DII-2021 International Conference

BUILDING SMART, RESILIENT AND SUSTAINABLE INFRASTRUCTURE IN DEVELOPING COUNTRIES

Editors: Innocent Musonda and Erastus Mwanaumo
Co-Editors: Chioma Okoro, Chipozya Tembo and Adetayo Onososen

UNIVERSITY OF ZAMBIA

Proceedings of the DII-2021 International Conference: “Building Smart, Resilient and Sustainable Infrastructure in Developing Countries”

Published by

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

ISBN: 978-0-620-86085-7

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DII- 2021 CONFERENCE PARTNERS

Proceedings of the DII-2021 International Conference: "Building Smart, Resilient and Sustainable Infrastructure in Developing Countries"

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FOREWORD

On behalf of the Organising Committee, I am pleased to welcome you to Livingstone, Zambia, the host city of the International Conference on Development and Investment in Infrastructure (DII-2021). The DII-2021 conference is part of the DII Conference series on Infrastructure Development and Investment in Africa. It 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.

The 2021 conference, themed "Building Smart, Resilient and Sustainable Infrastructure in Developing Countries 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:

- Sustainability in Infrastructure Development
- Smart Infrastructure and Cities
- Quality and Resilient
- Gender Equity, Empowerment, Wellness and Development
- BIM, Digital Twins, And Innovation
- Environmental and Waste Management
- Infrastructure, Investment and Finance- Issues, Trends and Forecasts

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

Special thank you also goes to all the conference delegates that have travelled from different continents. Thank you for attending the event.

Innocent Musonda

For/DII-2021

ACKNOWLEDGEMENT

The Organising Committee of the DII-2021 is grateful to the University of Zambia, Copperbelt University, Zambia, National Council for Construction (NCC), Zambia, University of Johannesburg, South Africa 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, produced these published proceedings of the highest standard. This includes satisfying the criteria for subsidy by the South African Department of Higher Education and Training (DHET), which is truly treasured.

DISCLAIMER

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

DECLARATION

All the papers in these conference proceedings were double-blind peer-reviewed at the 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 comments to authors, modification of papers by authors whose papers were not rejected by the reviewers, and re-evaluation of revised papers to ensure the quality of content.

CONFERENCE COMMITTEES

Organising Committee

Zambia

Dr Erastus Mwanaumo (Chairman: Technical Programme)

Dr Chabota Kaliba;

Dr Charles Kahanji

Dr Chipozya Tembo-Silungwe

Ms Chama Mwansa

Mr Brian Mutale

Mr Sampa Chisumbe

South Africa

Prof Maria Ferentinou

Dr Chioma Okoro

Mr Adetayo Onososen

Mr David Tholang Nena

Mr Godfred Fobiri

Ms Motheo Meta Tjebane

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 Table of Contents.

Prof Innocent Musonda (Chairman)

Prof Trynos Gumbo

Prof Maria Ferentinou

Dr Chioma Okoro

Dr Chipozya Tembo-Silungwe

Dr Balimu Mwiya

Dr Justus Agumba

Technical Review Committee

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

Panel of Scientific Reviewers

Dr Abdulrauf Adediran – University of Cape Town, South Africa
Dr Alireza Moghayedi – University of Cape Town, South Africa
Dr Alice Lungu – Copperbelt University, Zambia
Dr Ayodeji O Aiyetan – Durban University of Technology, South Africa
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Prof Ephraim Munshifwa – Copperbelt University, Zambia
Prof Sing S Wong – University College of Technology, Sarawak, Malaysia

THE PEER REVIEW PROCESS

The need for high-quality conference proceedings, evident in the accepted and published papers, entailed a rigorous two-stage blind peer review process by no less than two acknowledged experts in the subject area. Experts, including industry professionals and academics, were assigned to ensure 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 relevance to conference theme and objectives, academic rigour, 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 considering the abstract review comments.

Second stage of review

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

Third stage review

Authors whose papers were accepted after the second review was 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 50 submissions, 36 papers were finally accepted and included in the DII- 2021 conference proceedings. At no stage was any member of the Scientific Review Panel or the Organising Committee, or the editors of the proceedings involved in the review process related to their own authored or co-authored papers. The role of the editors and the scientific committee was to ensure that the final papers incorporated the reviewers' comments and to arrange the papers into the final sequence as captured on the Proceedings

Regards

Innocent Musonda

Chair: Scientific Programme

UNIVERSITY OF JOHANNESBURG

The University of Johannesburg (UJ) is the largest, multi-campus, residential university in South Africa. Born from a merger between the former Rand Afrikaans University (RAU), the Technikon Witwatersrand (TWR) and the East Rand campuses of Vista University in 2005. The University of Johannesburg's unique academic architecture reflects a comprehensive range of learning programmes, leading to various qualifications ranging from vocational and traditional academic to professional and postgraduate programmes across the four campuses: Auckland Park Kingsway, Auckland Park Bunting Road, Doornfontein and Soweto campuses. The campuses vary in size, and each has its 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, with more than 87 rated researchers. Five of these researchers are A-rated - all of whom are recognised as world leaders in their field. The university is also home to nine research centres.

The University fosters ideas rooted in African epistemology. It 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. 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 to enrich campuses' academic, social, and cultural diversity. It is also the recipient of the highest levels of external financial support from donors and partners worldwide. This demonstrates the high esteem in which are held internationally.

In its mission, UJ commits itself to the following:

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

The values guiding all University activities include:

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

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

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

THE COPPERBELT UNIVERSITY

History

With its motto "Knowledge and Service", the Copperbelt University (CBU) was established in 1987 as part of the University of Zambia. It was initially intended to be located in Ndola, about 50km Southeast of Kitwe, as UNZANDO (the 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 were being established), the Copperbelt University was the only other university after the University of Zambia. 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. Therefore, the School of the Built Environment (SBE) 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 a 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 built environment fields. Currently, there are five undergraduate and one masters' degree programme 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 successfully completing 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 master's programme, which takes up to two years to complete, all our undergraduate programmes should take five years. 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 a masters' degree and that the masters' degree must be in the same discipline as the lecturer's first degree. In addition to this profile, the SBE has a very ambitious programme where it intends to expand the school by introducing more programmes like the MSc. Degree in Land Management. This will help in meeting the ever-increasing demand for qualified professionals within and outside the SADC region. More information on CBU in general and SBE, in particular, can be found on our website at www.cbu.edu.zm.

UNIVERSITY OF ZAMBIA

THE SCHOOL OF ENGINEERING, UNIVERSITY OF ZAMBIA

Introduction

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

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

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

POSTGRADUATE PROGRAMMES OFFERED IN THE SCHOOL

PhD research programmes

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

Taught MEng programmes

Part I – Taught Component (First Year)

1 Master of Engineering in Agricultural Management (Taught or by Research)

2 Master of Engineering in Engineering Management (Taught or by Research)

3 Master of Engineering in Structural Engineering (Taught or by Research)

4 Master of Engineering in Environmental Engineering (Taught or by Research)

5 Master of Engineering in Construction Management (Taught or by Research)

6 Master of Engineering in Project Management (Taught or by Research)

7 Master of Engineering in Water Resources Engineering (Taught or by Research)

8 Master of Engineering in ICT (Taught)

9 Master of Engineering in ICT Security (Taught)

10 Master of Engineering in ICT Regulation, Policy and Management (Taught)

11 Master of Engineering in Computer Communications (Taught)

12 Master of Engineering in Telecommunications Systems (Taught)

13 Master of Engineering in Wireless Communications (Taught)

14 Master of Engineering in Electrical Power Engineering (Taught or by Research)

15 Master of Engineering in Geo-Information & Geodesy (Taught)

16 Master of Engineering in Production Engineering & Management (Taught or by Research)

17 Master of Engineering in Thermo-Fluids Engineering (Taught or by Research)

18 Master of Engineering in Renewable Energy Engineering (Taught or by Research)

19 Master of Engineering in High Voltage Engineering and Power Management (Taught or by Research)

20 Master of Engineering in Electromagnetic Compatibility and Electrical Safety (Taught or by Research)

Part II – Research Component (Second Year)

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

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

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

DII-2021 KEYNOTE SPEAKERS

The Infrastructure Investment and Development (DII) conference is an international conference that 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. The conference is an excellent platform for international delegates, including Built Environment professionals, researchers, academics and postgraduate students passionate about eliciting solutions to the challenges faced in infrastructure provision and sustainability. The conference further offers a platform for brainstorming and probing into strategies to realise Africa’s vision in securing the future and attaining full potentials in infrastructure development and investment.

