 Test method

Initially six different types of RAs were selected for the study including those displayed in Figure 1. Test standards used for testing of both aggregates and concrete properties are listed in Table 1. Type I Portland cement 42.5 R meeting the ASTM C 150/C150M – 16 standard specification was used as the cementitious material in the concrete mixture. Locally available natural sand with a calculated fineness modulus of 1.917 following the procedure described by ASTM C136 /C136M-14 was used in this research. The NA sized from 4.75 mm to 9.5 mm was procured from the local material supplier.

It was found from previous studies of RAC that water-to-cement (w/c) ratio higher than 0.55 would achieve the comparable compressive strength with conventional concrete (Rao, 2005). The maximum replacement rate at 30% of coarse RA to NA was recommended by Limbachiya *et al* (2012). Following

ACI 211.1-91, the mixture design starting from the batch with the w/c ratio at 0.57 and 30% of replacement rate of RA to NA by weight is presented in Table 2.

Table 1: Tests on aggregate and concrete properties

Task	Standard	Laboratory facilities
Sieve analysis of fine and coarse aggregates	ASTM C136/C136M -14	Sieve shaker, weight scale
Relative Density and water absorption of coarse aggregates	ASTM C127-15	Apparatus including container, water tank, and oven
LA abrasion	ASTM C131/C131M-14	Los Angeles testing machine
Concrete mixture design	ACI 211.1-91	Concrete mixer
Making, pouring, and curing concrete	ASTM C 31/C 31 M – 06	Steel cylinder molds sized at 15 cm × 30 cm (6" × 12"), tamping rod.
Slump	ASTM C143/C143M-15a	30-cm high metal Mold, tamping rod, measuring device
Compressive strength	ASTM C39/C39M-16	Compression Testing machine
UPV	ASTM C 597-09	Portable Ultrasonic Non-destructive Digital Indicating Tester (PUNDIT)

Table 2: Mix design for concrete batches with 30% replacement rate of natural aggregate

Design compressive strength on Day 28 (MPa)	w/c ratio	Water (kg/m ³)	Cement (kg/m ³)	NA (kg/m ³)	RA (kg/m ³)	Fine aggregate (kg/m ³)	Design Slump (mm)
27.6	0.57	208	364	561	240	905	25 to 50

2.3 RA properties

2.3.1 Density

Following ASTM C127-15, the dry densities of RAs from multiple waste sources and NA were tested and listed in Table 3. It can be indicated from Table 3 that RAs had slightly lower densities than NA. This could be due to the attached mortar portions to the old concrete and the lower density of waste sources such as brick and tile.

Table 3: Dry densities of RAs and NA

RA source	Red bricks	Tile	Pavement	Building demolition	Laboratory waste	Unknown source	NA
Density (kg/m ³)	2,062	2,239	2,389	2,336	2,374	2,454	2,641

2.3.2 Water absorption

Following ASTM C127-15, the water absorptions of coarse RAs and NA were tested with samples at the same weight. Samples were emerged in water for 24 hours and the full-wet masses were measured. The saturated-surface-dry mass and the oven-dry mass were later measured. The percentage of water absorption was calculated based on Equation (1),

$$Absorption (\%) = [(SSD - OD) / OD] \times 100 \quad (1)$$

where SSD denotes the saturated-surface-dry sample mass, and OD represents the oven dry mass. The result from Equation (1) is the moisture absorbed within the internal voids of the coarse aggregate and cannot be included in the w/c ratio calculation of the concrete mixture. The moisture absorption rate would affect the concrete workability as water added in the concrete mixture could be absorbed by dry RAs. The total moisture of coarse aggregate was calculated following Equation (2),

$$Total moisture (\%) = [(FW - OD) / OD] \times 100 \quad (2)$$

where FW stands for the full-wet mass of RAs or NA. The surface moisture was calculated by subtracting the water absorption in Equation (1) from total moisture in Equation (2).

$$Surface moisture (\%) = Total moisture, \% - Absorption, \% \quad (3)$$

The water absorption, total moisture, and surface moisture of the RAs sized from 4.75 mm to 9.5 mm are listed in Table 4.

Table 4: Water absorption test results of multiple coarse aggregates sized from 4.75 mm to 9.5 mm

RA source	Red bricks	Tile	Pavement	Building demolition	Laboratory waste	Unknown source	NA
Total moisture (%)	30.6	32.7	11.0	11.6	12.2	15.6	6.1
Absorption (%)	19.8	20.0	6.0	6.6	4.8	7.5	0.7
Surface moisture (%)	10.8	12.7	5.0	5.1	7.4	8.1	5.4

Table 4 shows that bricks and tiles have significantly higher water absorption rate compared to other old concrete material-based RAs, with absorption rate around 20%. The RAs from the old concrete sources generally had internal moisture rate from 4.8% to 7.5% after 24-hour emergence in water. As the control group, the NA had much lower water absorption rate of well below 1%.

2.3.3. Los Angeles abrasion percentage

LA abrasion measures aggregate toughness and resistance against crushing. In this study, the MH-II LA abrasion testing machine was used to for the test following ASTM C131 /C131M-14 and Equation (4),

$$LA abrasión (\%) = (G_1 - G_2) / G_1 \times 100 \quad (4)$$

where G_1 denotes the initial mass of the test sample, and G_2 is the remaining mass of aggregates sized over 1.7 mm (No.12) after the abrasion test within the machine.

A higher LA abrasion percentage would mean higher loss of aggregates after the abrasion test within the machine, indicating a lower toughness of the tested aggregate. The test results of RAs and NA are displayed in Figure 2. The two horizontal lines (i.e., Line 1 and Line 2) in Figure 2 represent the LA abrasion percentages of 50% and 40%, which are the maximum permitted values of coarse aggregates for construction in building and road sectors respectively according to ASTM C33/C33M-08. The LA abrasion

percentages of RAs from red bricks and tiles were both close to 60% and over the 50% limit. Therefore, these two types of RAs were initially weeded out due to the practical reason. Other old-concrete based RAs were within or close to the 50% limit, especially the RA from pavement demolition showed even better LA abrasion value than NA. For the comparison purpose, the RA produced from a waste rock sample collected in a local tunnel construction site was also tested of its LA abrasion percentage. The RA from natural rock showed the best LA abrasion performance.

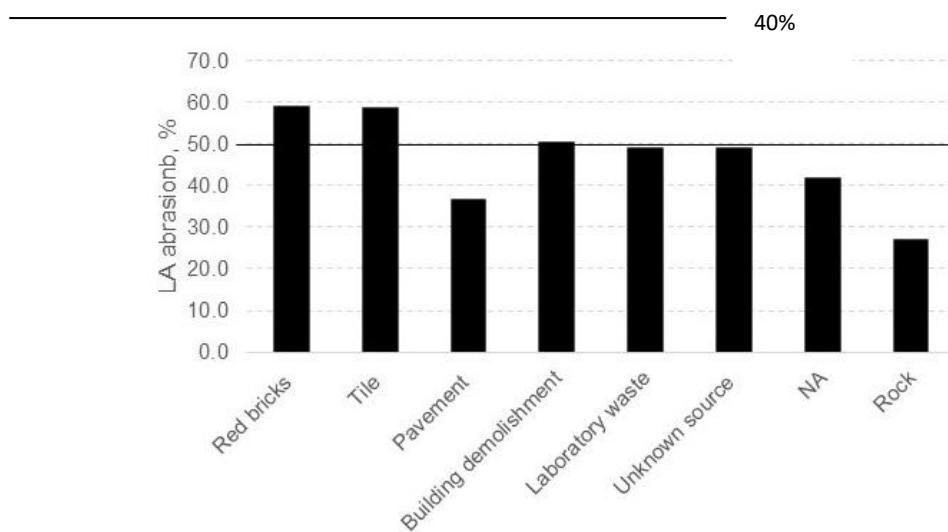


Figure 2: The Los Angeles Abrasion results of RCA and NA

Based on the raw property analysis of these multiple coarse aggregates, pavement, demolished concrete from an urban building, laboratory waste, an unknown source of old concrete were selected as RA sources adopted for this experimental study of RAC. The concrete batch using only NA without RA was recruited as the control group. All the concrete batches were mixed and casted within the laboratory condition with the constant indoor temperature. Slump tests were performed immediately after the mixing. Concrete cylinders were removed from steel molds after 24 to 48 hours for water curing.

3. Findings and Discussion

The properties of RAC using different sources of RA in terms of slump, compressive strength, and UPVs were compared and analysed in this section. Five different types of concrete batches were mixed based on Table 2, four of them adopting 30% replacement rate of each different type of RA to NA, and the control group using only NA as the coarse aggregate.

3.1 Slump

The slump tests were performed according to ASTM C143/C143M-15a. The results are displayed among the five different concrete batches in Figure 3. It can be observed that generally 30% RA replacement rate did not significantly affect fresh concrete slump, though the RA from laboratory waste tended to reduce

the workability more than other batches. It is worth noticing that the mixture design in this batch targeted on low-workability concrete with the design slump below 50 mm (2 inches). The effects of RA source on concrete workability need further investigation to explore other impact factors from both the RA property and the concrete mixture design perspectives. For example, the target design slump.

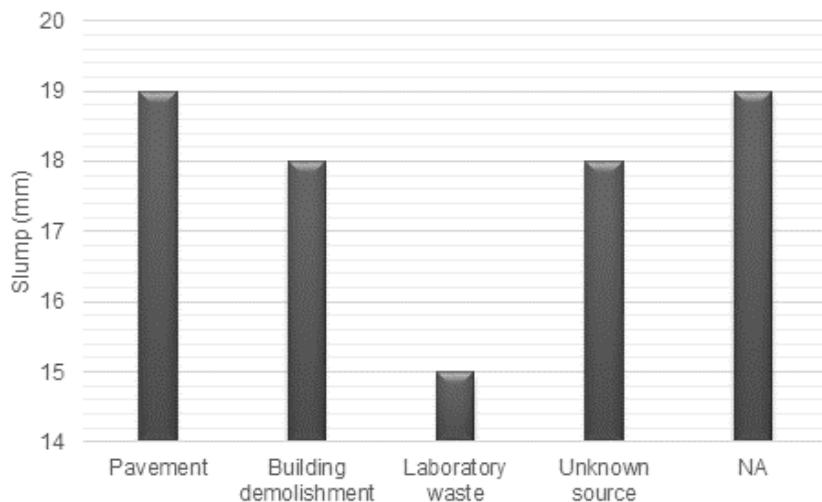


Figure 3: Slump comparison among five different batches

3.2 Ultrasonic pulse velocity (UPV) test

The UPV test is a non-destructive test to check the quality of concrete cylinders. It was performed using the PUNDIT machine shown in Figure 4. A higher value in the test result in terms of velocity (m/s) would indicate a better continuity of the tested cylinders. In contrast, a lower velocity value would infer that the concrete specimen is subject to more cracking.



a) PUNDIT facility



b) UPV test

Figure 4: Portable ultrasonic non-destructive digital indicating tester (PUNDIT)

UPV values of the five different batches of concrete at three different curing ages (i.e., Day 7, Day 14, and Day 28) were obtained. Figure 5 compares the UPV values of these batches. Generally, no significant differences of UPVs were identified from the five different batches. The highest differences of UPV at early ages were found between batches of pavement RA and laboratory waste, at only 3.9% on Day 7 and 5.6% on Day 14. The UPV turned out even closer on Day 28. The standard deviations of the five batches were 63 m/s, 98 m/s, and 25 m/s respectively on Days 7, 14, and 28, within 2% of the mean values of UPV.

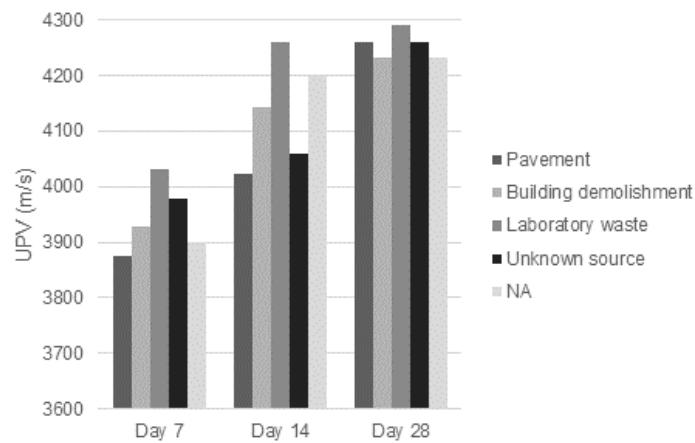


Figure 5: UPV test results of concrete cylinders at three different ages

3.3 Compressive strength

The compressive strength tests for each batch were performed on Day 7, Day 14, and Day 28 using the test machine shown in Figure 6. The compressive strength obtained following ASTM C39/C39M-16 is analyzed in Figure 7 by comparing the values among the five different batches at three different ages. The horizontal line in Figure 7 represents the design strength of C28 (equivalent to 4,000 psi) on Day 28 according to ACI 211.1-91. It is indicated from Figure 7 that RA would have more significant effects on concrete compressive strength at early ages. The concrete batch using 30% replacement rate of laboratory waste, showed 34% lower strength compared to that of the control group on Day 7. Instead, other RAC batches tested on Day 7 did not vary significantly in compressive strength. The strength of other RAC batches excluding the laboratory wastes were generally 25% lower than the control batch on Day 7. However, as the concrete age increased, the difference would decrease between concrete batches using only NA and mixed with 30% of RA. On Day 28, the compressive strength of RAC using other sources of RA other than the laboratory waste turned out close to or even exceeding that of the control group, and close to the design strength at 27.6 MPa (4,000 psi). The only batch showing lower strength was the one adopting RA from the laboratory waste, with its compressive strength 19% lower than the design value. The potential causes of strength difference among different batches were explored from the perspective of RA properties in terms of LA abrasion and water absorption.



Figure 6: Compressive strength test of concrete cylinders

C28: the design compressive strength
on Day 28

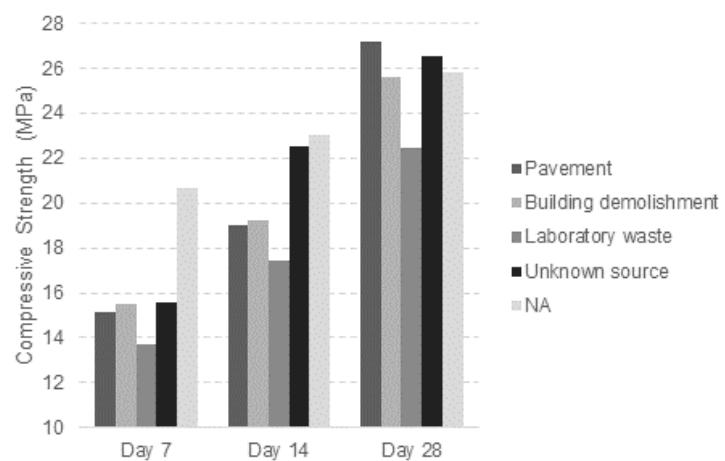


Figure 7: Comparison of compressive strength

Figure 8 measures the linear relationship between RAC compressive strength and the individual RA property. Overall, no significant linear relationships between compressive strength and RA properties were found, except that the compressive strength on Day 7 displayed certain linear relationship with water absorption with the R^2 value at 0.63. This could be explained by the fact that the higher moisture content absorbed by RA internal voids would prevent the further hydration of cement in early age after the initial setting, and hence barricading the strength development of concrete during the early curing age. As concrete age increases, the inferior properties of RA would be minimized of their effects on concrete strength. It is inferred that other RA properties besides water absorption and LA abrasion might have impacts on concrete strength. The concrete batch tested in this study was based on the sole w/c ratio at

0.57 and low workability, when these factors within the concrete mixture design change, the RA effects on the performance of concrete specimen may also vary.

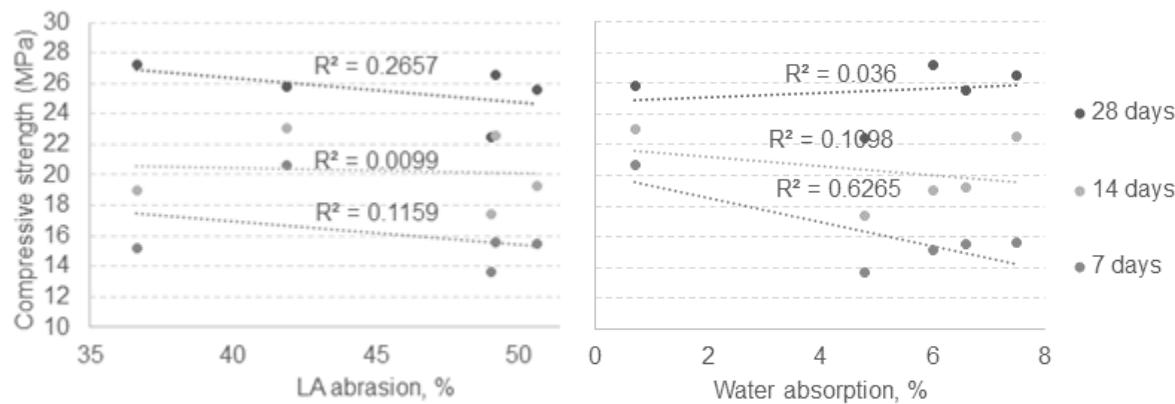


Figure 8: Linear regression analysis between concrete compressive strength and RA properties

4. Conclusion

This study explored how different sources of construction wastes would affect the recycled aggregate concrete properties. Four different sources of concrete-based construction wastes were targeted and collected from multiple local demolition sites in China. Compared to the conventional concrete using natural aggregate, no significantly adverse effects of recycled aggregates were found when replacing 30% of natural aggregate with the recycled content in concrete mixture in terms of slump, ultrasonic pulse velocity, or 28-day compressive strength, except for the recycled aggregate produced from laboratory concrete wastes. The lower strength in early ages of concrete containing recycled content suggested that extra supplementary cementitious materials or chemical admixtures may be used to complement the strength loss. No significant effects of two identified aggregate properties (i.e., water absorption rate and Los Angeles abrasion) on concrete strength were found in this study, indicating that other recycled aggregate properties that might affect concrete performance need to be further explored, for example, the mortar content and the chemical mixture of the recycled aggregate.

The findings from this study provide some initial insights on whether different sources of recycled aggregate would affect concrete properties. Although this study indicates that different sources of recycled aggregates had no significant effect on concrete slump, ultrasonic pulse velocity, and the 28-day compressive strength, in order to gain a more comprehensive understanding of recycled aggregate effects on concrete properties, extra mixture design samples should be explored by involving concrete batches in different w/c ratios and target slump values according to the concrete application. Future study will be expanded to investigate recycled aggregate on durability of concrete and the structural performance of recycled aggregate in reinforced concrete members.

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9

INTEGRATED INFRASTRUCTURE INVESTMENT, PROCUREMENT AND FINANCE

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Assessment of Credit Accessibility to Construction SMEs in the South African Construction Industry using Binary Logistic Regression

Olanrewaju Abdul Balogun¹, Nazeem Ansary², Justus Agumba³

Abstract

Unavailability of credit, especially trade credit, is one of the primary reasons for high failure rate of construction SMEs. This paper empirically investigates the determinants of trade credit to construction small and medium enterprises (SMEs) in the Gauteng Province of South Africa. The data were obtained through questionnaire survey from 179 small and medium contractors who were conveniently sampled in the Gauteng province. Data analysis was done using Statistical Package for the Social Sciences (SPSS) version 22 software. Results indicated that managerial competency, the availability of business plan, relationship with financial institutions, location of the firm, firm size, firm tax number and incorporation are significant determinants of credit accessibility in South Africa. These findings could be useful to construction SMEs in identifying and accessing trade credit from financial institutions.

Keywords: construction SMEs, credit accessibility, Gauteng, logistic regression

1. Introduction

South Africa grieves from high unemployment with an official estimate of approximately 23.5% of the economically active population unemployed (Statistics South Africa Labour Force Survey, 2009). SMEs are therefore expected to be an important vehicle to address the challenges of job creation, sustainable economic growth, equitable distribution of income and the overall stimulation of economic development. In the South African context in the construction industry, small enterprise is defined as having less than 50 employees, having an annual turnover of less than R5million, while medium enterprises have between 51 and 200 employees and less than R20million turnover (National Business Act, 2004). SMEs contribute immensely to the gross domestic product of most countries including South Africa. According to Schumpeter, firms are the vital force behind the progress of capitalism.

The innovative activity of entrepreneurs feeds a creative “destruction process” by causing constant disturbances to an economic system in equilibrium, creating opportunities for economic. According to

¹Postgraduate student/Lecturer, Department of Construction Management and Quantity Surveying, University of Johannesburg, South Africa; lbalogun@uj.ac.za

²Head, Department of Construction Management and Quantity Surveying, University of Johannesburg, South Africa, nansary@uj.ac.za

³SeniorLecturer, Department of Construction Management and Quantity Surveying, University of Johannesburg, South Africa; jagumba@uj.ac.za

Maas and Herrington (2006) SMEs are seen as a significant component of the solution to South Africa's development issues which include poverty, income inequality and unemployment. However, the creation rate of SMEs in South Africa as measured by the total early-stage entrepreneurial activity is one of the lowest in the world. Herrington *et al.* (2009) observe that in 2008, South Africa ranked 23rd out of 43 countries, with a Total Early-Stage Entrepreneurial Activity (TEA) of 7.8% which was below the average rate (10.6%) of all the countries surveyed by global entrepreneurship monitor. Despite their importance to the economy in South Africa, small and medium construction enterprises (SME) sector is described as largely underdeveloped and lacking the managerial and technical skills and sophistication enjoyed by larger well established firms (Department of Public Works, 1999). Martin (2010) opined that lack of knowledge including knowledge of pricing procedures, contractual rights and obligations; law, management techniques and principles as well as technology were a challenge to SMEs. Furthermore, SMEs are more likely to have limited formal education, which is based on a construction craft or trade training such as carpentry, plumbing, electrical installation and bricklaying. This training is probably in the form of learnership (CIDB, 2008). Past studies in South Africa revealed constraints and challenges of capacity and financial resources among SMEs (Fatoki, 2014; Agumba *et al.*, 2005). Grimsholm and Poblete (2011) inferred that SMEs are not able to access finance or credit hence it stifles their growth and capability.

According to FinMark Trust (2006) provides evidence that only 2% of SMEs in South Africa are able to access bank loans/credit and that the use of suppliers' credit to SMEs is virtually non-existent. Balkenhol and Evans-Klock (2002) put the use of trade credit to SMEs in South Africa at only 0.2%. Stiglitz and Weiss (1981) term this occurrence as credit rationing. According to Stiglitz and Weiss (1981) agency problems such as asymmetric information and moral hazards can impact on the availability of credit and hence the capital structure of SMEs. Stiglitz and Weiss termed this phenomenon credit rationing. The core of the argument is that suppliers of finance may choose (due to asymmetric information, adverse credit selection and monitoring problems) to offer an array of interest rates that would leave a significant number of potential borrowers without access to credit. This is a contrast to the situation in most developed countries. Statistics Canada (2007) points out that 45% of SMEs are able to access trade credit.

Trade creditors play a dominant role in the SMEs venture creation process. A study by the Kauffman Foundation (2007) on the capital structure decisions of SMEs in the United States of America finds that contrary to widely held beliefs that SMEs rely heavily on capital from family and friends, external debt financing such as bank credit and trade credit are the more common sources of funding for many new SMEs during their first year of operation. This is consistent with the pecking order theory, which expects firms to first use internal equity before moving to debt and external equity. Availability of debt finance (both from banks and trade creditors) is one of the reasons for high levels of entrepreneurship and relatively low failure rate of SMEs in developed countries.

According to the study done by Hawkins *et al.* (2000) on SMEs and access to credit in South Africa have completely ignored the impact of trade credit and focused mainly on bank credit. Wilson and Summers (2000) focused on the study of SMEs on the issues of credit in Africa and South Africa from the supply-side typically focus on bank credit and more particularly on bank credit. However, banks are not the only principal source of external finance for SMEs. Berger and Udell (2006) note that although trade credit is

extremely important to construction SMEs, it has received much less interest than commercial bank lending which provides only slightly more credit to SMEs.

Trade credit provides a cushion during credit crunches, monetary policy contractions or other shocks that leave financial institutions less willing or less able to provide small business finance. Since only a limited number of SMEs have access to loans from financial institutions, trade credit may often be the best or only available source of external funding for working capital.

Construction SMEs may prefer trade credit financing during the early years when the risk of default is high. Also, trade credit is a substitute to bank credit for firms that are credit-rationed by banks. The question now is whether suppliers accept those requests. If they do, then trade credit could alleviate credit rationing for SMEs. This suggests that trade credit could be one of the solutions to the credit constraints faced by construction SMEs in South Africa.

According to Smorfitt (2009) SMEs in South Africa do struggle to raise finance from credit providers. The question is why? There has been little, if any, in-depth research into why trade creditors are not lining up to grant credit to SMEs in South Africa. That is, the reasons why debt is not available from trade creditors to SMEs in South Africa. Therefore, it is significant to understand the determinants of access to trade credit for SMEs in South Africa.

1.1 Problem statement

According to Agumba and Otieno (2005) stated that, it is accepted that SMEs are a vehicle of economic empowerment in the construction industry in South Africa. However, they are phased with an overabundance of challenges to be able to maximize their economic potential. Furthermore, construction SMEs find it difficult to access trade credit they applied for from the financial institution. It can be clearly indicated that there is lack of studies to determine the predictors determining trade credit and partial credit accessibility by construction SMEs.

1.2 Research question

Based on the above discussion, this study is guided by this single specific research questions: What determines access to trade credit among South Africa construction SMEs?

2. Literature Review

2.1 Trade credit and empirical evidence

According to Huyghebaert *et al.* (2006) trade credit arises when a firm purchases goods and services for which payment is delayed. It is an impulsive source of financing, as it arises from ordinary business transactions. Trade credit is usually extended for an intermediate period of thirty to sixty days at which point payment is due. If payment is not made on the date, financing charges are applied and trade credit becomes an alternative method of financing business expenses. Selima (2007) also points out that trade credit theory can be broadly classified into four main groups. These are market deficiency asymmetric information, transaction costs, price discrimination and finance. The asymmetric information theory occurs when sellers face uncertainty about their customers' creditworthiness and financial health. Because of asymmetric information sellers cannot reliably make the best selling decisions. Frank and Maksimovic

(2004) opinion out that another theory of trade credit is the transaction costs theory. The combination of the supply of both goods and finance from one source can lead to cost advantages and to a reduction in transaction costs. Furthermore, when the transactions take place on credit, the timing of the payment is less uncertain which enables firms to improve their cash-flow forecasts and simplify cash management. Selima (2007) discusses the price discrimination theory of trade credit and points out that as demand for a product can vary, suppliers can manipulate the product price through the variation of the credit terms offered to each separate customer. So varying the trade credit terms gives the supplier a more flexible approach to pricing and to discriminate among customers, as it is much easier to adjust credit terms (based on the payment period) than product price in order to respond to fluctuating demand. Frank and Maksimovic (2004) opinion out that another theory of trade credit is the financing theory. When non-financial institutions offer credit, they play an intermediary role by obviating the need for purchasers to obtain finance from their banks to pay for their purchases. Furthermore, customers that are rationed by financial institutions tend to turn to trade credit, considering it a cheap way of getting short-term funds. So suppliers that are financially sound and can relatively easily get access to external funds tend to play this intermediary role by financing their customers' stock through trade credit. Therefore, trade credit becomes an attractive way of obtaining required contractions or other shocks that leave financial institutions less willing or less able to provide small business finance.

2.2 Challenges preventing SMEs from accessing credit

According to Alhassan and Sakara (2014), results, the factors that stifle SMEs from accessing trade credit are, management expertise, high default rate and monitoring as the challenges banks faced in giving trade credit to SMEs. Bondinuba (2012) found that the key challenges that make it difficult for SMEs to access finance include policy regulation, inadequate financial infrastructure, stringent collateral security requirement, and lack of institutional capacity of SMEs sector. The key barriers identified include informational barriers, lack of managerial skills within SMEs. Nkuah, Tanyeh and Gaeten (2013) found that financial activities such as business registration, documentation/recording, business planning, asset ownership, impact heavily on SMEs access to bank credits.

Other challenges that SMEs encounter when trying to access trade credit can be due to an incomplete range of financial products and services, regulatory rigidities or gaps in the legal framework, lack of information on both the banks and the SMEs side. Banks may avoid providing financing to certain types of SMEs, in particular, start-ups and very young firms that typically lack sufficient collateral, or firms whose activities offer the possibilities of high returns but at a substantial risk of loss. There are many challenges to construction development and growth. These include policies regulations, inadequate financial infrastructure, firm regulations, trade regulations, tax regulations, changing government policies, tax rates, corruption, labour regulations, cost of capital, and keen competition for limited opportunities (Uriyo 2004).

Kayanula and Quartey (2000) argued that factors like availability and cost of finance are the most common constraints faced by SMEs. Others are lack of collateral, informational barriers, regulations and rules that impede construction firms access to credit, the legal framework and policies around investment and financial institutions (FI's) lending are fundamental, lack of access to appropriate technology, weak institutional capacity, lack of management skills and training in the construction firms, and lack of proper

book keeping. The legal and regulatory frameworks that exist in Ghana also fail to provide the right support infrastructure to facilitate SMEs lending by the financial institutions. The lack of collateral, lack of proper financial management, lack of fiscal incentives for SMEs, strict prudential regulations which restrict flexibility of FI's, unduly complex or onerous administrative procedures and even simply the lack of a consistent definition or enabling law for SMEs are some of the impediments to SMEs financing. Even though SMEs tend to attract motivated managers, they can hardly compete with larger firms.

Angela and Motsa Associates (2004) revealed that entrepreneurs face several problems in their efforts to access trade credit , particularly from banks; viz., lack of collateral security, refusal to use own collateral, failure to make a remarkable own contribution, blacklisting, failure to review attractive financial records and/or business plans and high risk of small entrepreneurs.

Foxcroft *et al.* (2002) explicates that lack of collateral is the most widespread problem, particularly if the entrepreneur is applying for working capital. Other issues affecting the decision to provide finance include blacklisting, and inadequate financial records. The report concluded that, based on international comparisons, for a significant proportion of unsuccessful applicants, the failure of the application would not seem to be entirely unreasonable.

The Organization for Economic Cooperation and Development (OECD, 2006) argued that banks may avoid providing finance to certain types of SMEs, in particular, start-ups and very young firms that typically lack sufficient collateral, or firms whose activities offer the possibilities of high returns but at a substantial risk of loss (OECD, 2006). It can be suggested from these discussions that different set of challenges prevents SMEs from accessing finance. Hence, the importance of determining the challenges faced by SMEs in the South Africa construction industry from accessing credit.

2.3 Determinants of access to trade credit

Fatoki (2014) in his study indicated that the availability of business plan, collateral, maintenance of a good relationship, managerial competency and a good credit score are critical lending requirements. In a study conducted by Kira and He (2012) in Tanzania, they found that there is interdependence and significant relationship between the firms characteristics i.e. location, industry, size, incorporation, age, size, availability of business information and collateral and access of debt to financing by SMEs.

According to Etonihu, Rahaman and Usman (2013) their findings suggested that education, distance to credit source and types of credit source as major factors that influenced farmers' access to agricultural credit. In a study by Chauke and Anim (2013) in South Africa they established that access to credit was negatively influenced by educational achievement, investment in production costs, access to market information and membership of cooperative. In a separate study by Chauke *et al.*, (2013) they found that the predictors for credit accessibility by smallholder farmers were, attitude towards risk, distance between lender and borrower, perception on loan repayment, perception on lending procedures and total value of assets. Ololade and Olagunju (2013) posited that gender, marital status, lack of guarantor, high interest rate predicted access to credit among rural framers in Nigeria.

Fatoki and Odeyemi (2010) results indicate that managerial competencies, business information, networking, location, crime, business size and incorporation are significant determinants of credit approval. Dzadze, Osei Mensah, Aidoo, and Nurah (2012), in their study established that extension contact, education level and saving habit had significant positive influence on farmers' access to formal credit.

Kimutai and Ambrose (2013) opined that the key factors that influenced credit rationing by commercial banks in Kenya are loan characteristics, firm characteristics and observable characteristics. The study established that most of the banks rationed credit in order to reduce risk and to avoid the risk of adverse selection and moral hazard. Beck *et al.*, (2008) found that banks in developing economies, compared to those in developed economies, tend to be less exposed to SMEs, hence charge them higher interest rates and fees. Musamali and Tarus (2013) inferred that profile such as ownership structure; size of the firm; business type; and age of the business indeed influence SMEs' access to finance. Alhassan and Sakara (2014), results indicated that, the number of employees, experience in credit use and number of fixed assets possessed, attitude towards risk, business size, sector and form of business in the economy are the critical success factors in accessing bank finance. In a study by Pandula, (2011) using chi square as statistical parameter, found that, education of the entrepreneur and having membership with business association are associated with access to bank finance. In view of these discussions there is no consensus of a set of determinants that will predict access to credit. Furthermore, no study has focused on full or partial credit accessibility from the financial institutions. Hence, this research poses the question: what are the socio-economic and demographic predictors of full credit accessibility from the financial institutions?