Themed, “BUILDING SMART, RESILIENT AND SUSTAINABLE INFRASTRUCTURE IN DEVELOPING COUNTRIES”, the 2021 conference will focus and address a broad range of topics around infrastructure investment, development and sustainability. The keynote speakers include:

Prof. Ephraim Kabunda Munshifwa

Prof Ephraim Kabunda Munshifwa is an Associate Professor of Real Estate and Dean of the School of the Built Environment at the Copperbelt University in Kitwe, Zambia. He is also the current chairperson of the Valuation Surveyors Registration Board (VSRB), Chapter Head of the Southern African Real Estate Society (SAfRES) and Advisory board member of the Cambridge Initiative for African Urbanism (CIAU). In addition, Prof Munshifwa is Director at Quest Real Estate Services Ltd and the immediate past chairperson of Mukuba Pensions Trust. He has been in the property/construction industry for the past 28 years, with experience in Zambia and Botswana’s private and public sectors. Prof Munshifwa holds a BSc. and MPhil. in Land Economy from the Copperbelt University (Zambia) and University of Cambridge (UK). He also obtained his PhD in Construction Economics and Management from Cape Town (South Africa). He is a member of several professional bodies, including Surveyors Institute of Zambia (SIZ), Society for Institutional and Organisational Economics (SIOE – USA), Institute of Directors Zambia (IODZ) and a fellow of the Cambridge Commonwealth Society (CCS). He has published in journals such as Land Use Policy, Habitat International, Urban Forum and Pacific Rim Property Research Journal.

Dr. David Oloke

Dr David Oloke is a senior academic at the University of Wolverhampton, United Kingdom. He is an experienced Centre Director with a demonstrated history of working in the construction industry. He is skilled in Engineering Consultancy, Sustainable Development, and Integration in the Built Environment. A Chartered Civil Engineer, Chartered Construction Manager, and experienced business development professional with a post-graduate specialization in Construction Engineering and Management. He has offered consultancy advice for various projects worth over 100 million British Pounds and facilitated training on numerous aspects of construction Health and Safety, and electronic Project Management. Dr Oloke is a member of the Institution of Civil Engineers (ICE) Health and Safety Expert Panel.

Mr. Marios Ntaflos

Mr Marios Ntaflos is a civil engineer with many years of experience in transportation planning and engineering. During his consulting experience in one of the industry’s most admired companies, he has participated in interesting projects in the UK and UAE in public transport, road network, airports, and railways. In his current role, Marios is helping organizations in Europe, Middle East, and Africa to implement digital solutions to meet their project needs and make better decisions with Bentley’s software CUBE and LEGION.”

Dr. Jeffrey Mahachi

Dr Jeffrey Mahachi is a registered professional engineer and construction, project manager. He holds a PhD, MSc and BEng in Civil engineering, including an M.IT degree. Jeffrey is the Head of the School of Civil Engineering and the Built Environment at the University of Johannesburg. He has held many positions, including acting CEO at the National Home Builders Registration Council, Council for Scientific and Industrial Research (CSIR) as a Research Engineer, and lecturer at Wits University. Jeffrey has also been involved in several engineering and construction projects, including sustainable human settlements and the roll-out of innovative building systems. Jeffrey has contributed to the development of standards and is passionate about developmental engineering and promoting innovation in the construction industry. He is currently serving as a Board Member of Agrèment South Africa. He has authored and co-authored books in structural engineering, construction, and several journal articles.

Prof. Yanxia Sun

Prof Yanxia Sun is the Acting Vice Dean of the Faculty of Engineering and the Built Environment at the University of Johannesburg. She received her joint qualification: DTech in Electrical Engineering, Tshwane University of Technology, South Africa and PhD in Computer Science, University Paris-EST, France, in 2012. She has, therefore, an approach that brings together computing and electrical engineering. Prof Sun has 14 years of teaching and research experience. Currently, she is serving as a Professor of the Department of Electrical and Electronic Engineering Science, University of Johannesburg, South Africa. Yanxia Sun has 130 papers published/accepted, including 45 ISI master indexed journal papers. She is an IEEE senior member and a South African Young Academy of Science member.

Prof. Daniel Mashao

Prof Daniel Mashao is the Executive Dean of the Faculty of Engineering and the Built Environment at the University of Johannesburg; he is a fellow of the South African Academy of Engineering (SAAE). Prof Mashao earned his PhD from Brown University, specializing in Artificial Intelligence, using Markov Models for Speech Recognition. Prof Mashao's research interests include 41R technologies to enable public delivery service. He has demonstrated commitment to faculty, staff, and student diversity, with UJ becoming the highest producer of doctoral students within Engineering in South Africa. Under Prof Mashao's leadership, FEBE has extensively engaged in outreach to the South African public services. The School of Civil Engineering is involved in research on 3-D printing of low-cost houses.

EXPERT PANEL ON SUSTAINABLE INFRASTRUCTURE DEVELOPMENT

Engr. Martin Manuhwa

Engr Martin Manuhwa is a managing consultant at Zimbabwe Africa Infrastructure Development Group and a seasoned Consulting Engineer. He is the Vice President of the World Federation of Engineering Organisations (WFEO), Anti-Corruption Committee Chair, and Vice President of the World Council of Civil Engineering (WCCE). He has led giant strides in capacities such as the World Council of Civil Engineering (WCCE): Education Committee (Chair). Past President: - Southern African Federation of Engineering Organisations (SAFEO). Past Chairperson: - Engineering Council of Zimbabwe (ECZ). Past President: - Zimbabwe Institution of Engineering (ZIE).

Prof. Nuno Gil

Prof Nuno Gil is a Professor of New Infrastructure Development at the Alliance Manchester Business School (AMBS), University of Manchester, where he is also the AMBS Infrastructure Development Research Group director. Gil's research focuses on the design of structure and processes to achieve collective ends. He teaches organisation n design and megaproject leadership and has worked or done research with various organisations, including CH2M HILL, Intel, Rolls Royce, BAA (now Heathrow Ltd), BP, Network Rail, London 2012, India's DDFCIL, and Nigeria's LAMATA amongst many others.

Engr. Greshom Sichinga

Engr Greshom Sichinga has over twenty years of experience in infrastructure: Civil, Building, Energy, Water, construction and development. Strong background in Project Management, Engineering and Finance. Founded Structural Solutions – A civil and Structural Engineering consulting firm; Sponsors a radio Program “Easy Homes” whose aim is to provide information to help people own their homes. He sits on several boards of companies. He holds a Bachelor of Science in Civil Engineering. He is an ACCA Affiliate and has a master’s in strategic management from Derbyshire Business School- University of Derby.

Prof. Nthatisi Khatleli

Prof Nthatisi Khatleli is an Associate Professor at the School of Construction Economics and Management at the University of Witwatersrand in Johannesburg, South Africa. Before joining academia, he was a Chief Quantity Surveyor for the whole country. He brought precious experience and practical perspective, especially on the issue of risk identification,

forecasting, and management. Prof Khatleli has a background in Quantity surveying, having obtained his BSc degree from the University of Salford in the UK. He furthered his studies at the University of Cape for his MSc and PhD programmes. He spent two years at

the University of the Witwatersrand as a post-doctoral fellow before being fully appointed as a permanent staff member. He has a passion for understanding and managing risk, especially in megaprojects.

Dr Sam Zulu

Dr Sam Zulu is a Reader at Leeds Beckett University. He will be the expert panel facilitator at the DII-2021 conference. Sambo Zulu has over 20 years of experience in industry and academia. He is currently a Reader in Quantity Surveying and Construction Project Management at Leeds Beckett University, Leeds, UK, is also the Postgraduate Research Studies Lead, responsible for managing postgraduate research provision in the School of the Built Environment, Engineering and Computing. He is the founder and lead for the Construction, Property and Project Management (CPPM) research group and is a research mentor to new academic and early career research staff. His research focuses on construction and project management issues in the Architecture, Engineering and Construction (AEC) industry, including sustainable infrastructure, organisational & management issues, project management, information & communications technology, Building Information Modelling and built environment education. His current research focuses on sustainable infrastructure, and the impact of technological advances on organisational and management practices in the AEC industry. He is currently involved in externally funded research and enterprise projects with a total value of £2.92million. He is an experienced PhD supervisor and examiner. He is a member of the review board of the Built Environment, Project and Asset Management Journal (BEPAM). He has also sat on the scientific committees of several academic conferences, including, among others, the Association of Researchers in Construction Management (ARCOM) conferences, Sustainable Ecological Engineering Design for Society (SEEDS) conferences, Development and Investment in Infrastructure (DII) Conferences and the International Council for Research and Innovation in Building and Construction (CIB) W099/TG59 conferences. In addition, he has acted as a reviewer for several journal and conference papers.

KEYNOTE SPEAKERS' PROFILES

6th October 2021

To whom it may concern

PEER REVIEW PROCESS (PRP) CONFIRMATION

On behalf of the DII-2021 International Conference on Infrastructure Development and Investment Strategies for Africa, we confirm that the manuscripts accepted for oral presentation and publication in the Conference proceedings were blind peer-reviewed by two (2) or more technical specialists.