3. Research Method

A structured questionnaire survey was used to collect data. Creswell (1994) describes a survey as a quantitative or numeric description of some fraction of the population – the sample, which enables researchers to generalize their findings from a sample of respondents to a population within the limitations of the sampling method. Convenience sampling was used which consisted of contractors registered with the CIDB. A total of 179 SMEs completed the questionnaire survey. Content validity was conducted on the questionnaire using pilot study administered to 30 construction SMEs.

SPSS version 22 was used to perform the binary logistic regression analysis. A binary logistic regression model with a dichotomous dependent variable of Yes or No was modelled. Yes response was defined as having accessed full trade credit and No accessed part of the trade credit. The dependent variable was coded as 1 and 0, for "Yes" and "No" respectively. The independent variables of the logistic regression model were also coded. They were the demographic and socio-economic characteristics of the SMEs: *gender* if male 1 and female 2; *age group*, 30 years and below 1, 31 years to 39 years 2, 40 years to 49 years 3 and 50 years and above 4; *current position*, director 1, owner 2, manager 3 and manager/owner 4; *ownership*, sole proprietorship 1, partnership 2, limited partnership 3, limited Liability company 4, corporation (for-profit) 5; *tax number* No, 0 and Yes, 1; *location of business*, city of Johannesburg Metropolitan Municipality 1, city of Tshwane Metropolitan Municipality 2, Ekurhuleni Metropolitan Municipality 4, West Rand District Municipality 4; *collateral* No, 0 and Yes, 1.

Logistic regression is recommended over linear regression when modeling dichotomous responses and allows the researcher to estimate probabilities of the response occurring (Hosmer and Lemeshow, 2004). The logistic regression equation takes the following form

$$\ln(p/(1-p)) = \beta_0 + \beta_1x_1 + \beta_2x_2 + \dots + \beta_kx_k \quad (1)$$

Where p is the estimated probability of passing, and x_1, x_2, \dots, x_k are independent variables.

The estimated probability of the response occurring or passing (p) divided by the probability of it not occurring or not passing (1-p) is called the odds ratio. Maximum likelihood method is used to estimate the odds ratios of the model. Values of odds ratios higher than 1 indicate positive association between the variables, odds ratios equal to 1 indicate no association, while odds ratios lower than 1 indicate negative association between each independent variable and the dependent variable of the model.

Furthermore, in order for an independent variable to be a predictor of the dependent variable the p-value should be less than 0.05 at 95% confidence, which connotes its significance in the model. In achieving a fitting model the Hosmer-Lemeshow goodness of fit test should be significant i.e. the value should be greater than 0.05 (Pallant, 2013).

The factors preventing SMEs from accessing trade credit were measured using Likert scale of 1 to 5. 1= Strongly disagree (SD), 2= Disagree (D), 3= Neutral (N), 4 = Agree (A), 5= Strongly agree (SA). The Likert-scale questions are discussed based on their mean score in the interval scale. The difference between the upper and lower ends of the used scale is 4.0 since there are five points. Each range can be equated to 0.80 because the extent of the range is determined by a division between 4.0 and 5.0 (4/5). However, in the current study the intervals are as stated:
 $> 4.21 \leq 5.00$ Strongly agree;
 $> 3.41 \leq 4.20$ Agree;
 $> 2.61 \leq 3.40$ Neutral;
 $> 1.81 \leq 2.60$ Disagree;
 $> 1.00 \leq 1.80$ Strongly disagree.

4. Results and Discussion

Table 1 indicates that male respondents were the majority than female respondents, at 63% to 37% respectively. Majority i.e. 51% of the respondents were in the age group between 40-49 years old. Furthermore, 82% of the respondents were owners of the organizations surveyed. Majority i.e. 72% of the respondents had business experience of between 6 to 10 years. 98% of the SMEs are sole. Furthermore, majority i.e. 41% of the SMEs were located in the city of Johannesburg metropolitan.

Table 2 indicates that the SMEs respondents strongly agreed that lack of collateral, lack of cashflow statement and owners equity were hindering SMEs from accessing credit from financial institutions. The mean values were in the band of 4.21 to 5.00. The sector of the business, lengthy and vigorous procedure for credit application, high interest rates, location of the business were in the band of 3.61 to 4.20 suggesting that the respondents agreed that they contributed to their difficulty of obtaining credit. Furthermore, the SMEs respondents disagreed that lack of appropriate education and training, and lack of managerial ability were hindering them from accessing credit. These two constraints were in the band of 1.81 to 2.60.

Table 1: Profile of respondents and organisation

		Frequency	Percentage (%)
Gender	Male	112	63
	Female	67	37
Age group	30 years and below	2	1
	31-39 years	49	27
	40-49 years	92	51
	50 years and above	36	20
Current position	Director	29	16
	Owner	146	82
	Manager	3	2
	Manager/owner	1	1
Experience	1-5 years	15	8%
	6-10 years	130	72%
	11-15 years	33	18%
	16-20 years	1	1%
Ownership	Sole proprietorship	175	98%
	Partnership	2	1%
	Limited partnership	1	1%
	Limited liability company (LLC)	1	1%
Location of company	City of Johannesburg metropolitan	74	41%
	City of Tshwane metropolitan	42	24%
	Ekurhuleni metropolitan	34	19%
	West Rand district municipality	29	16%

Table 2: Constraints in obtaining credit

Constraints of credit accessibility	Mean	Stdev.	Rank
Lack of collateral	4.69	0.58	1
Lack of cash flow statement	4.51	0.98	2
Owner's equity	4.39	1.01	3
Sector of the business	4.14	1.21	4
Lengthy & Vigorous procedure for credit application	4.13	1.37	5
High Interest rates	3.81	1.51	6
Location of the business	3.76	1.27	7
Lack of good reference on integrity	3.03	1.66	8
Lack of awareness of existing credit schemes	2.97	1.71	9
A general lack of experience and exposure on construction project	2.75	1.73	10
Lack of information on the cost obtaining such service	2.72	1.74	11
Lack of appropriate education & Training	2.21	1.68	12
Lack of managerial ability	2.09	1.59	13

The results in Table 3 suggest that out of the 179 respondents, one respondent did not get credit at all. Therefore, 21.91% i.e. 39 of the respondents received part of the credit they applied for and 78.09% i.e. 139 of the respondents obtained the full credit. It can be indicated that some of the SMEs did not receive the full credit they applied from the financial institutions. This is imperative to this study as there is lack of

studies that have determined the predictors that influence full credit accessibility and partial credit accessibility globally.

Table 3: Full or partial credit accessed

Credit accessed	Respondents	Percentage
Accessed partial credit	39	21.91%
Accessed full credit	139	78.09%
Total	178	100.00%

The results in Table 4 indicate that of the seven demographic and socio-economic independent variables modelled to predict full credit accessibility. Age group 40-49 years were likely to receive full credit than applicants who were in the age group 30 years and below. This finding suggests that financial institutions might deem applicants who are 30 years and young as being risky clients. The results in Table 4 further indicate that the current position of the applicant predicted full credit accessibility. However, no category of current position in the organization stated indicated prediction of full credit accessibility. The results indicated the level of significance (p-value) were greater than 0.05 for all categories of current position in the organization. It was found that when the SMEs provided their tax number they had a greater chance of accessing full credit at 0.05, compared to those who do not provide there tax number. The level of significance was less than 0.05 at 0.015 hence a strong predictor. Furthermore, the SMEs whose premise were in Location, Ekurhuleni metropolitan municipality in Gauteng province had a higher probability of getting full credit, compared to SMEs in the city of Johannesburg metropolitan municipality. This predictor was significant at 0.043 which was less than 0.05. The odds of getting the full credit was 0.247 more than those in city of Johannesburg. The gender of the respondent, and type of ownership did not predict full credit accessibility. Furthermore, it is imperative to mention that collateral was not statistically interpreted in the output result of SPSS despite being included in the analysis as a predictor. However, prior to testing this model, the goodness of fit of the model was tested which indicated a good fit. This result was justified by the Hosmer and Lemeshow test. The significance of the model was greater than 0.05 at 0.271. The result suggests that the independent variables were fitting in the proposed theoretical model.

5. Conclusions and Recommendations

The study found that SMEs are stifled from accessing credit because of lack of collateral/security, lack of cash flow statement and owners' equity despite the results suggesting that majority of SMEs received the full credit they applied for compared to those who did not receive the full credit. However, this is still alarming as partial credit can hinder the progress of these organizations economically. It can be indicated that when SMEs receive part of the credit they might apply for credit in other financial institutions or request financial assistance from friends in order to cover for the deficit.

The researchers established that for SMEs to access full trade credit from the financial institutions age group, current position in the organization of the respondent applying for credit predicated full accessibility. Furthermore, tax number and location of the business in the Gauteng province were also

predicators of full credit accessibility. However, the gender of the respondent, type of business ownership and collateral (security) did not predict full credit accessibility by SMEs. These findings should be interpreted with caution as SMEs from Gauteng were the only respondents who participated. It is opined that the results might have been different if a country wide survey was undertaken within construction SMEs.

Table 4: Predictors of accessing full credit

Variable	Exp. (B) Odds ratio	95% C.I. for EXP (B) Lower	95% C.I. for EXP (B) Upper	P-value
Gender (1)	2.102	0.929	4.757	0.075
Age group				0.133
31-40 years (1)	135383335.57	0.000	.	0.999
2	2			
40- 49 years (2)	0.269	0.079	0.916	0.036
50 years and over (3)	0.668	0.215	2.074	0.485
Current position				0.040
Owner (1)	0.000	0.000	.	1.000
Manager (2)	0.000	0.000	.	1.000
Manager/owner (3)	2.191	0.000	.	1.000
Ownership				1.000
Partnership (1)	0.000	0.000		1.000
Limited partnership (2)	1.357	0.000	.	1.000
Limited Liability company (LLC) (3)	1.274	0.000	.	1.000
Tax number (1)	0.050	0.004	0.564	0.015
Location (municipality)				0.085
City of Tshwane Metropolitan Municipality (1)	0.785	0.218	2.828	0.711
Ekurhuleni Metropolitan Municipality (2)	0.246	0.063	0.958	0.043
West Rand District Municipality (3)	0.707	0.175	2.863	0.627
	34707472280			
	46773200.000			0.999

Dependent variable: full credit accessibility (0=partial credit; 1=full credit) sig. at 5%

Based on these findings, the researchers recommend that SMEs should provide the age, and current position in the organization of the person applying for the credit. Furthermore, they should provide the tax number and the location of the business in order for them to obtain full credit from banks. It is worth indicating that SMEs should also be aware of the requirements that the financial institutions will request them to submit as they apply for trade credit.

In relation to these findings, the researchers propose the need to use other socio-economic and demographic factors that were not used in this study as the current factors are not exhaustive in relation to the full characteristic of SMEs. The factors recommended for testing are marital status of the applicant, bank account statement and managerial ability of the respondents.

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Sovereign Bonds and Infrastructure Development in Africa: The Case of Zambian Road Infrastructure

Ephraim Kabunda Munshifwa¹

Abstract

African countries have in the recent past borrowed heavily from the European bond market to fund repayment of old debts and infrastructure development; with total debt now estimated around US\$30bn. Evidence shows not just the increase in total debt but also an increase in interest rates (rate of returns) on bonds (which has risen from 5.75% on the Egyptian bond of 2010 to 10.75% on the Ghanaian one of 2015), an increase of 87%, ostensibly in line with increasing risk. The general theoretical understanding is that there is a relationship between risk and return, but some African investors argue that Africa's risks are often just perceived and not real; thus disputing the assertion that increasing risk is responsible for rising interest rates. This study uses regression analysis to investigate major causes of the rise in interest rates on African Eurobonds. Using a dataset of bonds issued between 2010 and 2015, the study identifies three variables, that is, borrowed amount, GNP growth rate and risk outlook (a proxy for credit rating) as key explanatory variables. The study then concludes by using Zambia as a case study, which like other African countries has in the recent past issued Eurobonds amounting to US\$3billion to raise finance for infrastructure development. The study found a weak link between interest rates and the three explanatory variables. It thus concludes that African countries need to do a more thorough cost-benefit analysis to understand the full impact of these loans; otherwise Africa may be paying too much in the pretence of covering risks.

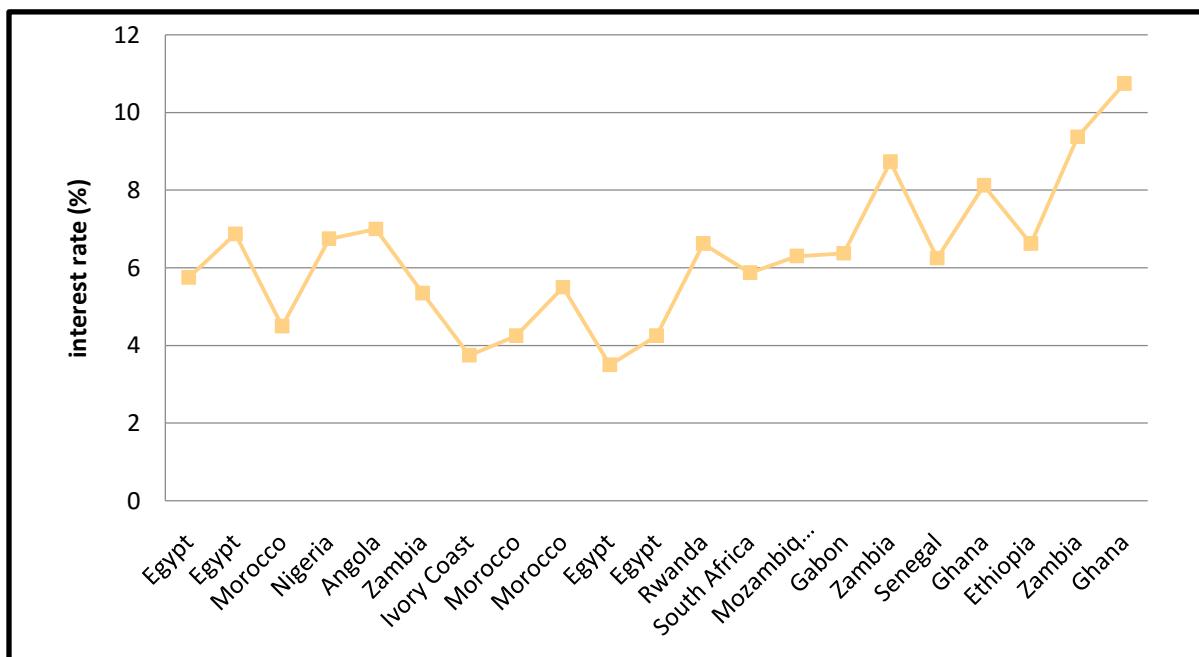
Keywords: Eurobonds, road infrastructure, risks, interest rates, GDP growth rate

1. Introduction

Road infrastructure is an important factor in economic development of any country (Donaldson, 2010; Mohommad, 2010). However evidence shows that many developing countries, particularly in Sub Saharan Africa, suffer from poor road infrastructure which could also be contributing to their development stagnation. This is compounded by the inadequacy in financial resources to undertake these developments. In the quest to improve infrastructure, many countries in Sub Saharan Africa have resorted to borrowing funds from various sources to support their infrastructure development agenda. *Sovereign debt*, defined as "debt instruments issued by the national government of a country which are denominated in a foreign currency" (KPMG, 2015: 8) has therefore come in handy. Evidence however shows that interest rates on

¹Dean/Senior Lecturer; School of the Built Environment/Department of Real Estate Studies; The Copperbelt University; P.O Box 21692, Kitwe; Email: ephraim.munshifwa@cbu.ac.zm

African bonds have risen, having increased from 5.75% on the Egyptian bond of 2010 to 10.75% on the Ghanaian one of 2015; an increase of 87% (see Figure 1). Many scholars argue that a continued borrowing spree by African governments and a sharp rise in interest rates could result in another “debt-trap” for most of these countries. Hence this study investigates the causes of this sharp rise in interest rates and how to better management proceeds from these loans.



Source: Trading Economics <http://www.tradingeconomics.com/>; Fitch Ratings www.fitchratings.com; S & P Global www.standardandpoors.com; World Bank <http://databank.worldbank.org/data/databases.aspx>

Figure 1: Interest rates on African Eurobonds (2010 to 2015)

Zambia, one of the Southern African countries, has found itself in a similar quandary. After many years of deterioration in infrastructure, the country has in the last eight years embarked on a large scale infrastructure development programme. Started just before the 2011 general elections by the previous Movement for Multiparty Democracy (MMD) administration in what was termed "Formula One" (Zambia Daily Mail, 2016) road development projects due to the speed at which they were envisaged to be constructed, Zambia has continued on this infrastructure development programme with the new Patriotic Front government. Since undertaking such large projects also demands huge resources, Zambia has found itself cash strapped and running a widening budget deficit year by year in order to continue with this programme, such that in 2012 the government resorted to borrowing from the European bond market in order to finance the infrastructure development programme.