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

The conference proceedings with ISBN 978-0-620-86085-7 will be provided at the conference to be held virtually from Livingstone, Zambia, from 6th – 7th October 2021.

Regards,

Dr Justus Agumba

DII-2021 PRP Manager

justusa@dut.ac.za

Conference website: www.diiconference.org

Email: info@diiconference.org

CONFERENCE PROGRAMME

DAY ONE (Wednesday, 6 October 2021)			
	https://us02web.zoom.us/j/82699524292?pwd=SXFJbGhvcTM1aDFGUWpjOVFsMERtZz09		
09:00-09:05	Arrival and announcements- Prof **Innocent Musonda** - DII 2021 ScientificChairperson		
09:05-09:10	Welcoming remarks: **Prof. Yanxia Sun,** *Vice Dean of the Faculty of Engineering and the Built Environment- UJ*		
09:10-09:30	Official opening of the conference and keynote: **Prof Daniel Mashao,** *Executive Dean of the Faculty of Engineering and the Built Environment- UJ*		
09:30-09:50	Keynote Address 1: **Prof. Ephraim Munshifwa,** *Dean of the School of the Built Environment at the Copperbelt University*		
09:50-10:15	Keynote Address 2: **Mr Marios Ntaflos,** *Engineer* | *Mobility Analytics & Simulation* | *CUBE, LEGION, LumenRT*		
10:15-10:15	Tea Break/Switching to Sessions		
	Technical Sessions https://us02web.zoom.us/j/87355044210		
	Breakaway Session 1	**Breakaway Session 2**	**Breakaway Session 3**
	SUSTAINABILITY IN INFRASTRUCTURE DEVELOPMENT **Session Chair**: Dr Nuru Gambo	**SMART INFRASTRUCTURE AND CITIES** **Session Chair**: Dr Bupe G Mwanza	**GENDER EQUITY, EMPOWERMENT, WELLNESS AND DEVELOPMENT** **Session Chair**: Ms Kolosa Madikizela
10:15-10:30	Establishing a conceptual framework for developing sustainable building materials- A. Moghayedi, K. Le Jeune, M. Massyn, and P. Byron	People, People, everywhere; The ArchitecturalDesign Response for Enugu City, Nigeria- **F. O. Okeke, F. O. Uzuegbunam, R.C.Nnaemeka-Okeke, and E. C. Ezema**	Socioeconomic Status, Gender and Outcome Expectations of Career Choices of Students in Construction Programs in South Africa- **M. Akinlolu and T. C. Haupt**

CONFERENCE PROGRAMME

10:30-10:45	On-site Infrastructure for Sustainable Water Resource and Wastewater Management for Newand Old Residential Areas - **F. M. Kakana and E. M. Mwanaumo**	Data sharing in the construction industry: exploring the willingness of industry stakeholders in South Africa- **T. O. Ayodele and K. Kajimo-Shakantu**	Skills Development in The Construction IndustryThrough Road Maintenance Activities- L. Matshidze, and A. Windapo
10:45-11:00	Sustainability awareness for architectural, engineering and construction professionals in Zimbabwe- **T. Moyo and B. Chigara**	Nigeria Public Transport System and The GlobalSmart City Crusade **J. J. Dukiya**	The Impact of an Industry Summit on Health andSafety (H&S) Practitioners' Industry 4.0 Perceptions- **J. Smallwood and C. Allen**
11:00-11:15	Influence of Team Integration and Adaptabilityin Project Team Cohesion in the Namibian Built Environment **J. Engelbrecht and C. Ferreira**	Renewable energy: the catalyst for a sustainable energy distribution sector in South Africa- **M. Bukula, B. Botha, D. Els and W. de Beer**	Effects of machine accidents on project delivery in the KwaZulu-Natal construction industry- **A. Mall and A. O. Aiyetan**
11:15-11:25	Tea Break/Switching to Sessions **https://us02web.zoom.us/j/87355044210**		
	Breakaway Session 4:	**Breakaway Session 5:**	**Breakaway Session 6:**
	INFRASTRUCTURE, INVESTMENT AND FINANCE- TRENDS AND FORECASTS **Session Chair**: Dr Chabota Kaliba	**INFRASTRUCTURE: ECONOMIC SUSTAINABILITY** **Session Chair**: Dr Peter M, Mukalula	**INFRASTRUCTURE: SOCIAL/ENVIRONMENTAL SUSTAINABILITY** **Session Chair**: Dr Neema Kavishe
11:25-11:40	Exploring The Impact of Asymmetric Lock-In on Cost Overruns in Megaprojects: The South African Energy Sector Projects- **N. Khatleli**	The Effect of Real Estate Obsolescence onEconomic Suitability- **T. Mkhwe-Mafereka, B. Botha, D. Els and K.Ntakana**	Evaluating the impact of leadership Styles andstrategic decisions on the performance of contractingfirms in South Africa **A. Daworaz, D. Nooraully, K. Alade, L.Matshidze, and A. Windapo**

CONFERENCE PROGRAMME

11:40-11:55	Measuring Procurement Performance UsingSigma Level Metric- **J. A. Ottou, B. K. Baiden, G. Nani and M. M.Tuuli**	Handling financial implementation challenges ofPublic-Private Partnerships (PPPs) in Zambia- **P. Mukalula**	The Impact of Indoor Environmental Quality on Building Occupants Productivity and Human Health:A Literature Review- **M. C. Mewomo**
11:55-12:10	The Impact of Project Cost Management onContractual Disputes in South Africa **C. Amoah and C. van der Linde**	A Framework for The Optimisation of Commercial Property Investment Opportunities in Africa- **J. J. Gouws**	Evaluation Of Current Maintenance Management Systems Adopted in South Africa: A Case Study ofPublic Facilities **M. G Mavangwa, F. Simpehand L. Wentzel**
12:10-12:30	Session Chairs Report		
12:30-13:00	Lunch Break		
13:00-15:30	Panel Discussion **https://us02web.zoom.us/j/82699524292?pwd=SXFJbGhvcTM1aDFGUWpjOVFsMERtZz09**		
	Discussants: Engr. Martin Manuhwa, Prof. Nuno Gil, Engr. Greshom Sichinga, Prof. Nthatisi Khatleli, Mr. Patrick Makape. **Facilitator:** Dr Sam Zulu		
15:30-15:45	Panel Discussion Outcome		
15:45	**Closing for Day 1**		

DAY TWO (Thursday, 7 October 2021)

THURSDAY, OCTOBER 7TH, 2021

https://us02web.zoom.us/j/82699524292?pwd=SXFJbGhvcTM1aDF GUWpjOVFsMERtZz09

09:00-09:10	Arrival & Welcoming Remarks- **Dr E Mwanaumo** - DII 2021 Technical Chairperson

CONFERENCE PROGRAMME

09:10-09:35	Keynote Address 3: **Dr David Oloke** *Centre Director & Senior academic at the University of Wolverhampton*		
09:35-10:00	Keynote Address 4: **Dr Jeffrey Mahachi,** *Head of the School of Civil Engineering and the Built Environment, UJ*		
10:00-10:05	Tea Break/Switching to Sessions https://us02web.zoom.us/j/87355044210		
	Breakaway Session 1:	**Breakaway Session 2**	**Breakaway Session 3**
	QUALITY AND RESILIENT INFRASTRUCTURE **Session Chair**: Dr. Charles Kahanji	**BIM, DIGITAL TWINS, AND INNOVATION** **Session Chair**: Dr. Balimu Mwiya	**ENVIRONMENTAL AND WASTE MANAGEMENT/ FACILITIES & REAL-ESTATE MANAGEMENT** **Session Chair**: Dr. Chioma Okoro
10:05-10:20	Poor management and maintenance of municipal infrastructure on socioeconomic development **O. Mazele and C. Amoah**	Research Trends of Human-Robot Teams/Roboticsin Construction: A Scientometric Analysis **A. Onososen and I. Musonda**	Construction Waste Management Practices in the Construction Industry **L. Nzima and E. Ayesu-Koranteng**
10:20-10:35	Effective Management for Perceived Success of Infrastructure Development FOR SOE's **F. Notununu, B. Botha and D. A. Els**	South African Building Information Modelling andOrganizational Size - a Quantity Surveyor's perspective **B. Venter, S. P. Ngobeni and Hendri du Plessis**	Success Rate and Implications of Contractual ClaimsDecisions on Contractors in South Africa **J. Khangale, I. Musonda and C. Okoro**
10:35-10:50	Assessment of African Countries Strategic Position to Leverage on China's Belt and Road Global Strategy **I. C. Anugwo**	Building Information Modelling in South Africa:Quantity Surveyors Perspective **G. Bruhns and A. Deacon**	Cost Efficiency: A Key factor for IT Outsourcing inFacilities Management- **B. O. Ilori**
10:50-11:05	On-time delivery of property developmentprojects- **T. L. Mkhwe-Mafereka, B. Botha and K.Ntakana**	Barriers to successful BIM applications: A literature review **T. James Olaonipekun and M.C. Mewomo**	Impact of value engineering in road construction oncost, quality, and time management- **F. M Kakana and E. M. Mwanaumo**

CONFERENCE PROGRAMME

11:05-11:20	Evaluation of the trend of residential mobility inUyo, Nigeria **G. O. Udo, A. K. Nwojo and U. E. Akpan**	Occupational Health and Safety Hazards in the KwaZulu-Natal Construction Industry: Causes andMeasures **A. Mall and A.O. Aiyetan**	Safety and Security in Urban Public Spaces as a a significant component of Social Sustainability **K. Ntakana, S. Mbanga and B. Botha**
11:20-11:35	Session chair report		
11:35-11:45	Tea Break		
11:45-14:05	PhD. Poster Presentation https://us02web.zoom.us/j/87355044210		
14:05-14:20	Award Presentation • Best Student Research Paper • Best Conference Research Paper • Best PhD. Poster Presentation • Best Reviewer		
14:20-14:25	**Conference Chair Closing Remarks**		

Proceedings of the DII-2021 International Conference: "Building Smart, Resilient and Sustainable Infrastructure in Developing Countries"

DII-2021-OO3

Establishing a Conceptual Framework for Developing Sustainable Building Materials

Alireza Moghayedi[1*], Karen Le Jeune[1], Mark Massyn[1] and Paimaan Byron[2]
**Corresponding Author*

Abstract

Sustainable building materials are products with a relatively positive impact on economies, communities, and the environment. Understanding the key indicators in developing sustainable building materials is a critical perspective for their development. Research in this field is a relatively new and ever-evolving field encompassing an interdisciplinary area. Therefore, the study examined existing literature to identify and cluster key indicators of sustainable building materials and propose a probable conceptual framework for developing these materials. Using a mixed bibliographic and bibliometric method, the study employed a verifiable and reproducible systematic literature review of building materials and scrutinising 203 academic articles for the co-occurrence of keywords. A clustering analysis based on the bibliometric method identified key indicators of emerging themes and their interconnections. It emerged from the study that Process, Material, Element and Technology themes seemed to have significant indicators loading on sustainable building material conceptual framework. It was found that Life-Cycle Assessment (LCA), embodied energy, and recycling appears to be the predominant processes in developing and evaluating sustainable building materials. Concrete bricks, C&D waste and fibres are the foremost materials, while walls and roofs are the main building components. Composite, 3D printing, nanotechnology, and prefabrication are leading technology features. The results from the analysis of interconnections of indicators revealed significant interconnection between embodied energy, LCA, concrete, composite, and durability to the sustainability of building materials. Based on the taxonomy of indicators and the analysis of their interconnections, a conceptual framework for developing sustainable building materials was proposed in the paper

Keywords: Bibliometric analysis, building element, Building material, Process, Sustainable building materials, Technology.

1. Introduction

Housing and building conditions reflect the living standards of society (Wang *et al.*, 2018). One of the main approaches to significantly improving housing and building conditions is to use sustainable materials to construct such projects (Allen and Iano, 2019). The sustainable building materials approach has a high potential to make a valuable contribution to sustainable development. Sustainable building materials have a relatively positive impact on economies, communities, and the environment (Berge, 2009).

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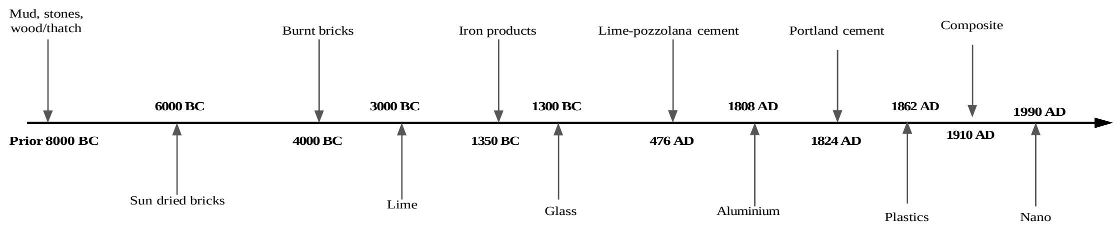

Figure 1: Building materials historical development. Source: Wu *et al.*, (2019)

Building materials, technologies and practices have evolved through the ages. However, cement, steel, bricks, aluminium, paints, ceramic products, and plastic products are examples of common building materials (Wu *et al.*, 2019). Figure 1 presents the history of the development of building materials on a timeline.

Challenges associated with delivering sustainable and affordable housing are linked to building materials and technology's efficiency and sustainability issues. Several studies showed that building materials constitute the most significant single input in the sustainability of housing (Moghayedi *et al.*, 2021; Adegun and Adedeji, 2017). Various building materials are available in the market; however, most of these materials are developed without considering the necessary sustainability. The result negatively affects the performance and sustainability of buildings and housing (Moghayedi and Windapo, 2018). Building materials must be sustainable to address the technical, environmental, social, and economic issues associated with the use of conventional building materials. According to Hill and Dibdiakova (2016), various characteristics of the building materials shown above need to be carefully considered before they are used in construction. These include raw materials and natural resources, life cycle energy consumed, safe disposal and recycling, environmental impact, long-distance transportation, and end-user satisfaction. The metamorphosis of building materials production from highly decentralized labour-intensive methods to a centralized, machine-dependent industry model (Wu *et al.*, 2019) makes transporting raw materials and the finished building materials over great distances imperative. Transportation of materials to and from processing plants also contributes to the cost of materials (Windapo and Moghayedi, 2018) and increases energy consumption and environmental issues (Roh *et al.*,2017; Windapo and Moghayedi, 2018). The promotion of sustainable construction practice has resulted in the development of sustainable building materials (Akadiri and Fadiya, 2013). However, the exclusive use of energy-efficient traditional materials presents challenges to satisfying the ever-growing demand for housing and buildings.

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The question that arises is whether the current production, consumption and distribution of building materials are sustainable. Optimum utilisation of available resources and raw materials to produce simple, resource- and energy-efficient, healthier, comfortable and environmentally friendly sustainable building materials to overcome these challenges becomes necessary. Sustainable building materials were developed to improve the sustainability performance of buildings through reduced water usage, higher energy efficiency, enhanced indoor quality and minimal construction waste (Windapo and Ogunsanmi, 2014). Sustainable building materials optimise building performance, make buildings' use more predictable for an extended period, and contribute to the competitiveness of building contractors (Takano *et al.*,2014). They have also been linked to the possibility of meeting the ever-increasing demand for buildings due to growing population and over-urbanisation (Durdyev *et al.*,2018). However, there are challenges to the development and manufacture of sustainable building materials. The sustainable building materials framework seeks to embrace the key indicators for developing sustainable materials in the context of the material, technology, process, and element and the interconnections between them. Besides contributing to the development of the sustainable building materials knowledge base, the taxonomy of key indicators in a format of a conceptual framework provides a foundation for developing and using the building materials efficiently in construction projects. Therefore, the novelty of this research rests in identifying and clustering all key indicators involved in developing sustainable building materials. In this paper, the terms features, indicators, and parts are interchangeably used.

Several studies have identified challenges to developing sustainable building materials, but previous studies did not provide extensive analysis and understanding of the indicators in developing sustainable building materials. Akadiri (2015) classified the challenges into five categories: perception of extra cost and time incurred, lack of access to sustainable material information, lack of comprehensive tool and data to compare material alternatives, and maintenance concern based on expert judgment. This method of classification lacks rationality, credibility, and empirical support. Besides, studies on sustainable building materials have not explicitly investigated nor extensively analysed or understood the challenges of developing sustainable building materials concerning their features and performance. Studies such as Darko and Chan (2017), Mesthrige and Kwong (2018) and Durdyev *et al.* (2018) have focused on the challenges of alternative and sustainable design and construction. Darko and Chan (2017), Ghisellini *et al.* (2018) and Darko *et al.* (2017) have investigated the challenges of developing and adopting green building technologies. There is a need for not only a deep and better understanding of key indicators of sustainable building materials to developing a framework for sustainable building materials and evaluating their impact on the building sustainability index (Kono *et al.*, 2018; Danso, 2018; Moghayedi and Windapo 2018; Conte and Monno 2012). but also for establishing the interconnections between the indicators of sustainable building materials. This research

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expands the boundary of and fills the gaps in knowledge in the areas of sustainable building materials by addressing the following questions:

i. What are the indicators of sustainable building materials in the context of the material, technology, process and element?

ii. What are the interconnections between the indicators of sustainable building materials?

2. Research methodology

The research questions are addressed by undertaking a systematic literature review described in the following section.