This move by government has brought back memories to many Zambians who remember that for a long time the country was burdened with unsustainable debt which qualified the country to the infamous group of Highly Indebted Poor Countries (HIPC). With consented austerity programmes and pressure from the

World Bank and IMF, Zambia's external debt which stood at USD6.3billion as at 2000 was written off (AfDB/OECD, 2003), giving the country an opportunity to start again. However by 2013, Zambia had acquired new debt amounting to US\$3.050bn or 11.5% of GDP and still on the rise (KPMG, 2015). Furthermore, interest rates have also continued to rise from 5.35% on the first bond of 2012 to 8.735% on the third bond of 2015, an increase of 63% over 3 years. This contracting of new debt to finance road development programmes has brought on serious debates in the country. The government's defence is that no country in the world could develop without debt. For the purpose of this paper, the key question was: what are the major causes of this steep rise in interest rates and how can Zambia, and other African countries, better management proceeds from these loans?

This paper is anchored in finance/investment literature, which looks at road infrastructure development as an investment. It is arranged as follows: Section 2 reviews literature, both theoretical and empirical, in order to understand the rationale of the bond market in relation to infrastructure development. Section 3 discusses the methodology used in this paper while Section 4 discusses findings and discussion of results; this includes discussion on the Zambian case. Section 5 concludes the paper.

2. Bond Markets and Development: A Literature Review

A bond is a financial security which promises the holder a sequence of guaranteed future returns at an agreed interest rate (Capinski and Zastawniak, 2003). Hence an interest rate is the cost to the issuer for using borrowed funds or a rate of return to an investor for forgoing the use of those funds. Theoretically, there is a relationship between bond price, interest rate (or rate of return) and risk; some of the earliest works on the subject being Markowitz (1952) and Modigliani and Pogue (1973). The relationship is such that the higher the risk, the higher the rate of return (or interest) investors will demand. A higher rate of return also means a rise in the bond price. Infrastructure bonds are a subset of corporate bonds (Larrain, 2011). The opening up of the European market to bond issuers has resulted in a borrowing frenzy from around the world, including USA, Canada and African countries. For instance, Peristiani and Santo (2010) examined the competitiveness of the US and Eurobond markets in a comparative study that covered a period of 10 years from 2000 to 2010. The study found that the US bond market had lost its competitiveness to the Eurobonds in that American firms now preferred to issue bonds in the Eurobond market than in the US market. Some of the reasons cited were the low cost of underwriting which has fallen drastically in the Euro-zone starting from the early 1990s after the introduction of the Euro as a common currency.

Claes *et al* (2002) earlier provided an extensive background to Eurobonds in reference to issuers (nationality, industry and ratings), intermediaries and bond structure (currencies used, size of issuers, terms to maturity and instruments). Claes *et al* (2002) also showed that the state/government was the third largest issuer of Eurobonds between 1980 and 2000.

Various empirical studies have emphasised different sides of the bond market. For instance, Debnath (2014) investigated the bond market in Bangladesh focusing on identifying the problems which impede the growth and development of that market. The study found that a number of factors, such as consistent GDP growth rate, budget deficit, significant role of private sector in credit disbursement, declining ability of state controlled banks to fund industrial loans, moderate inflation and exchange rate, huge fund of

insurance companies, increasing investors' confidence on the capital market, and benefits of bond market participants, do support an effective bond market (Debnath, 2014). The study however concluded that despite the potential, the current size of the debt market in Bangladesh was still very low.

Studies, such as Sawant (2010) and Buchner and Kaserer (2010), focused on examining the risk-return relationship in the bond market. For instance Buchner and Kaserer (2010) analysed the risk, return and cash flow characteristics of infrastructure investments by using a dataset of 1,200 private-equity funds. The study concluded that infrastructure deals have higher performance than non-infrastructure funds despite lower default frequencies. The study further found that infrastructure funds are positively correlated to public equity markets, but uncorrelated to GDP growth. Buchner and Kaserer (2010) then argued that returns could be influenced by the regulatory framework as well as by defective privatisation mechanisms.

Other studies, for instance Marlowe (2015), Inderst and Stewart (2014) and Mbeng (2012), had focused on bond finance and state and local government infrastructure development. For example Marlowe (2015) examined a case of municipal bonds and infrastructure. The main finding of this study was that approximately 90 percent of state and local capital spending is financed with traditional municipal bonds. Inderst and Stewart (2014) also investigated the infrastructure development in emerging and developing countries, but financed through institutional investors. The findings were that although the volumes were still low, international and domestic investors use a variety of means including equity, debt and fund instruments. However Sinha (2014) found that for India, most infrastructure projects do not qualify for investment by insurance and pension funds because of their complex risk profiles.

Mbeng (2012) took a comparative approach by investigating whether international experiences on financing infrastructure can be used in Africa. This review showed that while many African countries have been able to successfully mobilise resources from domestic markets to finance infrastructure projects, these instruments are not structured as infrastructure bond but as conventional government bonds with a promise to spend the money on infrastructure investment.

A number of factors are responsible for the rise in African Eurobonds. Amadou (2015), for instance, alludes to five factors which have contributed to the rise in issuance of sovereign Eurobonds by African countries, these include: changes in the institutional environment, reduced debt burden, large borrowing needs, debt management needs and low borrowing costs. Ironically, part of the reason for Africa's reduced debt burden was the cancellation of its US\$100billion debt through the Multilateral Debt Relief Initiative (MDRI) in mid 2000s (Adams, 2015). However as pointed out earlier, the combined effect of a rise in debt and interest is a huge repayment by African governments, which in a few years may become unsustainable.

Masetti (2015) argued that the major contributory factor to these changes is the fall in commodity prices which has meant a fall in revenue to service bond payments; hence increasing the default risk. The result is that African countries have had to reduce the order book and offer higher yields in order to attract buyers. Others, such as Tyson (2015), have argued that Sub Saharan Africa's is also a very risky environment due to a number of other factors. For instance Tyson (2015: 1) argued that "Sub-Saharan Africa has the potential to repeat the problems which occurred in the early 1990s in Asia and Latin America when damaging financial crisis pushed millions back into poverty for a decade". Reference here is to risks such as exchange rate risks, liquidity risk and interest rate risk. These risks are used by credit rating agencies such as TE, Standard and Poor's and Fitch Ratings to provide a composite credit rate for each country.

Tyson (2015) concludes that risks are moderate but growing while Standard and Poor's Ratings Services posits that the majority of these sovereigns in Sub Saharan Africa will direct an increasing share of revenues in the coming three years to servicing their debt (S & P, 2015).

3. Methodology

The study used a dataset of 21 African Eurobonds issued from 2010 to 2015 (see Figure 1 above). Data on month/year of issue, amount borrowed, interest rates, GDP growth rates (preceding issue), and risk outlook (as proxy for credit rating) were compiled for each bond, using information from various sources including databases by World Databank, Trading Economics (TE), Fitch Ratings, Standard and Poor's (S & P) Global, and individual prospectuses. A regression model was used to determine whether interest rates on Eurobonds are dependent on GDP growth rate (before the issue of the bond), amount borrowed or risk outlook at the time of issue (measured as negative, stable or positive). A credit rating of a country is used by sovereign wealth funds, pension funds and other investors to gauge the credit worthiness of a country; thus argued to impact both on the amount borrowed and expected return by investors.

The following generic regression equation was used in this analysis:

$$Y_i = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + e_i$$

Where: Y is the interest rate, being the dependent variable; b_j is the value of the coefficients, $j = 0, 1, 2, 3$; X_1 is the amount borrowed; X_2 is the GDP growth rate before the issue; X_3 is the dummy factor for risk outlook (used as proxy for credit risk); and, e_i is the error in the observed value for the i^{th} case.

4. Findings and Discussion

Regression results showed a weak relationship between interest rates and the three explanatory variables. For instance, while the relationship between interest rates and risk outlook is positive, as revealed by a beta coefficient of 0.118, the overall R^2 of 18.4% showed that the combined explanatory power of the model is still low (see Table 1). This is an indication that others factors also have an effect on interest rates. Results in Table 1 also revealed that GDP growth rate has a much stronger positive relationship with interest rates, with a beta coefficient of 0.391. A further perusal of these results showed that in fact the negative result between interest rates and amount borrowed, with a beta of -0.018 and t value of -0.075, is meaningless in this relation.

Table 1: Interest rates, GDP growth rate, amount and risk outlook

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error			
(Constant)	4.930	1.283		3.842	.001
Amount borrowed	-5.620E-008	.000	-.018	-.075	.941
GDP Growth Before	.233	.132	.391	1.758	.097
Risk Outlook	.273	.543	.118	.503	.622

a. Dependent Variable: Interest rates; $R^2 = 18.4\%$

These results imply that other factors, besides risk and GDP growth rate, have an effect on interest rates. This is also consistent with findings in Debnath (2014) and Buchner and Kaserer (2010) that showed other extended factors such as regulatory framework, budget deficit, inflation, exchange rate, and others. Therefore although risk is an important consideration for Eurobonds, its inclusion in the lending equation is implicit hence a weak quantitative relationship. This means that for African governments to better manage the proceeds from these loans, it is important to improve on the quantitative analysis not only of the risk-return relationship but also on the extended fiscal and legal frameworks.

4.1 Case study: Eurobonds and road infrastructure in Zambia

Zambia has a land area measuring 752,000 square kilometres with a population of 13.8 million people (and projected to increase to 24 million by mid-2025), giving it a population density of 18 people per square kilometre (UN-HABITAT, 2012). Although Zambia has 10 provinces, most of the population is situated along the line of rail with the majority found in the Copperbelt and Lusaka Provinces. Zambia's huge expanse and scattered population also means that it needs to build more roads to connect the country. One of the Patriotic Front (PF) government's goals is the provision of infrastructure to support economic development.

Due to the inadequacy of the national budget, the government has opted to borrow funds from the European market to support this goal. Zambia has up to this point issued three Eurobonds to European investors which now total US\$3bn. This has included US\$750m in 2012 at 5.35%, US\$1bn in 2014 at 8.735% and the third US\$1.25b in 2015 at 9.375% (Table 2 below). At the time of the first issue GDP growth rate was 6.7% (2011) and risk outlook *stable* (2012), for the second bond GDP growth rate was 6.7% (2013) and risk outlook *positive* while for the third bond GDP growth rate was 5.7% (2014) and risk outlook *stable*. The overall picture is that interest rates on Zambia's Eurobonds have been rising despite the fact that risk outlook was positive in 2014 when the second Eurobond was issued. Thus if risk outlook was the key determinant of interest rates, one would have expected a lower rate than on the first bond. This reinforces the results from the regression analysis showing a weak positive relationship between interest rates and risk outlook.

Table 2: Profile of Zambian eurobonds (2012 to 2015)

Year	Rate of interest (%)	Amount borrowed (US\$bn)	GDP Growth Rate (%)	Risk outlook
2012	5.35	0.75	6.7	Stable
2014	8.735	1	6.7	Positive
2014	9.375	1.25	5.7	Stable

Source: Zambia's Prospectuses for 2012, 2014 & 2015

In terms of the use of proceeds from Eurobonds, Zambia's prospectuses show that the main goal of these funds was to provide finance for infrastructure development. Much of this money has been spent on road infrastructure within and between towns and cities. For instance, US\$310m out of the first US\$750m was used in the road sector, with US\$145m used to repay funds borrowed on the Lusaka Urban Roads Projects

(Ministry of Finance, 2016). The balance was used on various on-going road maintenance and upgrading works such as the Kitwe-Chingola dual carriage project and the link Zambia 8000 programme. The use of proceeds from the second and third Eurobonds has not been fully disclosed with many arguing that much of it has been spent on social infrastructure with little economic gain (Hambayi, 2015).

A perusal of the three prospectuses however does not show why or how these projects were selected amongst many others around the country which need to be done. Traditionally, development funds in Zambia are allocated through Parliament in a budgetary system. Consideration in this allocation process, while aimed at economic development, is not based on any economic criteria. For instance even if the Sixth National Development Plan (SNDP) of 2011 aims "to achieve sustained economic growth and poverty reduction by accelerating infrastructure development, economic diversification and rural investment and by enhancing human development" (GRZ, 2012: 46), the actual allocation of funds to projects is not based on any clear formula. Thus although government's intentions are clear, the linking of infrastructure funding/investment and economic outcomes at decision-making stage is however a loose one. No clear economic appraisal process is followed in the allocation of funds. Even at implementation stage agencies such as Road Development Agency (RDA), National Council for Construction (NCC) and others simply implement decisions made at the higher level. As earlier stated, there is need to improve quantitative analyses in relation to bonds and infrastructure development, which at project level, means the use of more cost-benefit analyses approaches.

5. Conclusion and Policy Implications

Despite the limitedness of the dataset, some conclusions can be made from this study. For instance there is need for African countries to carry out more thorough cost-benefit analyses to understand the full implications of these loans to the continent. Otherwise Africa may be paying too much in the pretence of covering risks. Furthermore, this study posits that Africa's race into indebtedness is being exacerbated by the financing process itself. Although corporate and financial entities use the same Eurobonds for their funding requirements, their treatment of such funds is different from countries. More specifically, corporate entities allocate these funds based on a financial criterion and often borrow based on specific projects. However for most African countries, the sourcing of such funds is divorced from its allocation or utilisation, as is the case for Zambia. For the Zambian case, the study suggests that besides Parliament approving the ceiling on how much the country should borrow, an additional safe guard could be to provide a further framework through which decisions on investing such funds are made. This inevitably includes an economic appraisal process for selecting projects in which borrowed funds should be utilised.

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Comparison of the Clients, Consultant and Contractors Perspectives of Pre-Tender Unit Cost Factors in Zambia

Chipulu Chipulu¹, Erastus M. Mwanaumo², Balimu Mwiya³

Abstract

Infrastructure development is essential to a nation's economic growth. However, because of the competing demand on limited resources, pre-tender cost estimates have become essential to the clients' decision to build and in the selection of construction contractors. This study compares the perspectives of clients, consultants and contractors on pre-tender unit cost. Through a survey questionnaire, the different perspectives regarding what unit cost factors considered severe to pre-tender cost estimate were investigated. Data collected were analysed using a severity index and the Cronbach's alpha was used to check the internal consistency reliability. The study revealed that there are differences in the perspectives of cost factors among the three respondent's categories. Clients opined that the three most severe cost factors were the design factors such as geometry and specification; clients' requirement on quality, cost and time; and physical location of the project. Consultants indicated that clients' requirement on quality, cost and time, design factors and environmental conditions of the site are the three most severe cost factors to them. Contrariwise, contractors' perceived that the cost of materials, physical location of project and exchange rate are the three most severe cost factors. However, comparing the top five cost factors between clients and contractors reveal significant similarities in perceptions. In addition, there is consensus among respondents concerning importance of certain cost factors. The differences in the perspectives of these category groups are important in that they affect the type of estimates they produce. This is the case because differences in perspectives lead to dissimilarities in assumptions made and consequently variances in developed cost estimates.

Keywords: Pre-tender estimate, cost factor, contractor, consultants, client

1. Introduction

According to Evans *et al.* (2007) cost is the expenditure necessary for the attainment of a goal while cost estimation is the prediction of the cost prior to undertaking the activity. Cantarelli *et al.*, (2009) however, defined estimated costs as budgeted or forecasted construction costs determined at the time of the decision to build. Further, actual costs are defined as real, accounted construction costs determined at the time of

¹ Post Graduate Student; Department of Civil and Environmental Engineering; School of Engineering University of Zambia; Box 32379, Email: chipulubrudel@gmail.com.

²Lecturer; Department of Civil and Environmental Engineering; School of Engineering University of Zambia; Box 32379; Email: Erastus.mwanaumo@unza.zm

³Lecturer; Department of Civil and Environmental Engineering; School of Engineering University of Zambia; Box 32379; Email: Balimu.mwiya@unza.zm

project completion (*Ibid*). Odusami and Onukwube (2008) as quoted by Enshassi *et al.* (2013) defines pre-tender cost estimating as the final costing of the work carried out by a consultant on behalf of a client before tenders are received. On the other hand, in Aibinu, Dassanayake and Chau (2011), pre-tender cost estimation was defined as the forecasting of the cost of a project during the planning and design stage. From these two definitions, one can note that pre-tender estimates are prepared before inviting bids. Furthermore, consultants on behalf of the client develop pre-tender cost estimates during project planning and design. Aibinu & Pasco (2008) indicated that a pre-tender estimate is an important source of information during project planning and design. Pre-tender estimates also form the basis for tender comparison or financial evaluation of bids (Asian Development Bank, 2010, p. 5). Therefore, if they are inadequate, award decision may be extremely difficult.

According to the American Association of State Highway Officials (AASHTO) (2007), cost estimation can be undertaken by using historical bid prices, cost based estimating, parametric estimating and probabilistic cost estimating methods. Conversely, “first principles” is the most frequently used cost estimating method in Zambia (Mwiya, 2016).