2.1. Databases, keywords, and inclusion criteria

The methodological framework of this study is illustrated in Figure 2 below. The bibliometric research approach was used in developing the bibliographical analysis, which assists in identifying the collection's characteristics and size and elaborating growing forecasts. The bibliometric research approach comprises four phases: keywords definition, database definition, documents search, and analysis of the defined literature sample. The methodological procedures for grasping the bibliometric examination described were developed from January 2021 through February 2021. With this potential result, the bibliometric research approach helps to fulfil the research aim of determining the key indicators of sustainable building materials and whether there are interconnections between these key indicators.

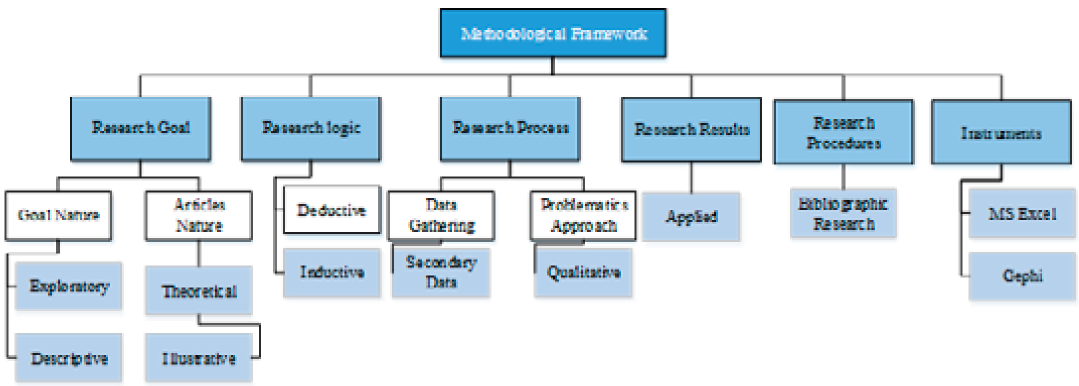

Figure 2: Methodological framework adopted in this research

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2.2. Keywords and database definition

The database definition phase offers the opportunity to establish the research boundaries. This would present the possibility of building the whole portfolio of articles, using the results found in the defined database, once the articles that emerge have been analysed. Keywords convey the main topics of studies and, as such, represent them. Thus, co-occurring keywords can be identified and analysed to reflect a given field's most popular research issues (Moghayedi *et al.*, 2021). The initial step for building this bibliometric examination was the definition of the keywords that were utilized in the databases to find documents potentially related to establishing indicators of sustainable building materials.

The search keywords used were “construction”, “sustainable”, and “building materials” to reflect the theme of this research. The search involved gathering document titles, abstracts, and author keywords. Two major scientific databases, namely, Scopus and Web of Science, were used to search for relevant documents to ensure that all pertinent papers were included. After that, the union sets of “construction*” AND “sustainable*” AND “building materials” were used for selecting documents.

2.3. Articles search

After the defined keywords, the bibliometric search was done on the two selected databases. The searches were undertaken considering the following specific parameters; thus, results were limited to environment, engineering, materials, and energy subjects. The research results were confined to the final peer-reviewed international conference proceedings and scientific journal articles published in English, and there was no restriction on the time of the publications. The initial search outcomes from the two databases yielded 297 documents (Scopus, 121 documents, and Web of Science, 176). The titles and keywords of the 297 documents were studied, looking for alignment with the research object (indicators of sustainable building materials). Based on the evaluation of titles and keywords, 94 articles that did not align with the research topic were excluded, obtaining a final sample of 203 articles.

3. Data analysis

The following criteria were used to analyse the articles portfolio: Trend of publications in time; Research territory analysis; Authorship and collaborations; Keyword analysis; Keyword clustering analysis; and Interconnection analysis.

3.1. Publication trend in time

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Figure 3 shows the publication trend of the documents on sustainable building materials. Although the publication period was not restricted, only five relevant documents (2%) were published before 2011, which indicates the novelty of the sustainable building materials research field. The increasing trend of publication has been slightly stable in the whole period of study. 62% of the sampled documents were published in the last four years. In the last four years, this large number of publications may have been driven by building materials manufacturers having been forced to develop new possibilities to reduce the embodied energy and carbon footprint of building materials and construction projects. This is because of the increased consideration around the integration of environmental and social sustainability (Wong and Zhou, 2015; Banihashemi *et al.*, 2017; Carvajal-Arango *et al.*,2019).

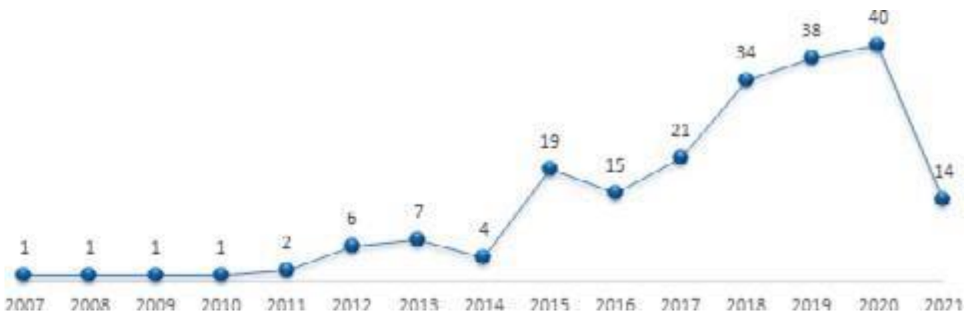

Figure 3: Publication trend in sustainable building materials

3.2. Territory of publication

The number of document publications in a country indicates the extent of research undertaken in a field there and acts to identify which countries are progressing more in this specific topic. Thus, it is meaningful to analyse the contributions of countries to sustainable building materials research. Figure 4 shows the number of selected research articles distributed by the countries of origin.

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Figure 4: Publication territory in sustainable building materials

Figure 4 shows that the top three contributors to sustainable building material research are Italy (24), Spain (18) and the United States of America (16), with more than 28% of all publications in the sustainable building materials field. Furthermore, Figure 4 shows that India (15) and Brazil (13) are the only developing countries among the top ten countries with the most publications in this area and that 32% of the selected documents are affiliated with developing countries. To a great extent, this indicates that research on sustainable building materials is a topic less published in developing countries, particularly in Africa compared to developed countries.

3.3. Authorship and collaborations

Overall, 664 authors contributed to the identified sustainable building materials literature. 92% of the authors published only a single article. 7% of authors published two articles, while less than 1% of the authors published more than two articles in this field of research. Table I lists the number of authors per document, which reveals that most documents (26.6%) were written by a collaboration of two authors, three authors (21.7%) and four authors (20.7%). The increased number of scholars interested in the sustainable building materials area and the interdisciplinarity of this research field, which requires interchanges and complementary knowledge across various research areas, have probably led to the increase in collaborations.

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Table I: Research authorship

Authorship	Frequency	Per cent
Single author	13	6.4%
Two authors	54	26.6%
Three authors	44	21.7%
Four authors	42	20.7%
Five authors	26	12.8%
Six authors	10	4.9%
Seven authors	10	4.9%
Eight and more authors	4	2.0%

Figure 5 illustrates international research illustrated in Figure 5, which was established based on the authors’ origins. Each node depicts a country, and its size indicates the number of articles published by authors from that specific country. Figure 5 shows that Italy and Spain published most of the papers identified on sustainable building materials. However, a significant number of articles came from the United States, India, and the United Kingdom. The links in Figure 5 represent the level of collaboration among countries, and the thickness of each link reflects the collaborative intensity between the two countries. Figure 5 shows that United Kingdom researchers have established the most extensive collaborations network with twelve other countries across the globe (5 African, 4 European, 2 Asian and 1 Oceania), while Italy and Spain have the most influential collaborations between any two countries.

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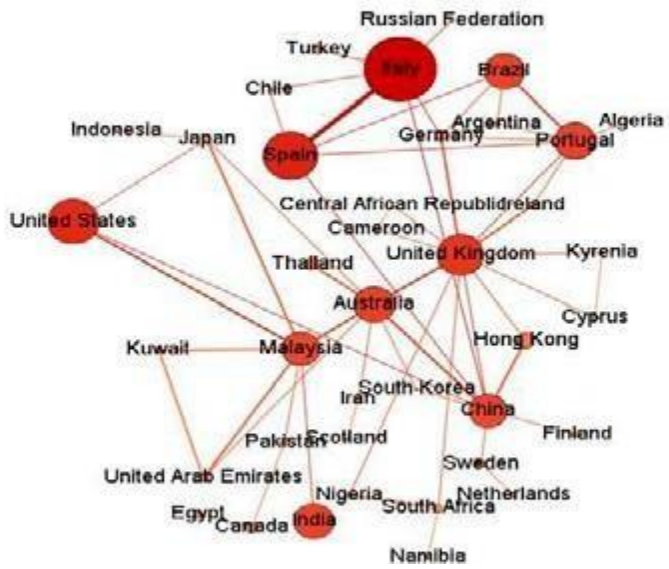

Figure 5: Research collaboration ranks and strengths

3.4. Analysis of keywords

The keywords were analysed to verify the findings of the key research topics, which established indicators of sustainable building materials. The analysis was done manually to eliminate keywords used to identify possible similarities in concepts signposted by different keywords—the resultant list comprised 339 keywords extracted from the 203 documents selected from the database for the study.

The frequency (also known as occurrence) of a selected keyword was calculated in the next step. Following this, the keywords were then ranked according to their frequency. The specific steps taken were as follows:

- MS Excel and MATLAB were used to build a node table, quantify the recurring keywords in the selected documents, and develop an edge matrix that quantifies the frequency of co-keywords appearing in one paper. In this way, 1,767 co-keywords were extracted.
- The node table and edge matrix were imported to the Gephi software to establish and visualise a keywords network, as presented in Figure 6.

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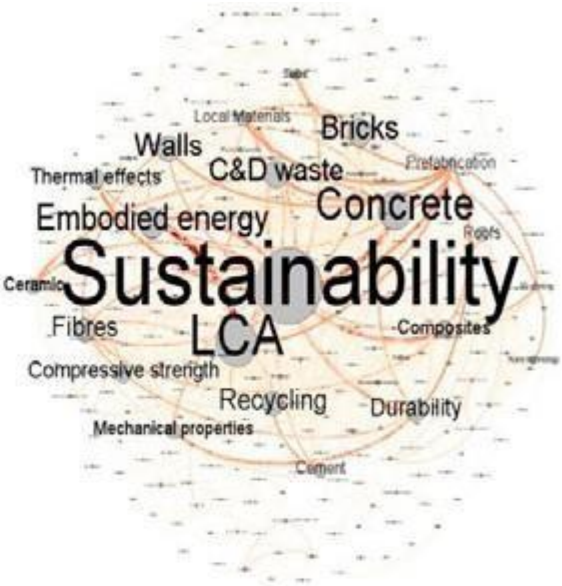

Figure 6: Keyword network

Figure 6 shows the keyword network. Each node represents a keyword, while the size reflects the number of recurrences of the keyword in the sample of documents. An overview of the size of nodes shows the most important indicators and their distinct importance in building materials studies. There are some high-frequency central keywords in the first focus. These include sustainability, Life-Cycle Assessment (LCA), embodied energy, concrete, Construction & Demolition (C&D) waste, bricks, and walls, which have received much focus and were used by most researchers on sustainable building materials. The keyword network also indicates the significant interconnection of key indicators to each other. The links in Figure 6 denote the interconnections among keywords, and the thickness of each link represents the interconnection strength (number of interconnections) between two keywords. Embodied energy and LCA; Sustainability and Concrete, Composites, Embodied energy, Durability; and Thermal effects are the pairs of keywords with the strongest interconnections. This finding suggests that significant research is being undertaken to determine the sustainability of concrete as a building material and the role of Embodied Energy in Life-cycle Cost Analysis.

3.5. Keyword clustering analysis

The Giant Component analysis was applied to the first network, and 19 nodes, which were not connected to the main network, were eliminated, which verified that more than 94% of selected keywords were integrated into the main network and considered in the further

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network analysis. According to Allen and Iano (2019), the sustainability of building material is associated with characteristics of raw materials, the manufacturing technology used, the building component for which the material is produced and the process of evaluating the material. The identified keywords were clustered into four groups: Material, Technology, Process and Element. In Figure 7, the presence of the four groups is indicated, which are indicated by green, blue, red and pink for groups Material, Technology, Process and Element, respectively.

The application of the four groups to the nodes network evolved from the keywords mapping with Gephi. The size of each group varies from 188 keywords in the Process group (red nodes), 104 keywords in Material group (green nodes), 22 keywords in the Technology group (blue nodes) to 22 keywords in the Building Element group (pink nodes), as shown in Figure 7. Furthermore, the network diagram clarifies the interconnections and relationships of each keyword within-group and with other groups. For instance, the strongest interconnection is between the LCA and embodied energy, while the most significant relationship is between the Material and Process group.

Figure 7: Clustering of 4 major groups

Advanced statistical analyses, such as connected components and average clustering coefficient, were applied to four groups of keywords to evaluate and validate the clustering. Table II shows the details of the statistical analysis of the connected components and the average clustering coefficient.

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Table II: Connected components and average clustering coefficient

Group	Connected components	Average clustering coefficient
Process	1	0.736
Material	1	0.688
Technology	1	0.557
Building Element	1	0.537

Table II reveals that the connected components of all four groups are 1, which shows that all keywords in each group were interconnected. The average clustering coefficients of all four groups are greater than 0.5, which shows that the nodes in each group are clustered tightly with strong interconnections (Saramäki *et al.*, 2007). The connected components and average clustering coefficient of groups validate the clustering of the keywords as proposed.

The most discussed topics are in the Process group with 56% of total keywords, followed by Materials with 31% of keywords, and Technology and Elements with 6.5% of keywords each, which revealed the importance of different groups for the researcher in this field study. Similarly to the frequency of nodes, the most edges are seen in the group of Process (59%), Material (35%), Element and Technology (3%), respectively (See Table III).

Table III: Frequency of nodes and edges

Group	Node		Edge	
	Number	Percentage	Number	Percentage
Process	188	56%	468	59%
Material	104	31%	276	35%
Technology	22	6.5%	24	3%
Element	22	6.5%	25	3%

Material cluster

The Material cluster includes 104 keywords related to the type of materials, such as concrete, bricks, C&D waste, fibres, ceramic, and local materials (see Figure 8).

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Figure 8: Material network

In this cluster, concrete becomes the main sustainable building material indicator studied and located in the centre of the network, and it has strong links to other materials and additives. Figure 8 shows a strong network between concrete, ceramic, bricks, C&D waste, fibres, cement, and local materials. This strong network between materials and additives outlines the potential of developing sustainable building materials by combining these materials and additives. For instance, utilising local materials and recycling bricks, ceramics and other (as the most common building materials) and C&D waste to the mixture of concrete can reduce the cost and negative environmental impact of concrete (Abed *et al*., 2020). Adding fibres to concrete also reduces the ratio of cement in standard concrete (Yousefie *et al.*, 2017).

Technology cluster

The Technology cluster contains 22 keywords, marked with blue, which mainly contribute to manufacturing the building materials, such as composites, prefabrication, nanotechnology, and 3D printing (See Figure 9). This group has 24 links to the other nodes (keywords) across the network. Among these keywords, composites and prefabrication are central, which outlines the importance of these two technical indicators. According to Gayevskaya and Rakova (2014), to optimise the sustainability and functionality of building materials, it is necessary to employ the combination of several new technologies in the procedure of manufacturing building materials. The complex relationships among the new technologies, such as composites, prefabrication, 3D printing, and nanotechnology, are shown in this network. This finding suggests that composites and prefabrication are generating much interest among researchers in the field of sustainable materials.

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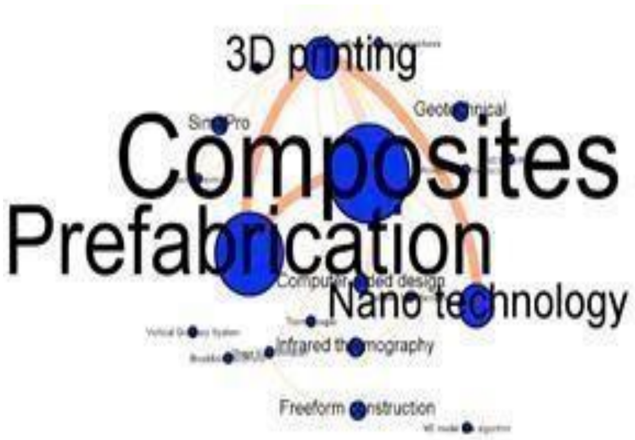

Figure 9: Technology network

Process cluster

The co-words in the Process group include 188 keywords that primarily concern processes to evaluate and assess building materials. There are some high-frequency central indicators in the first focus, such as LCA, embodied energy, durability, recycling, and thermal effects. The network map in Figure 9 highlights the relationships of sustainability to the other process keywords because of the economic and environmental issues of building materials, such as high cost of materials, high impact on the environment, and consuming resource consumption, water, and energy (Adegun and Adedeji, 2017, Wijayasundara *et al.*, 2017). The processing cluster receives increased interest from researchers and is connected with keywords with the other three clusters.

Figure 10: Process network

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Figure 10 shows that the line between LCA and embodied energy within the cluster is thicker than the other edges. This signifies the emphasis of several scholars on the life cycle assessment and embodied energy of building materials (see, for example, Wen *et al.*, 2015; Ajayi *et al.*, 2019). Indicators, such as compressive strength and mechanical properties. Are also included in this network, which suggests a close association between technical processes and the sustainability of building materials.