Cost estimates are critical because, unreliable cost estimates lead to inaccurate ranking of projects based on viability, which may result in inferior projects being implemented (Cantarelli *et al.*, 2010). In addition, inaccurate early estimates can lead to lost opportunities, wasted development effort, and lower than expected returns (Oberlender, 2000).

1.1 Factors that affect pre-tender cost estimate

Knowledge of cost factors is a great asset to the cost estimator. Different researchers have identified different factors that affect cost; a few are presented in this section. Cunningham (2013), in assessing the factors affecting the cost of building work within the Irish context, established that the client's priorities in relation to quality, cost and time constraints, appointment of the design team, location physical, environmental conditions and design factors (geometry, specifications) are the essential cost factors. On the other hand, Memon *et al.* (2010) identified several factors that affect construction cost, however, the fluctuation in prices of materials was established to be the most dominant factor affecting construction cost, which is contrary to the finding of Cunningham (2013). In investigating the factors of construction cost in Nigeria, Eshofonie, (2008) conclusively stated that, the main factor affecting cost of construction as opined by the three key players in the construction industry is cost of materials. Conversely, in their study of the factors that affect construction unit rates in the Zambian roads sector, Mwiya *et al.* (2014) revealed that eight factors were significant to the development of unit rates in Zambia. These are location of the project, haulage distance, delayed payments, the quality of project management, material source, equipment availability, and exchange rate.

A careful review of the above presented studies seems to suggest that the severity of the cost factors' differs from country to country. For instance, according to Cunningham (2013) client priorities in relation to quality, cost and time is the most severe in the Irish construction industry, while Memon *et al.* (2010) and Eshofonie (2008) reveals that material price fluctuation is an important factor in Malaysia and Nigeria.

1.2 Problem definition

A review of the project cost estimates by clients and contractors on selected projects reveal significant variances as can be noted from the table 1. These discrepancies in cost estimates maybe attributed to various factors considered or not considered during estimation. The US Government Accountability Office (2009) indicated that cost estimates developed by an estimator are based on either ground rules or assumptions made. This seem to suggest that the underlying assumptions made by different contractors, clients and consultants estimators regarding which cost factors are critical to the project cost estimates developed.

Table1: Contractors project estimate compared to clients (engineers) project estimate

Contractor Estimate (ZMW)	Client Estimate (ZMW)	Contract Variance(ZMW)	Project
236,899,704.00	196,736,091.00	40,163,613.00	Road to Chief Mpande
824,568,899.40	614,811,270.88	209,757,628.52	Mbala to Kasaba Bay road

Source: (Road development agency, undated)

1.3 Purpose of study

The purpose of the study was to compare the perspectives of clients, contractors and consultants regarding severity of pre-tender unit cost factors in the Zambian construction industry.

2. Methodology

The secondary data of the research was collected through literature review. Primary data on the hand was collected using a self-administered semi-structured questionnaire and the target group was the road construction clients, consultants and contractors. This group of respondents was requested to rate the unit cost factors on a five point ordinal Likert scale in which “important” and “very important” were assigned weights of one and five respectively. The target sample size was 60.

The severity index also known as the relative importance index was calculated using equation 1 (Kaliba, 2010):

$$SI = \frac{\sum_{K=1}^n S_K P_K}{5 * \sum_{K=1}^n P_K} * 100 \quad \text{equation 1}$$

Where SI is the severity index

S_k= is the assigned severity weight assigned to option k

P_k= is the number of participants who responded in favour of an option k

n= is the Total number of respondents

Internal consistency of the data was measured employing Cronbach's alpha calculated using SPSS. Hair *et al.* (1998) as quoted by Peter & Peter (2008) contends that the Cronbach's alpha as a measure of internal

consistency of items overcomes the potential problem of half splits to which Hof (2012, p. 8) agrees. According to Jonsson and Svingby (2007), a Cronbach's alpha greater than 0.7 indicates a higher degree of internal consistency.

3. Findings and Analysis

3.1 Internal consistency reliability

The targeted sample population was 60 and the response rate was 66.7%. The Cronbach's alpha for the data was established to be 0.895. This therefore implies that the data collected had higher internal consistency reliability (Peter & Peter, 2008).

3.2 Establishing important cost factors

The factors that had severity indices above 70 percent were regarded as being important by the respondents Cong *et al.* (2014), Enshassi *et al.* (2013) and Nor *et al.* (2012) shared a similar line of thought in that they considered cost factors with higher relative importance indices (RII) to be perceived as important in their respondents' opinions.

3.3 Perspectives regarding unit cost factors

3.3.1 Client's perspective of the unit cost factors

According to the clients and client's representatives, the unit cost factors that were perceived as important to development of pre-tender estimates are shown in table 2. Design factors (SI=90%) were ranked first, whilst clients' requirements on quality, cost and time, physical location of the project, environmental conditions of the site, and haulage distance, all with SI of 88% were ranked second. On the other hand, financial ability of the client and project duration both with SI of 70% were least-ranked.

Table 2: Clients' perspective of pre-tender cost estimate unit rates factors

Factor	SI (%)	Rank
Design factors (geometry, specifications, etc.)	90	1
Clients requirement on quality, cost and time	88	2
Physical location of the project	88	2
Environmental conditions of the site	88	2
Haulage distance	88	2
Material availability	86	3
The design team competence	84	4
Fluctuation in material prices	82	5
Cost of materials	82	5
Cost of labour	82	5
Completeness of the project information	78	6
Interest and inflation	78	6
Exchange rate	76	7
Market stability	72	8
Financial ability of the client	70	9
Project duration	70	9

3.3.2 Consultants' perspective on the unit rates

According to the consultants, clients' requirements (SI 91%) were ranked first, whilst quality, cost and time (SI 86%) ranked second. Project duration (SI 71%) was however least-ranked. The other cost factors were rated as shown in table 3.

Table 3: Consultants' perspective of pre-tender cost estimate unit rates factors

Pre-tender Estimate Unit factors	SI (%)	Category rank
Clients requirement on quality, cost and time	91	1
Design factors (geometry, specifications, etc.)	86	2
Environmental conditions of the site	85	3
Completeness of the project information	85	3
Haulage distance	85	3
Material availability	84	4
Physical location of the project	83	5
Cost of materials	83	5
The design team competence	81	6
Fluctuation in material prices	81	6
Delayed payment	81	6
Unforeseen ground conditions	76	7
Financial ability of the client	76	7
Level of construction activity	76	7
Cost of labour	76	7
Access to site and storage limitation	76	7
Deadline requirements of the client	75	8
Quality of project management	74	9
Construction techniques	74	9
Project duration	71	10

3.3.3 Contractors' perspective of the unit rates factors

The contractors considered 13 unit cost factors has important. Cost of materials (SI 96%) ranked first, whilst physical location of the project (SI 93%) and exchange rate (89%) were ranked second and third respectively. Design factors and cost of labour both SI 73% were least-ranked. The ranking of the other unit cost factors for pre-tender estimates are as shown in table 4.

4. Discussion

A thorough consideration of the above results reveal that there are differences in the perception of the category groups in terms of which unit cost factors are severe or important to pre-tender cost estimate development.

For instance, a comparison of the contractors and clients ranking of pre-tender unit factors bring out this difference in perception. The clients regard design factors as the most severe or important factor that affect pre-tender unit cost estimates while the contractors ranks this factor as the least severe. The contractors instead regard cost of materials as being the most important unit cost factor, which is in agreement with

Eshofonie (2008). Further, though the contractors considered exchange rate as critical by ranking it third, the clients are of the different perception as the rank this factor thirteenth on their severity scale. This implies that clients do not regard exchange rate has being a severe factor, which affect the cost of construction. However, Sheppard *et al.*, (2006) concludes that fluctuations in exchange rates have a significant effect to infrastructure investments, which supports the contractors' perception. These differences in severity or importance criteria results in difference of estimates produced by these categories of respondents. However, there is consensus between contractors and clients categories in that, they both consider the physical location of materials as being critical to the development of pre-tender cost estimate though the differences in the severity indices is significant as can be noted for tables 2 and 4.

Table 4: Contractors' perspective of pre-tender cost estimate unit rates factors

Cost factors	SI (%)	Category Rank
Cost of materials	96	1
Physical location of the project	93	2
Exchange rate	89	3
Material availability	87	4
Interest and inflation	87	4
Clients requirement on quality, cost and time	84	5
Fluctuation in material prices	82	6
Haulage distance	82	6
Completeness of the project information	80	7
Level of competition	80	7
Cost of labour	80	7
Insufficient analysis of tender documents	76	8
Design factors (geometry, specifications, etc.)	73	9
Environmental conditions of the site	73	9

Comparing the contractors' responses to those of consultants also reveals a significant difference in perception. Contrary to the contractors' perspective, consultants opine that client's requirements on quality, cost and time is the most severe pre-tender cost factor, which agrees with Cunningham (2013). However, this factor is ranked fifth on the contractors' severity-ranking criterion. Cost of materials though regarded by contractors as the most important pre-tender unit cost factors as can be noted from table 4, this factor is ranked fifth on the consultants severity or importance scale. However, Eshofonie (2008) established that the cost of materials has a significant effect on the cost of infrastructure. The physical conditions of the site and the exchange rate, though considered very significant to the development of a pre-tender estimate by the contractors, these unit cost factors are ranked by the consultants fifth and below the 70% severity threshold. Sheppard *et al.* (2006) and Gatti (2008) consider exchange rate fluctuations as one of the significant factors that can affect the cost of the project. It follows that the neglecting of exchange rate by any estimator can result in a poor cost estimate.

Likening the clients' top five unit cost factors to those of the consultants, reveal a similarity in the perception of the critical cost factors. This similarity is attributed to the relationship between the clients and consultants. Consultants in most building and engineering contracts act in such a manner to achieve clients' satisfaction. In order to achieve this, consultants endeavour to translate clients' needs into a design

that meets the technical, functional and quality standards of the clients (Bowen *et al.*, 1999, as cited by Ramabodu, 2014). Further, consultants achieve clients' satisfaction, delivering the project with specified time and cost (Kaliba, 2010). For them to achieve the delivery of project within specified cost, their perspective of unit cost estimate are likely to harmonise with clients'.

A critical analysis of these perceptions also reveal similarities in that certain factors are regarded as being important by all the respondents. Factors like the physical location of the project materials. Even though this factor ranked differently by the respondents category the differences in the indices are not so significant (92%, 88%, and 83%).

The differences in the perspectives of these category groups are critical in that they lead to subsequent differences in the cost estimates produced. These perspectives influence the assumptions made by the estimator and the subsequent pricing of the project, US Government Accountability Office (2009). For instance, the failure to consider location and other relevant cost factors by the client and his consultant may lead to a lower engineer's estimate hence affecting the type and quality of the selected contractor. It is probable that the lowest bidding contractor may be selected. In summary difference in perspectives can cause many contractual disputes, compromise on quality and duration of construction projects. The differences could further result in outrageous variations, which are not desirable on projects.

Harmonising the perspectives, the different perceptions of key stakeholders could provide accurate and consistent estimates at project inception thereby avoiding unnecessary and expensive variations in them of time cost and quality. Anderson *et al.* (2009), contends that the prevalence of inaccurate and inconsistent project cost estimates is what impelled the NCHRP 8-36 to produce the cost estimation guidebook to be used in Departments of Transportations. The development of a cost estimation framework or guidebook may be one way of dealing with this situation.

5. Conclusions

This study aimed at comparing the contractors, clients and consultants perspectives regarding unit cost factors. The study established that there are differences in perceptions of these three categories of respondents. The contractors considered cost of material to be the most severe unit factor, seconded by physical location and followed by exchange rate. However, the clients perceived dominant cost factor as design factors, seconded by clients' requirement on quality, cost and time then physical location of the project. The consultants on the other hand indicated that the clients' requirements on quality, cost and time, design factor and environmental conditions of the site were the most important or severe factors. However, likening the clients' top five unit cost factors to those of the consultants, reveal a similarity in the perception of the critical cost factors, which is attributed to the consultants' role of being clients' agents.

A critical analysis of these perceptions further reveal similarities in that certain factors like the physical location of the project are regarded as being important by all the respondents. The differences in the perspectives of these category groups are important in that they affect the type of estimates they produce. This is the case because differences in perspectives lead to dissimilarities in assumptions made and consequently variances in developed cost estimates.

This study did not consider all the construction industry. However, it was restricted to the Zambian roads sector due to time constraints. The study recommends the investigation of the possibility and viability of standardising unit rates for the construction industry.

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Dispute Causation in Integrated Procurement System in Gauteng, South Africa

Modupe Cecilia Mewomo¹, Marthinus Johannes Maritz²

Abstract

The study investigates disputes that are peculiar to the integrated system of procurement by examining major factors relating to actions and inactions of project participants and external factors. It evaluates the criticality and intensity of the identified causes of disputes on projects procured by the integrated procurement strategy. Data were obtained through questionnaire survey from construction professionals that are involved in integrated system of procurement in Gauteng, South Africa. The results revealed that “design related problems”, “claim and contractual problems” and, “financial issues” are the three prominent dispute areas in the integrated procurement system. The results also showed that disputes were most intense in financial and payment issues. The study finally concluded that adequate provisions for disputes avoidance strategies are required to address the identified dispute areas under the integrated procurement strategy.

Keywords: construction, disputes, procurement system, South Africa

1. Introduction

Completion of a project that meets the objectives of time, cost and function have been noted to be the goal of every construction project stakeholder (Maritz, 2009). To get these objectives achieved, many researchers have recommended the use of integrated procurement systems, which are design-build, turnkey, innovation and package deal contract strategies (Ndekugri and Turner, 1994; Conlin, Langford and Kennedy, 1996; Yusof, Ismail and Chin, 2011). According to Grobler and Pretorius (2002); Larkin, Odeyinka and Eadie, (2012), the integrated system of procurement has been rising in popularity due to the advantages it can provide, such as minimal rework and error, constructability of design, and reduction in disputes and claims. Moreover, the reported weaknesses, drawbacks and dissatisfaction with the use of the traditional method of procurement have led to the noticeable increase in the usage of the integrated system in the construction industry worldwide (Gidado and Ashi, 2004; Mfongeh, 2010; Dada, 2012). These advantages have in most cases resulted in cost and time saving.

While it has been noted that procuring a project through integrated system significantly lead to reduction in disputes occurrence, it is however clear that, reduction in disputes occurrence does not indicate absence of disputes on construction projects. One intense dispute may have serious devastating effects on projects

¹Ph.D Student; Department of Construction Economics; University of Pretoria; Building 5, Room 2-9, South Camus,modupemewomo@yahoo.com, modupe.mewomo@up.ac.za

²Head; Department of Construction Economics; University of Pretoria; Building 5, Room 3-5, South Campus,tinus.maritz@up.ac.za

than many non-intense disputes. Therefore, dispute has been identified as one of the major factors preventing successful completion and good performance in construction projects (Alkhamali, Matowa and Ogunlana, 2010). Disputes of any magnitudes are therefore capable of depriving various construction stakeholders from enjoying the advantages of a procurement system. Considering the severe negative effect of disputes on projects, avoidance and prevention of construction disputes become very important. This depends on a sound knowledge and sufficient insight of dispute causation. Thus, this study investigated the disputes that are peculiar to the integrated system of procurement by examining the factors relating to actions and inactions of project participants and external factors. The study also evaluated the criticality and intensity of the identified causes of disputes on projects procured by the integrated procurement strategy.

2. Literature Review

Disputes have been regarded as one of the major contributors to poor project performance in the construction industry (Oladapo and Onabanjo, 2009). To minimize disputes occurrence, there has been an increased urge for a better procurement system with more integrated options. Thus, construction clients have been searching for effective project delivery methods that could be used to maximize project performance (John, Oyeyipo and Ajayi, 2011). The quest for effective project procurement options has in no doubt led to the increase in the usage of a more integrated procurement system. Masterman (2005) defines an integrated system of procurement as a system that incorporates all of those methods of managing the design and construction of a project, where the two basic elements of design and build are integrated and become the responsibility of one organization. Literature suggests that this procurement system is experiencing an extraordinary growth worldwide due to the fact that it can be used to alleviate the problem of fragmentation under the traditional procurement system (Yusof et al., 2011). Design and build as one of the contract strategies of the integrated procurement system has recorded increased popularity in project procurement across the world (Ndekugri and Turner, 1994; Masterman, 2005). For instance, it has been widely used in the UK and other western countries (Grobler and Pretorius, 2002; Lam, Chan and Chan, 2008). Its application has also witness a great increased in Hong Kong construction projects (Lam et al., 2008).