Element cluster

The Element cluster mainly highlights the components of building/construction; it contains 22 items, such as walls, roofs and slabs. The keywords in this network are relative with fewer linkages with the keywords in other groups (clusters), evidencing that the research on sustainable building materials has less association at the elements scale (see Figure 11).

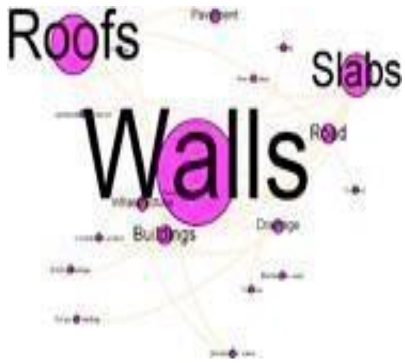

Figure 11: Element network

4. Interconnection Analysis

Clustering analysis provides a comprehensive profile of sustainable building materials studies and reveals the main streams of keywords concentration. The process, material, element and technology indicators are all directed toward the concept of sustainable building materials. This section deals with the attribute filter applied to the developed keyword network to evaluate the interconnections between identified vital indicators. The range of edge degrees was adjusted at 50% recurring to illustrate the interconnections of key indicators of sustainable building materials, and the results are presented in Figure 12 and Table IV.

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Figure 12: Interconnection network between the key indicators

Table IV shows that the more occurrence indicators with more robust interconnection are situated closer to the centre of the network. The identified critical indicators of sustainable building materials, their occurrence and interconnection size are listed in Table 4.

Table IV: Key indicators of sustainable building materials

Indicators	Occurrence	Group	Rank
Sustainability	98%	Process	1
LCA	62%	Process	2
Concrete	49%	Material	3
Embodied energy	38%	Process	4
Bricks	36%	Material	5
C&D waste	35%	Material	6
Walls	33%	Element	7
Recycling	31%	Process	8
Fibres	29%	Material	9
Durability	27%	Process	10

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Compressive strength	26%	Process	11
Thermal effects	24%	Process	12
Composites	22%	Technology	13
Ceramic	20%	Material	14
Mechanical properties	20%	Process	14
Roofs	18%	Element	15
Local Materials	18%	Material	15
Cement	18%	Material	15
Slabs	13%	Element	16
3D printing	9%	Technology	17
Nanotechnology	9%	Technology	17
Prefabrication	9%	Technology	17

Table IV shows that the number and occurrence size of four groups indicators emphasise the significant role of each group in improving the sustainability of building materials. The sustainable building material clusters were distributed according to Process (8 indicators), Material (7 indicators), Element (3 indicators) and Technology (4 indicators), with Process being the most significant sustainable building material cluster.

As shown in Figure 12 and summarized in Table IV, Sustainability, LCA, Concrete and Embodied energy are the most important indicators with the highest occurrence and interconnection, particularly LCA, embodied energy and concrete being the core areas with a close connection to sustainability. Figure 12 shows an intense connection between LCA and Embodied energy, which indicates the high importance of building materials' embodied energy in evaluating the building materials' LCA. This is due to the high embodied energy of common building materials because of the high use of virgin resources and the inefficient consumption of energy and water during manufacturing conventional building materials (Ajayi *et al*., 2019).

Also, the indicator network shows the direct and indirect interconnections between the key indicators. Sustainability, as the most important identified indicator with the highest number of occurrences and largest interconnections, has a direct interconnection to Concrete, Embodied energy, Composite, Thermal effects, Durability, C&D waste, LCA, Local materials, Fibres, Ceramic, Slabs, Cement, Walls, Roofs, 3D printing, Nanotechnology,

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Prefabrication and Mechanical properties. Moreover, Sustainability has a robust indirect interconnection to Recycling, Nanotechnology, Compressive strength, and Bricks.

Figure 13 shows the conceptual framework that summarizes the identified features of sustainable building materials and their interconnections. The proposed conceptual framework will be beneficial for developing sustainable building materials.

Figure 13: Sustainable building materials framework

The sustainable building materials framework elucidates the cycle of developing and evaluating building materials based on the identified suitable materials and additives, applicable technologies, most relevant building elements, and appropriate processes to evaluate the sustainability of the building materials. The developed conceptual framework provides a roadmap for creating and using more sustainable materials to enhance the housing and building conditions and improve society's living standards.

5. Conclusion

This study provided a holistic assessment of key indicators of sustainable building materials in the context of four major groups, namely, material, technology, process, and element. The research employed a verifiable and systematic review of relevant publications (total of 203 papers), summarized the status of research in sustainable building materials, developed a sustainable building materials concept framework and prospected for future research trends. The major findings of this study are that: research into sustainable building materials is a

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relatively young field with a stable increase in publication trend. The results revealed that developed countries, such as Italy, Spain and the United States, contribute to sustainable building materials research. In contrast, developing countries, such as India and Brazil, where construction will continue to be one of the key economic activities in the coming years, are strong contributors to this field of research. However, developing countries, such as South Africa, Egypt, and Nigeria, which are dealing with grave housing problems, remain inactive and should strengthen their research efforts concerning sustainable building materials to solve their housing issues.

This study reveals the key indicators in sustainable building materials, the interconnections of co-indicators, and the benefits of studies that straddle the theoretical sciences and construction projects. It emerged from the research that Process, Material, Element and Technology groups contained the highest number of features and the most significant indicators of sustainable building materials that are actively researched. Furthermore, based on the analysis of keyword networking, in developing and evaluating sustainable building materials, sustainability, LCA, embodied energy and recycling are the predominant processes investigated; concrete, bricks, C&D waste and fibres are the foremost materials. Walls and roofs are the main building elements, and composite, 3D printing, nanotechnology, and prefabrication are the leading technical indicators. Also, the results of the interconnection of indicators analysis revealed the strong relation of embodied energy, LCA, concrete, composite and durability to the sustainability of building materials, which proves that the other key indicators are frequently examined in relation to sustainability.

Meanwhile, the proposed sustainable building materials conceptual framework highlights the clusters that must be examined to facilitate the development of sustainable building materials, providing economic, social, and environmental solutions and cleaner production compared to current building materials issues. Although the study of sustainable building materials has been increasing over the past years, there are still many research gaps. The specific results of this study provide insight into gaps in literature and research opportunities. Future research may consider conducting a bibliometric analysis to identify the challenges and barriers to developing and adopting sustainable building materials. Future research could also use the conceptual framework of sustainable building materials to develop and evaluate the impact on the social, environmental and economic aspects of construction and housing projects. However, this study is limited because it considers only articles published in peer-reviewed scientific journals, international conference proceedings and chapters in books, and some relevant articles may have been excluded.

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6. Acknowledgements

The Royal Academy of Engineering, UK, this research was financially supported under the Frontiers Champions (Grant No. FC-2021-1-39). The authors express their gratitude to the National Home Builders Registration Council (NHBRC) of South Africa panel members who provided their expertise for this research.

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DII-2021-009

On-site Infrastructure for Sustainable Water Resource and Wastewater Management for New and Old Residential Areas

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Abstract

Water is one of the significant resources required for human health and development. Water provision has continued to play an essential role in agriculture, industrialisation, mining, construction, transportation, and hydropower energy production, which are critical sectors of socio-economic development. The opening up of planned and unplanned settlements coupled with an improved urban water supply and individual domestic connections in non-serviced areas has increased water consumption with increased water pollution and wastewater disposal problems. The continued use of non-coordinated and unsupervised borehole drilling and construction of septic tanks for water supply and wastewater treatment, respectively, have polluted underneath aquifers, remaining unsafe or toxic for decades or even centuries. This study, therefore, aims to propose a sustainable onsite water resource and wastewater management mechanism for residential areas to aid authorities in non-serviced areas to manage sustainably, protect existing groundwater and water body resources from further pollution and management of wastewater as well as reduce impacts of climate change on water-related issues. Respondents scored waste monitoring – 68.4%, secondary raw material market – 78,9% and prior sorting of waste as some of the approaches for sustainable disposal of residential solid waste. Greywater can also be sustainably managed through reuse and separation of sewer networks. Rain harvest -97.4%, improved drainages – 84.2%, engineered soakaway pits – 68.4% and catchment reservation – 63.2% were recommended for sustainable management of stormwater. Further, full casing, bottom plug, gravel pack and sanitary seal should be installed for any successfully drilled borehole for sustainable groundwater management and protection. Furthermore, the draining field should replace soakaway pits in a domestic sewer treatment structure to provide effective natural filtering and remove impurities from sewer water before it infiltrates groundwater. These sustainable water resource management systems play an essential role in delivering utilisation water for human activities, plant growth and soil formation, and contributing to socio-economic development.