Generally, there is perceived time saving by the client from integration of design and construction (Dada, 2012). Several authors have highlighted a number of advantages associated with the integrated construction procurement method (Anumba and Nosa, 1997; Larkin, Odeyinka and Eadie, 2012). These advantages include improved communication, better price certainty, involvement of the contractor during the design process, reduction in the construction time and incorporation of buildability consideration. Despite these advantages, it has been argued that the perceived time saving in the integrated system could result in a serious contractual problem (Taylor and Carn, 2010). The perception, among the industry role-players, is that clients' needs are increasing and becoming more complex, the desire to build more and more in shorter periods of time could lead to pressure on the contractor. This increased pressure to design and build at a minimum time may increase the likelihood of disputes occurring (Taylor and Carn, 2010). As such, Anumba and Nova (1997) ascribes several disadvantages to the design and build method of procurement which could lead to disputes. Some of these include reduced design quality, uncertainty of expected performance, inhibition of changes by clients, lack of flexibility in accommodating client

changes, high tendering costs and poor quality of design. All these are factors that can cause disputes on construction projects.

Once a dispute occurs, there is a possibility of disruption in the progress of work. Construction participants should therefore look for all possible means to prevent disputes, if the goals of the projects will be achieved. There have been numerous studies undertaken to determine the causes of disputes in the construction industry. Conlinet *al.*, (1996) identify six major dispute areas: these include payment, performance, quality, delay, negligence and administration. Rhys (1994) mentions ten factors in the development of disputes which involve poor management, poor workmanship, adversarial culture, poor communication, inadequate design, economic environment, unrealistic tendering, influence of lawyers, unrealistic client expectations, and, inadequate contract drafting. Oladapo and Onabanjo (2009) summarize the causes of disputes from eleven different researchers between the periods of 1991 to 2007. The dispute causation factors were categorized into nine major areas ranging from unrealistic schedules and expectation to change in economic situation. This research compresses the factors identified by various authors into seven major disputes areas based on their mode of occurrences. These disputes areas are examined to know the disputes that are peculiar to the integrated system of procurement in South Africa.

3. Research Methodology

The methodology adopted in this study included a literature review on dispute causation onconstruction projects followed by a descriptive survey research. Based on the literature review, this paper classified disputes into seven major areas and the numbers of possible causes of disputes under the major dispute areas were also identified. The seven categories under this study for a dispute to occur are as a result of: human behavior; claim and contract documents; design error; delay and technical problems; project client goals; financial and payment issues, and external factors. The survey research process comprised the design and administration of a structured questionnaire. The questionnaire was delivered to the targeted stakeholders that are involved in the integrated procurement system, in Gauteng through the face to face approach in order to clarify any arising queries. Out of a total number of 30 questionnaires administered to the construction professionals, 25 completed questionnaires were received. Twenty two (22) of them were adjudged usable by the researcher thus bringing the response rate to 73%. The questionnaire used a five-point Likert-type scale to measure a range of opinions from "strongly disagree" to "strongly agree". The significant agreement or otherwise of the factors being tested was determined by adopting the mid-point value of the index $(1+2+3+4+5)/5=3$ as hypothesized mean (Coakes and Steed, 2001). This implies that all scores above 3 are significant while scores below 3 are insignificant.

4. Data Analysis and Discussion

This section presents the analysis and discussion of the findings obtained from the copies of the administered questionnaire. Table 1 reveals the demographic data of respondents. The analysis shows that respondents are involved at different construction sectors. The majority of the respondents have more than 11 years of experience. Eighteen (18%) have more than 20 years of working experience in the construction industry, 18% have between 16 to 20 years, 27% have between 11 to 15 years, 32% have between 6 to 10 years, only 5% have less than 5 years of experience, therefore their responses are of great value to this

study. The procurement methods used by the respondents uncovers that 45% have procured projects using the design and build method, 9% have used turnkey system, 22% have used the novation method, 14% have used package deals while 5% have used more than one variants of the integrated system as procurement method. Forty one percent (41%) of the respondents have used the integrated method for private clients, 27% have used the method for public clients while 27% have used the method for both private and public clients.

Table 1: The demographic data of respondents

Number of Respondents = 22	Frequency	Percentage	Cumulative %
Working experience			
1-5	01	05	05
6-10	27	32	37
11-15	06	27	64
16-20	04	18	82
Above 20 years	04	18	100
Construction industry sector			
Private	11	50	50
Public	01	05	55
Both	10	45	100
Variants of integrated system of procurement used by respondents before			
Design and build	10	45	45
Turnkey	2	09	54
Package deal	3	14	68
Novation	5	22	90
More than one method	1	05	95
Others	1	05	100
Type of clients			
Private	09	41	41
Public	06	27	68
Both	06	27	95
Others	01	05	100

4.1 Prominent dispute areas under the integrated procurement system

The respondents were asked to rate the seven areas of disputes as established from the literature. The first three most prominent areas of dispute under the integrated procurement system as shown in Table 2 are ‘design related issues’ which rank first, followed by ‘claims and contractual related issues’ which rank second and, ‘payment and financial related issues’ which rank third. ‘Delay and technical problems’, ‘project clients goal’, ‘behavioural problems’ and, ‘external factors issues’ were ranked fourth, fifth, sixth and seventh respectively. ‘Behavioural problem’ and ‘external factors issues’ had a mean score value of less than 3.00, the mean standard score of the rating. Therefore they are not considered prominent dispute areas under the integrated procurement system.

4.2 Causes of disputes under identified aspects

The most prominent causes of disputes resulting from the project stakeholders' behavior is poor communication. This ranked first with mean score of 3.94 as shown in Table 3. Following this is lack of proper flow of information with mean score 3.78, ranking second and, poor feedback system with mean score 3.21, ranking third. Lack of team spirit, negligence and adversarial/controversial culture ranked fourth, fifth and sixth respectively. The last three factors were considered insignificant causes of disputes under the integrated procurement system. The first three most prominent causes of disputes under human behaviour indicate the importance of proper and clear communication as one of the major factors for avoiding disputes. According to Stanslaus (2011), effective communication is a two-way phenomenon, which involves interpreting the message in the same meaning as sent by the sender. Where this is lacking conflict is likely to occur. Communication that will achieve good performance must therefore be clear and easily understood.

The dynamics of today's construction environments require that risks are properly apportioned in order to avoid unnecessary claim and opportunistic behavior. Table 3 reveals that all the identified factors under claims and contractual matters are significant causes of disputes in an integrated procurement system. Unfair risk allocation ranked first followed by different interpretation of contract documents which ranked second, ambiguities in contract documents which ranked third. Other causes of disputes in claims and contractual issues are inadequate tender documents, incomplete tender information, and excessive claims by contractors which all ranked fourth. One of the essential features of dispute avoidance is fair risk allocation. As noted by Davis (2007), inappropriate or unclear allocation of risk is one of the most significant causes of project failure. It is therefore pertinent that risk should be carried by the party that can manage the risk best and risk which nobody can control should be properly insured in other to prevent disputes.

Table 2: Mean item scores and ranks of prominent dispute areas under the integrated system of procurement

Identified areas of disputes	Mean score	Rank	Mean deviation	$(\text{Mean} - \mu)^2$
Behavioural problems	2.73	7	0.57	0.32
Claims and contractual related issues	3.64	2	-0.36	0.13
Design related problems	3.89	1	-0.61	0.37
Delay and technical problems	3.36	4	-0.08	0.01
Project Client goals	3.10	5	0.18	0.03
Payment and financial issues	3.47	3	-0.19	0.04
External factors	2.78	6	0.50	0.25

Table 3: Mean score and ranking of disputes causation under behavioral issues and contractual claims

Behavioral issues	Mean Score	Rank	Contractual claims factors	Mean score	Rank
Adversarial/controversial culture	2.42	6	Ambiguities in contract documents	3.21	3
Poor communication	3.94	1	Unfair risk allocation	3.57	1
Lack of team spirit	2.73	4	Inadequate tender documents	3.11	4
Negligence	2.57	5	Different interpretation of contract documents	3.42	2
Lack of proper flow of information	3.78	2	Incomplete tender information	3.11	4
Poor feedback	3.21	3	Excessive claim by the contractor	3.11	4

Considering causes of disputes in relation to a design problem, inadequate time for design ranked first as can be seen in Table 4. This is in line with the study conducted by Taylor and Carn, (2010) which discloses that fast tracking and pressure to design and build more and more in a lesser time increases the likelihood of disputes on construction projects. All the identified factors are significant disputes causation factors under a design problem except quality of design which ranked fifth with mean score of 1.68.

With regard to the causes of disputes relating to delay and technical issues, Table 4 reflected that extension of time is the major cause of disputes under delay and technical problems. Delay in progress of work, technical inadequacy of the contractor and tendering pressure are ranked second, third and fourth respectively. All the identified factors significantly lead to occurrence of disputes under the integrated system of procurement.

Table 4: Mean score and ranking of disputes due to a design problem

Causes of disputes due to a design problem	Mean Score	Rank	Causes of disputes due to delay	Mean score	Rank
Design error	3.21	3	Delay in work progress	3.63	2
Inadequate time for design	3.42	1	Extension of time	3.68	1
Inadequate or incomplete specification	3.42	1	Tendering pressure	3.00	4
Quality of design	1.68	5	Technical inadequacy of the contractor	3.05	3
Inadequate brief	3.05	4			

In Table 5, ‘Unrealistic expectation’ ranked first, ‘scope change’ ranked second, ‘acceleration’ ranked third while ‘late giving of site possession’ ranked fourth under the causes of disputes relating to project client goal. The most prominent disputes causation factor under payment and financial issues is poor financial projection on the side of the client. Inadequate contract provision for timely payment and unnecessary delay in payment by the client ranked second, while financial failure of the contractor ranked fourth. This is an important factor to put into consideration if the objectives of a project will be realised.

There should be a proper budget and cash flow forecasting and adequate preparation should be made for timely payment to the contractor.

Table 5: Mean score and ranking of causes of disputes in project clients goals and payment issue

Causes of disputes in project clients goal	Mean Score	Rank	Causes of disputes in payment and financial issues	Mean score	Rank
Variation initiated by the owner	3.05	4	Financial failure of the contractor	2.68	4
Scope change	3.36	2	Poor financial projection on the side of the client	3.21	1
Late giving of site possession	2.95	6	Inadequate contract provision for the timely payment	2.89	2
Acceleration	3.32	3	Unnecessary delay in payment by the client	2.89	2
Unrealistic expectation	3.47	1			
Owner not satisfied with quality	3.05	4			

Disputes resulting from the external factors ranked sixth under the major dispute areas with mean score of 2.78. The analysis of the causes of dispute under external factors shows the agreement with the earlier rating. The result, as can be seen in Table 6 reveals that external factors are not significant causes of disputes under the integrated procurement system. All the identified factors have mean scores less than 3 which is the base criterion for significant disputes causation under the integrated system of procurement.

Table 6: Mean score of causes of dispute resulting from external factors

Causes of disputes due to external factors	Mean score	Rank
Site condition	2.94	1
Force Majeure	2.94	1
Weather	2.84	3
Legal and economic factors	2.74	4
Lack of permit from regulatory authority	2.52	5

4.3 Comparison between commonality and seriousness of disputes under different disputes areas

The construction process under the integrated system strategy can be categorised into three stages which are; planning and predesign stage, construction stage and post construction stage. The main purpose of this section is to identify stages in which most disputes are experienced. The analysis of the responses, presented in Figure 1, disclosed that disputes are experienced mostly at the construction stage. “Delay and technical issues”, “design issues”, “claim and contractual related issues” and, “payment and financial issues” are the areas where disputes occur most frequently during the construction period. Considering the frequency and the intensity of disputes under different dispute areas, Table 7 clearly shows that the major contributor to frequency of disputes is design problem; followed by claims and contractual issues and then financial and payment issues. A further examination of the analysis indicates that in terms of degree of intensity of disputes ‘payment and financial issues’ ranked first. This was followed by ‘claims and contractual related issues’ then delay and technical matters. It should be noted that although payment and

financial issues ranked third under frequency of occurrence, which indicates that it is not the most prominent under the integrated procurement system, it has a very great intensity whenever it occurs. This supports the assertion that one intense conflict or dispute may have very adverse consequences on a project than many non-intense conflicts or disputes (Dada, 2012). Table 7 provides illuminating information of commonality and seriousness of disputes under the integrated procurement system. While design problem has been identified as the most frequent dispute area, payment and financial problems has been established to be the most intense whenever it occurs.

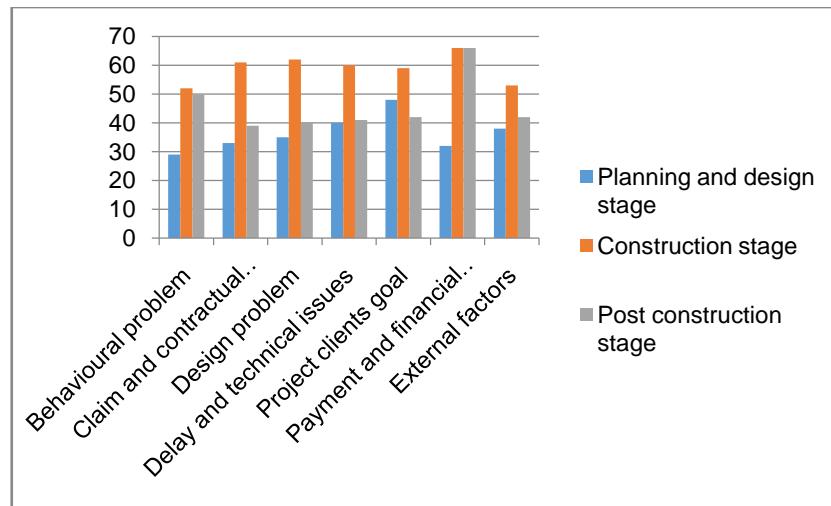


Figure 1: Frequency of disputes at various stages of construction

Table 7: Mean item scores and ranks of frequency and intensity of prominent dispute areas under the integrated system of procurement

Identified disputes areas	Frequency/commonality		Seriousness/intensity	
	Mean score	Rank		
Behavioural problems	2.73	7	2.79	7
Claims and contractual related issues	3.64	2	3.63	2
Design related problems	3.89	1	3.00	5
Delay and technical problems	3.36	4	3.36	3
Project client goals	3.10	5	3.21	4
Payment and financial issues	3.47	3	3.94	1
External factors	2.78	6	2.84	6

5. Conclusion

This study investigates the nature of disputes under the integrated procurement system in the Gauteng province of South Africa. It also assesses the causes of disputes under different dispute areas and further evaluates the criticality and intensity of the identified causes of disputes on projects procured by the integrated procurement strategy. A total number of seven dispute areas were identified from the literature scan. Using the empirical data obtained from the respondents, issues relating to disputes causation under the integrated procurement strategy in the study area were analyzed. The orders of commonality among the

areas identified are: design related problem, claims and contractual issues, payment and financial issues, delay and technical problems, project/client goal, external factor and behavioral problems. Design related problem was ranked to be the most prominent area of disputes while behavioral issues and external factors were identified as not significantly contributing to disputes occurrence in terms of their frequency under the integrated procurement system. Disputes were found to be most intense in financial and payment issues. Major causes of disputes in payment and financial issues are poor financial projection on the side of the clients and unnecessary delay in payment to the contractor. Adequate provision for its avoidance and appropriate mechanism for swift resolution are therefore required because of the criticality and intensity of occurrence. It is therefore suggested that payment and adjudication act similar to that in the UK should be enacted to address the need for prompt payment and quick resolution of financial disputes whenever it occurs. This will not only contribute to quick payment and balance cash flow on construction projects but will definitely enhance the overall performance of the construction industry.

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Critical Considerations in Transport Service Demand Forecasting: A Literature Review

Chioma Okoro¹, Innocent Musonda², Justus Agumba³

Abstract

Infrastructure plays important roles in the development of cities, improvement in the quality of lives and overall socio-economic development and growth of economies. Infrastructure projects are, however, fraught with uncertainties regarding costs, benefits and performance. These uncertainties, if not accurately predicted in the planning of projects, could result in undesirable financial, social and economic consequences. The aim of the current paper is to identify critical factors which influence transport infrastructure performance forecasting outcomes and which should essentially be considered in order to minimize or eliminate errors. A review of related literature was conducted from journals, conference proceedings, magazines, theses and dissertations using databases including Science Direct, Emerald, Ebscohost, Academic Search Complete and ASCE library. The studies reviewed were based on international and South African context. Results revealed that project characteristics including size of project, capacity improvement and time lapses between construction life cycle phases, availability and type of data used, methodology used as well as traffic demand factors influence the outcome and validity of transport infrastructure feasibility studies. The study provides invaluable information to built environment professionals and stakeholders as well as infrastructure policymakers in accurately assessing probable outcomes, positive, in terms of benefits and negative, with regard to costs of proposed projects in order to avoid financial and economic risks. In addition, the study will be indispensable to infrastructure financiers and developers in effective allocation of scarce construction/development funds.

Keywords: demand, forecasting, infrastructure, planning, traffic performance, transport

1. Introduction

Transportation infrastructure, like other forms of infrastructure, helps to shape an economy and quality of life, being a major component of economic activity and social sustainability, both in itself and as an input factor to most other sectors, meeting the demands for people and cargo delivery and providing access to working, shopping and travelling (Zou *et al.*, 2011; Kaare and Koppel, 2012; Cheteni, 2013). According to van der Westhuizen (2007), transit is perceived as a means of overcoming developmental and amenity challenges based on spill-over potentials such as the revitalization of neglected urban precincts. Countries require a 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). Locations of households, businesses and social activities become more attractive and lucrative (Robins, 2015). Changes in land use,

^{1, 2,3} Construction Management and Quantity Surveying Department, University of Johannesburg, South Africa;
chiomao@uj.ac.za, imusonda@uj.ac.za, jagumba@uj.ac.za

increase in property value and employment opportunities also emanate from transport infrastructure developments (van der Westhuizen, 2007; Renner and Gardner, 2010; Robins, 2015; Bon, 2015).

Despite the importance of transportation service to the economy and citizenry, transport projects are complex and fraught with uncertainties with regard to cost, schedule, demand and risk estimation and control (Hampton, 2009; Kim, 2010; Salet *et al.*, 2013). These uncertainties, if not accurately predicted in the planning of projects, could result in undesirable financial, social and economic consequences. The aim of the current paper is therefore to identify critical factors which influence transport infrastructure performance forecasting outcomes and which should essentially be considered in order to minimize or eliminate errors. In order to achieve this, a review of extant literature is conducted with the objective of identifying critical factors for valid, reliable and holistically desirable estimates/predictions with regard to travel or transport service demand. The study provides information which will be useful to governments, project owners, financial institutions and investors in risk assessments of projects and decision-making regarding transport infrastructure investments. Low margins of inaccuracy in prediction of future performance and potential risks in transport infrastructure projects is critical as reliable predictions of performance can save significant amounts of public resources through better planning (Kuhi *et al.*, 2015).

The succeeding sections present the motivation/rationale for the study and related research on the subject area; a brief explanation of the research method employed; and results of this review. The paper concludes with a summary of the factors and recommendations to reduce forecasting accuracy as evinced from literature.

1.1 Motivation and related research

Transport infrastructure such as highways and railways, usually start with a single primary function (for instance, the interconnection of several urban nodes on a line of infrastructure), but in practice can become very complex (Salet *et al.*, 2013). Current approaches in handling these uncertainties and complexities in the planning of infrastructure projects are inadequate, adopting excessively simple structures to these complex projects and there is no consensus on how to improve (Salet *et al.*, 2013) in order to avoid undesirable financial, social and economic consequences. The inherent uncertainties and risks make it difficult for decision-making regarding investment in transport infrastructure. Transport project owners, decision makers, and investors decide to proceed with a given project based on the results of the feasibility study of travel demand on a particular project. Traffic/travel demand forecasts are used to determine the capacity of transport infrastructure. However, they appear to be uncertain, highly inaccurate and often displaying a concerning degree of bias (Nicolaisen *et al.*, 2012).

Highly inaccurate forecasts combined with large standard deviations translate into large financial and economic risks, which are unfortunately downplayed by planners and decision-makers, to the detriment of social and economic welfare (Flyvbjerg *et al.*, 2006; 2008). To determine the capacity and viability of proposed transport infrastructure projects, accuracy in forecasts during planning and feasibility studies should be achieved. Inaccuracies in forecasting outcomes expressed as forecasting bias (general tendency of deviation in a specific direction) and/or imprecision (general tendency of a large spread or deviation from the mean), both pose problems to the validity of subsequent decision support based on such demand forecasts (Nicolaisen *et al.*, 2012). High estimation errors can lead to politically untenable levels of under-

utilisation or at the other extreme, high levels of congestion (especially in the case of road projects) and increased need for capacity expansion, all of which reflect inefficient resource allocation as limited funds, which could otherwise have been utilized for other necessary infrastructure development projects may have been wasted or will be channeled into the existing transport project. A case in point is the Gautrain service which currently requires additional trains to cater for the unexpected surge in the demand for the train service (Nicolaides, 2016). Another noteworthy example is the Kazungulabridge which is currently catering for an unexpected traffic flow from neighbouring countries which was initially not allowed for. Other undesirable eventualities could include contract renegotiations and flexibility of concession period for cost recovery (Welde and Odeck, 2011; Tan *et al.*, 2012).

Research on critical factors which influence transport infrastructure performance forecasting outcomes and which should essentially be considered during planning in order to minimize or eliminate errors is warranted because as Wardman (2006) aptly stated, there is a need to constantly update parameters and framework to accommodate the influence of those factors. Due to the complex interaction between transport related activities and other parts of society, there is a wide range of impacts that are desirable to evaluate when appraising transport infrastructure projects in order to reduce inaccuracies in forecasts (Nicolaisen *et al.*, 2012).

Previous studies which have either dwelt on forecasting methodology used, nature of the project (including quality and capacity expansion) and availability of data (Flyvbjerg *et al.*, 2007; Locateli and Mancini, 2010; Nicolaisen *et al.*, 2012; Litman, 2015). Other factors such as traffic demand factors including level of economic activity (Wardman, 2006), demography (Nicolaisen *et al.*, 2012), tax policies and legislation (Musso *et al.*, 2012; Feng *et al.*, 2012); competing alternative modes in terms of parking availability, travel time, comfort, security, etc. (Wardman, 2006; Taylor, 2008; Zou *et al.*, 2011; Panou, 2014); living conditions and quality of life, cultural habits and societal norms (Zou *et al.*, 2011; Jarv *et al.*, 2012) have also been identified as influencing forecasting outcomes. However, although there has been extensive research on forecasting inaccuracy and causes of large magnitudes of inaccuracies in estimation, very few studies have incorporated all possible factors which could influence accuracy in prediction. Some literature focused on methodology and data availability on specific projects (Flyvbjerg *et al.*, 2007); some literature focused on income level as a determinant of Swedish public transport demand; and others focused on other traffic demand factors (Wardman, 2006; Taylor, 2008; Zou *et al.*, 2011; Panou, 2014). Attention to more variables which determine and cause variations in transport service demand is important in order to predict the future demand (Holmgren, 2013).

1.2 Research method

A detailed review and distillation of extant literature from online journals, conference proceedings, magazines, theses and dissertations were conducted. Databases including Science Direct, Emerald, Ebscohost, Academic Search Complete, Google and ASCE library were consulted. Articles spanning a 10-year period from 2006 to 2015 were included based on their relation to the subject. Keywords and phrases including transport infrastructure, traffic/travel demand factors, forecasting accuracy, and forecasting/estimation methods in transport service demand forecasting were used in the search. Common themes which emerged from thematic analysis were identified and are presented hereunder.

2. Critical Factors in Transport Infrastructure Performance Forecasting

Following the above discourse, this section reviews models which have been documented as predictive of performance of transport infrastructure projects in terms of traffic/travel demand. A panoply of factors have been propagated as influencing the outcome of estimation studies in infrastructure planning. These factors, which form the bases on which a project's benefits and implications can be evaluated, are indicated in extant literature and are discussed hereunder.

2.1 Forecasting method employed and variables included

Some studies contended that the forecasting methodology used for a given project influences the estimation outcome (Flyberg *et al.*, 2006; Jeerangsuwan *et al.*, 2014). The criterion for measuring adequacy of forecasts should ideally reflect the impact of the error into the decision that is going to be taken. Quantitatively, the forecast error in time Θ is the difference between the forecasted value and the actual value in time t , but subjective forecasting methods using judgements and opinions can also be employed (Hassan *et al.*, 2013). However, Etemadnia and Abdelghany (2011) opined that traffic forecasting methods/systems that have been used in recent times have been unable to meet the real-time processing needs, especially for large-size networks, and that there is a high dependency on historical information which could be misleading considering the highly dynamic and stochastic nature of congested urban networks. Rudžianskaitė-Kvaraciejienė *et al.* (2015) developed a model for prediction of effectiveness and impact of proposed and existing projects, based on return on investment/financial success and societal advantages. In the authors' opinion, environmental factors such as noise pollution, environmental protection measures, and health and ecological safety issues; social factors including creation of network places, local area image, service quality, and community consent; economic factors such as inherent risks, use of local resources, technology upgrading and business expansion; technical issues including performance qualities and durability; and financial factors such as degree of risk, financial sources, operation costs, investment demand and financial rates.

Rudžianskaitė-Kvaraciejienė *et al.* (2015) advocated the use of their model in early feasibility studies to determine the benefits and negative impacts of a proposed project which will reflect future acceptability and demand by the citizenry. However, the study included road infrastructure projects developed through PPPs and therefore might not be generalisable to other types of projects. This view was expressed in Flyvbjerg *et al.* (2006) and Jeerangsuwan *et al.* (2014) which concurred that projects develop and perform differently; concession rates and forecasting methodologies differ with project type, which may alter the traffic forecasted. For instance, variations in inaccuracy in rail projects occur due to trip distribution, deliberately slanted forecasts, forecasting model/methodology and trip generation, whereas, trip generation, land use development, trip distribution and forecasting models used, mostly cause inaccuracies with regard to prediction in road project performance (Flyvbjerg *et al.*, 2006). The traditional cost-benefits analysis of transport projects, such as used in Norway for road projects, relies heavily on the accuracy of the estimates being used (Welde and Odeck, 2011). If traffic levels turn out to be significantly lower than the estimated, the total benefits derived from time savings, reduced accidents or lower-vehicle operating costs can be affected. On the other hand, the capacity relief on the congested links could turn out to be lower than planned, which may distort the viability of the project.

Bianchi *et al.* (2014) developed a predictive model for financial performance and returns on infrastructure investment, using asset pricing models. Likewise, Kim (2010) propagated a cost-schedule-risk based model for assessing risks in mega construction projects. However, these models did not include risks associated with demand for services related to the projects.

In his study which assessed the strategies, actors and risks of Chinese infrastructure investment in Latin America, Gransow (2015) expressed that feasibility studies should include assessment of associated social and environmental risks. In the author's view, infrastructure expansion strategies should assess and promote associated social benefits such as poverty reduction. However, poverty reduction was unfortunately not high on the agenda of Japanese assistance to China in the infrastructure expansion strategies in 2008 and this resulted in large-scale consequences including displacements and environmental damage (air and water pollution).

Other studies contended that inclusion of factors which chiefly motivate the demand for a particular transport service is vital (Wardman, 2006; Jarv *et al.*, 2012; Musso *et al.*, 2012; Holmgren, 2013; Litman, 2015). Factors such as car ownership, quality of life, cultural habits, societal norms, vehicle operating costs, level of economic activity, policies and legislation (tax/toll fares), alternative land uses, competing transport modes (in terms of park-and-ride possibilities, length of trips and frequency of rides), security, extent of pollution, walking distance from station, travel time, income, employment, number in household, age, and so on, vary over time and should be critically considered in forecasting transport service demand performance.

2.2 Project characteristics

Causes of inaccuracy in predictions vary with the nature of project (Flyvbjerg *et al.*, 2006). Projects are dissimilar in terms of nature, size, type, participants and location (Jeerangsuwan *et al.*, 2014). For instance, for highway infrastructure, traffic demand risks and factors associated with project revenue are extremely critical because revenue from traffic volume is almost the only source of recovery of investments and making profits (Jeerangsuwan *et al.*, ibid.). In addition, the size of the project, which could influence the time-span, is critical. Attention to the traffic forecasted at the time of decision-making is critical as traffic volume generally follows a time sequence (Flyvbjerg, 2006; Liu and Sharma, 2007). Furthermore, forecasting outcomes could become obsolete if there are huge time lapses between construction life cycle phases, especially in the case of mega projects, which usually takes a number of years to implement (Flyvbjerg *et al.*, 2006; Kennedy, 2015). Improvements in capacity also influences demand for a particular transport service (Lee, 2008; Holmgren, 2013; Jeerangsuwan *et al.*, 2014).

2.3 Availability and type of traffic data

Accuracy of forecasts depends on accuracy of historical demand data used (Etemadnia and Abdelghany, 2011). In their study, Flyvbjerg *et al.* (2006) found that availability of/incomplete data influences feasibility outcomes. Obtaining data availability from public sector is an uphill and time-consuming process. Sometimes, "embarrassing data" that could make a project look bad in the public eye, might be held back, which may influence the outcome of prediction. This is especially prevalent in privately owned projects and in cases where forecasted traffic is much higher than the actual traffic. Readiness of project

managers to release actual data to use in predictions, and use of adjusted data (instead of actual data) influence outcome and accuracy of predictions. Generated traffic data made up of excess, induced and diverted traffic data should be taken into account in estimation (Litman, 2015). Reference data used in forecasting (for instance, in some cases, data from the first year of operation of a similar project may not yield reliable results because the project has not stabilised) (Flyvberg *et al.*, 2006).

3. Summary

Extant literature revealed that non-validity of feasibility studies, managerial control, forecasting methodology used, time lapses between construction life cycle phases, nature of data used/available, nature of project as well as traffic demand factors such as level of economic activity, demography, tax policies and legislation, competing alternative modes in terms of parking availability, travel time, comfort, security, living conditions/quality of life, cultural habits and societal norms, and so on influence forecasting outcomes. These factors influence the degree to which forecasting outcomes are accurate with regard to knowledge and understanding of the variables and the processes involved in forecasting.

The uncertainty of traffic demand can be addressed by analyses of the above-discussed individual key variables taken one at a time. Although Tan *et al.* (2012) argued that some of the undesirable consequences of inaccuracy in forecasts can be overcome with improved flexibility in contracts (that is, shortening the term in case of high demand and *vice versa*), especially where the contract term is endogenously determined by the realized level of future demand and subsequent revenue/cash flow. In other words, the revenue from demand uncertainty could be moderated by the selection of flexible and adjustable contract variables (such as the toll charges and concession period) and the realized demand in turn depends on the road capacity and investment level.

4. Conclusion

The study set out to establish factors which could influence the accuracy of transport service demand forecasts. The factors have been established. The objective of the current study has therefore been met. There is a need to continuously review parameters and framework for more valid estimates especially with the numerous uncertainties and realities attributable to transport infrastructure investments.

The current study has a major limitation being a review paper. Therefore future studies could adopt primary data collection techniques to investigate the factors which should be included in transport infrastructure demand performance forecasting for infrastructure planning. In addition, the future research could explore application of different scenarios to investigate factors which could alter/moderate the demand for particular/specific modes of transport, especially in South Africa, where such research appears to be limited. There is a need to develop a more comprehensive and holistic model of feasibility factors for transport infrastructure planning.

These findings would provide invaluable information to built environment professionals and stakeholders as well as infrastructure policymakers in accurately assessing probable outcomes (positive and/or negative) of projects to avoid risks. In addition, the study will be indispensable to infrastructure financiers and developers in effective allocation of scarce construction/development funds.

5. References

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The Effect of Johannesburg Inner-City Regeneration of the Resident Communities

Nthatisi Khatleli¹, Prabir Paima², Tanita Rodrigues³, Molote Machipi⁴

Abstract

The relationship between the community members, the private sector and the local authorities in the regeneration process is understood to be a circular one. The regeneration process is generally a government initiated process and the results are meant to be beneficial to the community. In Gauteng the relocation of people who have been residing legally in the city for many years attracted the scrutiny of the process followed to ensure continuity or an upgrade of their living conditions as they adopted new neighbourhoods with differing standards of amenities. A case study on two private sector companies that are directly involved in the regeneration of the inner city of Johannesburg was conducted. A series of interviews were conducted with the main figures in the companies, as well as views from both the government and community representatives. Although urban regeneration has to be welcomed in South Africa, an apparent social neglect of the financially marginalized, the superficial inclusion of their views and concerns will result in social kickbacks which could negatively boomerang on the positive developments in the inner cities. Since urban regeneration is a new drive in major cities in South Africa which is happening post-apartheid, there is a lot to learn. It has to be acknowledged that a lot of people have converged in inner cities where they were hitherto restricted. This is driven by low salaries and the apartheid spatial planning which tried to locate people away from their places of work. The new political and economic realities make town living a reality to all classes and this has to be incorporated when upgrading inner cities.

Keywords: community, relocation, regeneration, neighbourhoods, inner-city.

1. Introduction

In South Africa, there is a growing need for capital reinvestments especially in the distressed inner city neighborhoods of the country (Robinson, 2008). This has given rise to numerous regeneration policies being formulated and implemented in South African cities, and more specifically, Johannesburg. The regeneration policies, especially the Johannesburg 2030 Vision, were responses to government's desire for Johannesburg to achieve world class African city status (Winkler, 2009). However, to achieve this goal, the regeneration policies have been focused on increasing economic growth and sustainability. Lipietz (2008) argues that this is contrary to the best interest of the local community members and that government, therefore, is playing an ineffective role in the regeneration process.

¹Senior Lecturer, Department of Construction Economics and Management, University of the Witwatersrand, Nthatisi.Khatleli@wits.ac.za, Tel No. +27 11 717 7651.

The City of Johannesburg in its pursuit for achieving a world class African city status, through the regeneration processs, may be doing more harm than good to the poorer communities residing within the city. The current urban governance has led to gentrification and community displacements, which is contrary to the purpose of the regeneration projects as described by Robert and Sykes (2005). The research was to investigate the effectiveness of the regeneration drive especially to the low-income earners in the inner-city, particularly when anecdotal evidence shows that individual members are affected differently by the regeneration process.

2. Contextual Background

Urban regeneration is the process whereby dilapidated areas are improved in order to resolve urban problems and ultimately improve the physical, economic and social aspects of the area (Roberts and Sykes, 2005). Various urban regeneration policies have been implemented in the Johannesburg inner city over the years.

The city of Johannesburg has a very unique history and as result of that has developed in a manner, socially and physically, unlike other cities around the world (Winkler, 2009). Shortly after the city's formation it became the economic hub of South Africa. However, over the past two decades due to socio-economic changes in the country capital investment has moved to other nodes in the greater Johannesburg area, for example Sandton, and the inner city has been beset by grime and crime. The Apartheid Regime spatial planning policies pretty much determined who lived where and the city's residential layout is still largely a testament of the original socio-economic stratification. Post-Apartheid, the inner city has evolved to accommodate typically low income households who live within close proximity to their places of employment (Winkler, 2009). The deterioration occasioned by the unrestricted influx of people into the inner-city resulted in the government devising strategies that would entice capital investment. Examples of these strategies include; the Jo'burg 2030 Vision and Inner-City Renewal Strategy (2003).

Studies have shown that the government has played an ineffective role in the regeneration process of inner city Johannesburg, when it comes to the protection of the economically marginalised (Winkler, 2009). Robert and Sykes (2000) suggest that the aim of the regeneration process should essentially be to resolve community problems. The inner city plays multiple roles as a residential hub because there is an ever increasing population coming into the inner city in search for employment and better lifestyle (Todes, 2012). Consequently, in the case of Johannesburg, one of the major government challenges is dealing with this high foot count effectively and efficiently (Robinson, 2008).

"Investment-led regeneration has further prompted large-scale public sector redevelopment projects to encourage investor confidence in the inner-city" (Winkler, 2009, p. 34). Since the local authorities who are drivers of the regeneration policies formulate them solely with the aim of growing the economy, community displacement is the norm as the financially marginalized are not the focus of the upgrade (Lipietz, 2008). The corollary to the upgrade is the increase in property prices, which increase further pushes the vulnerable to the margins of the development. This fact has been attested by the work of Winkler (2009) who concluded that "the local state failed to recognize that there is no (empirically justified) link between economic growth and social equity" (Winkler, 2009, p. 389). This means that if

international regeneration policies are to be implemented, they need to be adapted to suit the local socio-economic peculiarities.

3. Literature View

Since its inception in 1886, the City of Johannesburg has undergone numerous changes and it continues to change further as time progresses (Winkler, 2009). Two years post-apartheid, the young democratic government was pressurized into reacting to the financial crisis that struck the country at the time (Panel and Robinson, 2006). In response to the crises, the IGoli 2002 was implemented as a form of City development strategy (CDS). The IGoli 2002 vision's strategies were centred on a three year revenue-led budget, credit control institutional rationalization and privatization. This strategy was created to remedy the immediate threats of the financial crises given the circumstances of the developing and structuring of the new look of the government (Panel and Robinson, 2006). The strategy received a lot of criticism based on the parties that the strategy favoured.

The IGoli 2002 was inspired by the international best practice theory which was also labelled as 'New Urban Policy' (Winkler, 2009). Winkler (2009) showed how the initial strategy completely undermined the community factor by its narrow focus on enhancing the economic condition of Johannesburg. Lipietz (2008) describes City Development strategies (CDIs) as action plans that are created to achieve the objectives of a 'Just City'. In the case of Johannesburg, Liepetz (2008) elaborates on the non-progressive nature of long term CDIs. The unique nature of the city, where there is still unresolved dynamics of politics and power, as well as the geographical segregation within the city. City development strategies are always amended to compliment the changing demands. Liepetz (2008) discusses how city development strategies often showed opportunity to frame development strategies around the community's needs, but never centred the development on the pro-poor concerns. Todes (2012) shows how the inner city is populated by a majority of low income people. The study conducted by Winkler (2009) which involved interviewing the poor, it was clear that most of them will rather stay in the city centre because of the pressing economic exigencies. This brings the issue of justice to the fore when rejuvenating city centres.

3.1 The just city concept

Since the current regeneration strategies neglect the plight of the poor, it is proper to explore other concepts that have been proposed to assess their potential utility. One of this is the just city concept. The Just City is a city where public investment and regulation produce equitable outcomes for those within it rather than assistance for those who are already well off (Fainstein, 2010). A Just City concept does not include the theories of a Good City, namely; a city aimed to aid in the development and success of its residents. It is important to note that justice can have a number of denotations subject to different social, geographical or historical contexts (Harvey 1996 in Fainstein 2010). There are a number of reasons why the Just City framework was conceptualized and why, in recent years, there has been a great deal of emphasis on achieving Just Cities. Cities, in general, normally display the same unjust characteristics, these include, but are not limited to; crime, violence and destitution. There are two major factors that have contributed to this:

- The rate at which cities develop and expand.
- The segregation of the population on the basis of ethnicity, income and gender.

3.1.1 Justice versus economic growth

Feinstein (2010) defines injustice as actions that may be to the detriment of the disadvantaged, by entitling those who are not more deserving to enjoyments. Feinstein (2010) further articulates that equality is not quantified by the sameness of conditions, as uneven benefits based on necessity or provisions of welfare are just. Should emphasis be placed on the need for justice at the planning stages of urban policies, a more favourable environment will be created for the residents of cities. The purpose is not to influence the structure of the city but to create a palpable change in its societal nature (Fainstein 2010). Although Fainstein (2010) argues that a Just City is a social construction that is created through deliberation, it however develops at various levels of investigation of whether or not policy encourages justice (Healey 2003 in Fainstein 2005).

3.1.2 Efficiency versus equity

The measurement of outcomes in aggregate monetary terms leads to an apparent trade-off between efficiency and equity (Fainstein, 2010). The tangible nature of efficiency makes it easier to quantify and the monetary nature of its benefits make it a government objective. The communicative rationality, theorized by Jürgen Habermas (1985) states that the outcome of a process will be equitable if its consideration conforms to the ideal (Fainstein, 2010). Just City theorists claim that it is of utmost importance that the outcomes of any urban process be equitable, democratic social involvement in the deliberation is, although necessary, less significant (Fainstein, 2010).

3.1.3 Process versus outcome

In the urban planning process there are a number of factors to consider; one of the most significant of these factors is the effect of the process, not merely the policy outcomes, on the community. The effects of urban policy on the community are present during and after implementation (Fainstein, 2010). This raises the question of whether or not the benefits of the policy outweigh the consequences of the process. Weber (1915/1958) differentiates between an absolute means and an absolute end (Fainstein, 2005). Fainstein (2005) argues that there is a theoretical weakness in isolation of process from context or outcome. This is because a sustainable city as one with environmental quality, economic growth and social justice that is governed with the best interests of its population as an objective. This form of governance is a means to an end not just an end.

4. Methodology

The main objective of the research was to investigate the effectiveness of the regeneration process in Johannesburg in protecting the interests of the poor. A qualitative research approach was proposed for this study. The theoretical perspective most often associated with qualitative researchers is phenomenology (Bogdan and Biklen, 2003). Following the phenomenological approach, researchers seek to understand meaning in events and in human interactions. Furthermore, the context is important to the interpretation of data. This approach requires that the researcher “centres on the attempt to achieve a sense of the meaning that others give to their own situation” (Smith, 2015). Qualitative research can either be in the form of and

inductive or deductive approach. Inductive approach is based more on observations to articulate theories, whereas a deductive research is based on developing a hypothesis based on theory that already exists and then crafting a research plan to investigate the hypothesis (Wilson, 2010). Our research followed a deductive approach.

The research methodology adopted involved a series of structured interviews with the respective role players in the regeneration process. Open-ended questions were used to give full understanding of the respondent's impression or experience, also allowing for a degree of flexibility and probing of new issues that may unveil (Knight and Ruddock, 2008). The Thematic Analysis method was used to identify, analyse and report on patterns (themes) within data (Braun and Clarke, 2006). The coded data was then subjected to detailed analysis using a code process, coding refers to organizing data into "chunks" prior to articulating meaning (Rossman and Rallis, 1998, p. 171). Four companies based in the Johannesburg CBD were approached in the end only South Point and AFCHO companies were available. An interview was also had with Dr. Winkler who is well known researcher and commentator on the issues of urban regeneration. Her input was considered valuable in enhancing the robustness and depth of the study. The Johannesburg Development Agency (JDA) was also interviewed to represent the government side. The JDA was established in 2001 to stimulate and support area-based economic development initiatives especially in the property sector. The process of the Just City framework, conceptualized by Susan Fainstein, (Fainstein 2010) was adapted to suit the Johannesburg environment. The reason for the use of this framework is because the framework is centered on the welfare of the community. The framework is also flexible which will accommodate the unique nature of Johannesburg. The Just City provides a framework that can be used to determine whether or not a city is just and equitable for its residents. Therefore the use and adaptation of this model will aid in determining whether Johannesburg is 'just' as a result of the regeneration process. The various research methods used resulted in a number of perspectives being analyzed and thereafter combined to triangulate the data. The following research objectives were considered when conducting the research and data collection.

- To investigate the state of the residents residing in the inner city of Johannesburg.
- To investigate the characteristics of the private sector companies to be interviewed.
- To investigate the social upliftment paradigms of the stakeholders on the regeneration process.
- To assess the extent of the government influence on company behaviour with regards to protecting the vulnerable.

Prior to conducting the interviews, the following ethical considerations were assessed:

- Do the participants have a full understanding of the research?
- Are the participants aware of what the consequences are regarding this research?
- What harm could be incurred to research participants? (e.g. legality and Job security)

5. Research Results and Analysis

Tables 1 and 2 show a sample of the data analysis methodology. The analysis was carried out in two phases in line with the Just City Framework. The concepts listed in phase one, as shown in table 1, were directly borrowed from the Just city Framework. The concepts were thoroughly studied from a theoretical

perspective from the literature reviews. The interviews were then analyzed according to these concepts and the perception of each role player of the government. The number of times that the respective player commented on the relative concept was recorded in the relevant column. The comments were judged as for or against. The purpose of this exercise was to determine the role players' perceptions of the government involvement. The second phase (table 2) followed the same principle of analysis, but here the differentiations between two opposing concepts were analyzed as per the Just City Framework.

Table 1: Data Analysis - Phase 1

	AFHCO		South Point		Dr Winkler		JDA	
	X	✓	X	✓	X	✓	X	✓
1) The advancement of equity	6	1	6	1	6	1	3	4
2) The advancement of diversity	2	4	5	1	2	4	1	5
3) The advancement of democracy	3	0	3	0	3	0	0	1

Table 2: Data Analysis - Phase 2

Data Analysis: Phase 2		
1) Justice versus economic growth	Justice 4	Economic Growth 5
2) Efficiency versus equity	Efficiency 9	Equity 4
3) Process versus outcome	Process 8	Outcome 3

5.1 The advancement of equity

In terms of the Just City Framework local council is not creating an equitable environment for the local community members. A city that is equitable distributes tangible and intangible advantages through public policy to the population that requires it the most. By creating an investor friendly environment the local council is not considering the needs of the poorer members of the community. Affordable housing for families has become scarce which has resulted in the displacement of families beyond the city limits. The removal and/or relocation of small business that operates within the inner city is not in line with the Just City framework, the survival and success of small business should be one of the key objectives of the regeneration processes rather than the creation of an environment that is favourable for large investors. Therefore, in terms of the advancement of equity, the regeneration processes within the inner city have not resulted in a Just City.

5.2 The advancement of diversity

The evidence suggests that the inner city of Johannesburg has become more diverse as a result of the regeneration processes, and this has been achieved without the removal of residents with the intention of bringing in new residents of a diverse nature. Although rezoning has taken place in order to complete the regeneration, the rezoning has not resulted in the desegregation of the population; instead it appears that more diverse people are coming together at newly created public areas. The newly created public areas include the Neighbourhoods Market and The Grove, the creation of these areas has resulted in people

coming into the city from suburbs located outside of the city limits. However, areas such as these do not aim to serve low income households that reside within the city. Therefore, in terms of the advancement of diversity, the regeneration processes within the inner city have resulted in a Just City.

5.3 The advancement of democracy

Presently, there is no committee or board that represents the needs of the community members residing within the inner city. A committee of this nature does not exist as a result of the largely transient nature of the community residing within the city, a population with no intention to remain in the city has no desire to partake in the planning processes. The remaining portion of the population does not have the resources required to get involved in representative committees. This means that the community needs are not being determined or represented at any stage of the regeneration process. The regeneration of the inner city of Johannesburg should be aimed at benefiting the community members residing within the city, however, this has not been the case due to the fact that the primary objective is economic growth and promotion of investment in the city. Therefore, in terms of the advancement of democracy, the regeneration processes within the inner city have not created a Just City.

5.4 Justice versus economic growth

Initially it was thought that the problems facing the community members of the inner city were as a result of structural issues within the city, however it has become apparent that the cause is in fact the societal structure that favors economic growth over social justice. During the decision making process of whether or not to regenerate a building the private sector companies conducted market analyses and feasibility studies. The aim of research of this nature is to determine the economic viability of the project. The fact that social justice is not a priority of the regeneration processes is not resulting in the city of Johannesburg being a Just City.

5.5 Efficiency versus equity

It proved to be somewhat difficult to categorize the intentions of both the public and private sectors as either efficient or equitable. However, the results of the regeneration processes indicated that efficiency was often achieved instead of equity as a result of the economic results of a free market. The only instances where equity was achieved were through the actions of the private sector. This shows that the council is not creating, or attempting to create, a just City by means of achieving social equity.

5.6 Process versus outcome

In an attempt to create a Just City the processes followed should never have greater negative consequences on the community members that the outcome has positive. In terms of the regeneration processes that have taken place within the inner city the process are successfully contributing to a Just City being created.

6. Summary

Over its history the city of Johannesburg has changed its form numerous times. There are various intended and unintended consequences of each change that the city undergoes. And it appears that the unintended consequences of these changes have negatively affected the welfare of the low income earning local

community members. The aim of this study was to determine the nature and magnitude of the consequences of the regeneration process on the welfare on these community members.

Since the end of the apartheid era the local government of Johannesburg has strived to create a city that depicts the new political thinking. To do this the City of Jo'burg implemented a number of processes to improve the physical, economic and social aspects of the city. To plan for an area, regardless of its size, it is important to understand the purpose of the area and the nature of the population within it. Johannesburg has a transient population. The vast majority of the populations who reside in the inner city do so with the desire to relocate to the outskirts of the city within the shortest possible time. City dwellers live in the city until they have earned enough to move away from the city center to relocate their families from their places of origin because they generally live in the city alone and go back to their families in their hometowns over weekends or holiday. Due to this fact the community is less willing to devote their time and resources in taking cognizance of their plight.

Urban regeneration has been taking place in the City of Johannesburg over the past two decades with numerous regeneration policies being implemented and ultimately set aside. As each new policy was implemented the focus on economic growth became more dominant, it has reached a point where the Johannesburg Development Agency has listed economic growth as one of their primary objectives. This has been detrimental to the poorer communities within the city.

7. Conclusions

Despite the regeneration processes contributing to a Just City in terms of the advancement of diversity and formulating policies that follow just processes there are too many other factors resulting in Johannesburg not being a Just City. Social justice is not being achieved through the regeneration processes and the community members who require the most assistance are suffering the most as a result of the consequences of regeneration. The welfare of these individuals and families has, on the whole, been negatively affected and many of these people have relocated beyond the city limits.

The research demonstrates that there are three major role players to the regeneration process: local government, private sector companies and local community members. In an ideal situation the relationship between these role players would be a cyclical relationship with communication in both directions. However, the actual relationship is a linear one with the local council at the top formulating regeneration policies and creating a favorable environment for public sector companies. On the second level is the private sector, companies in the private sector communicating with the local council in order to obtain approvals for the regeneration projects. And on the lower level are the members of the community who are not being communicated with or being included at any stage of the regeneration process. This presents three factors that are negatively affecting the welfare of the community members:

- The local council is creating an investor friendly environment and not considering low income earning community members
- Private sector companies base their investment decisions purely on financial feasibility studies and possible economic profit

- The needs of the community members are not being accommodated and addressed due to the lack of community representation

It has been observed that if these three considerations are not dealt with in future developments then the public kickback might lead to unsustainability of these regeneration initiatives.

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