Keywords: Aquifer, Effluent, Groundwater, Pollution, Scum, Sludge, Sustainable Management.

1. Main Body of the Paper

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Subsurface water that exists in the pore spaces or channels caused by dissolution of soluble rock is known as Groundwater, and it's the leading reservoir of safe water globally after polar ice caps comprising 100 times greater the volume of surface safe water (Brands *et al.*, 2018). It is primarily accessible within 1km of the earth's surface, and beyond that depth, its quality decreases due to salinity and mineral concentration. Groundwater quality is mainly influenced by; the dissolved constituents of the recharge water, contacts between the water and the earth, reactiveness of the soils, gases and rocks water contact within the unsaturated zone, and the dwelling time. Because of these factors, there can be a lot of variation in groundwater quality within the same area due to differences in rock composition and dissolution, which are influenced by "aquifers physical (dispersion/dilution, filtration and gas movement), geochemical (complexation, acid-base reactions, oxidation-reduction, precipitation-solution, and adsorption-desorption) and biochemical (microbial respiration and decay, cell synthesis)" (Meybeck *et al.*, 1996). With an expected increase in population by twice its current size between 2000 and 2030 coupled with a failure by two-thirds and one-third of the continent's population in rural and urban areas to access safe, adequate clean water and proper sanitation. This calls for immediate sustainable management of the major freshwater supply (Nkhuwa, 2018). Traditional practice shows that the groundwater rights are vested in the overlying landowner, which has led to overexploitation of aquifers, estimated at 24%. 36% of the earth's surface is covered with major aquifers consisting of sedimentary rocks, 18% are complex aquifers, and heterogeneous geology and 47% are locally and underneath the land surface and along stream valleys and lowlands. There are two types of aquifers, confined and unconfined aquifers, and mostly unconfined aquifers are usually vulnerable to pollution. Groundwater contributes significantly in providing utilisation water for human activities, plant growth and soil formation and is an important component of the hydraulic cycle (Chilton, 1996). Compared to surface water bodies, monitoring and tracking groundwater is challenging; hence, modelling and mapping have been employed to understand its storage, distribution, and flow patterns to establish measures for sustainable use and mitigate pollution (Brands *et al.*, 2018). Current available and future groundwater aquifers threats such as climate change, over-abstraction, pollution, agriculture use, natural contamination, industrial contamination etc., requires sustainable water policy and planning.

Climate change has impacted groundwater quantity in two major ways; it has affected precipitation to a point where it has become less predictable. These precipitation patterns have affected aquifer recharge. An increase in temperature has also favoured evaporations of surface water, resulting in drylands (Meybeck *et al.*, 1996). Over abstraction of groundwater to meet human activities has also reduced aquifer capacity leaving most surfaces permanently compacted while forming sinkholes, making such areas vulnerable to flooding (Danielopol *et al.*, 2003).

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Human activities largely depended on groundwater, and due to its variation in availability and accessibility coupled with uneven distribution of human population, especially in mine and urban cities, has led to high demand resulting in overexploitation and contamination of major aquifers ((Harter, 2003; Sadat-Noori *et al.*,2013; Talabi and Kayode, 2019). Water's ability to sustain various uses and processes meets the specific physical, chemical, and biological characteristics known as water quality. It has also been established that groundwater quality increases with depth from the land surface, with excellent water quality found at a depth of 25 – 80m (Sadat-Noori *et al.*, 2013; Wahaab *et al.*, 2019; Chungu *et al.*, 2019; Gupta and Sarma, 2013). Both natural and human influences have affected the quality of water (Meybeck *et al.*,1996). Poisonous elements and ions such as arsenic, radionuclide and fluoride have been found in groundwater, making it unhealthy for human consumption. Other elements such as calcium and magnesium tend to have a less human health-related impact but form deposits that cause blockages and affect domestic use. The foul smell and water taste are mainly affected by sulfur compounds, and reddish dyes on fabrics washed with groundwater caused by high iron levels (Brands *et al.*, 2018). Pollution of the aquatic environment has primarily been associated with an increase in industrialisation and urban centres. Contamination of land surface due to human activities such as mining, industrialisation, waste management, farming, toxic substance disposal and leakages, domestic waste disposal and effluent from a septic tank not serviced by municipal councils have continued to pollute groundwater. Most of it originates from the recharge of rainfall infiltration from polluted surfaces (Singh *et al.*, 2016; Talabi and Kayode, 2019). There is variation in the toxicity of this human behaviour, just like there are a lot of remade measures to restore groundwater quality.

Agriculture activities have introduced Nitrates to groundwater which is highly soluble and contaminated (Danielopol *et al.*,2003). The concentration of nitrate can significantly be reduced from the source and through prevention approaches. Dense non-aqueous phase liquids (DNAPLs), which are less soluble and mobile compounds such as trichloroethylene, are more expensive to remove as they are denser than water and settle at the bottom, where they gradually break down produces poisonous substances. Petroleum products leaking from the ground tank are mostly non-aqueous phase liquids (LNAPLs) that usually float on groundwater in the aquifers (Mumba *et al.*,2019). Inappropriate siting of septic tanks has continued polluting groundwater by introducing microbial coupled with untreated municipal council sewer water discharged into water bodies and infiltrated into aquifers (Brands *et al.*,2018). Faecal pollution of ground water has occurred due to the three following major reasons (i) lack of community facility for waste disposal, (ii) inadequate or improper operation of treatment facilities and (iii) direct draining of onsite sanitation facility into the aquifer (Meybeck *et al.*,1996). An increase in agriculture yield has decreased groundwater

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quality and quantity due to unsustainable cultivation methods such as fertilizer, insecticides, and irrigation (usually groundwater is used).

Mining has been one of the significant groundwater polluters because both open and underground mining activities extend beyond water tables. Major dewatering of heavily concentrated mineralised water is required to allow the mining process to continue. Implemented mining techniques such as hydraulic fracturing or fracking used in extracting oil have exposed groundwater to significant threat as 8 – 20 million litres of water are used and aquifers contaminated during the process (Chilton, 1996; Raghavendra and Deka, 2015). Mining products such as Coal, salt, potash, phosphate and uranium are toxic to groundwater joined with tailing dams and settling ponds. Also, disposal of saline water from production wells with oil has been a significant problem. Overpopulation and concentrated human activity in mine cities have also favoured the formation of the potential source of contamination on the land surface underlined by aquifers and aid by favourable geology for transfer between the two have continued to contaminate groundwater (Xu *et al.*, 2019).

Statistics have shown that the polar ice caps and glaciers contain 68% of freshwater, inaccessible for public use, while 30% is found underground. Only 1.2% is found in streams and lakes hence the need to implement measures that mitigate threats to groundwater and promote sustainable use as recommended in (Brands *et al.*,2018; Raghavendra and Deka, 2015; Smith *et al.*,2016; Xu *et al.*, 2019; Giordano, 2009; Ojo *et al.*, 2012; Talabi and Kayode, 2019; FAO *et al.*, 2003).

One major approach to safeguarding groundwater quality is through the step-up of policy interrelated to the protection and conservation of groundwater aquifers (EASAC, 2010). Several approaches have been suggested for circumstances where aquifers are over abstracted through technology in farming to meet human needs. Some of the approaches being implemented for depleted aquifers include; aquifer restoration through infiltration ponds and injection of surface water and municipal wastewater treatment (Brands *et al.*, 2018).

Careful monitoring of land use in aquifer recharger areas and its supporting catchment areas is another approach to protect groundwater from pollution. This depends on human activities and land use in areas where rainfall percolates into the aquifer (Meybeck *et al.*, 1996). Due to rapid escalation demands for water whose quantity have continued to be affected by climate change, it is sustainable that approaches such as sewer treatment for re-use are reinforced to form an integral part of sustainable water resource management. Effluent re-use for agricultural purposes should be recommended to uphold food production for a rapidly growing population. This concept will help re-channel wastewater for irrigation purposes that have not been widely used in developing countries whose installation of sewer treatment facilities has generally lagged behind and solemnly re-channelled back into streams and

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rivers for retreatment in water provision. As additional extensive, urban, water-borne sewerage schemes are set up, it is expected that effluent re-use for irrigation becomes integrated. This should be guided by public health and agronomic effects to prevent impacts on the environment and groundwater (Chilton, 1996).

The Holding Company for Water and Wastewater (HCWW), in Egyp, depends on the Nile River for fresh water and has implemented programs to develop riverbank filtration (RBF) sites. Riverbank filtration is a technique used to abstract water by pumping wells adjacent to the river from aquifers that are hydraulically connected. This should be governed by "(i) a good hydraulic connection between the river and the aquifer, (ii) erosive river flow conditions to prevent riverbed clogging, (ii) sufficient aquifer thickness (>10 m) and hydraulic conductivity ($K > 1\times10{-}4$ m/s), and a low natural (pre-RBF) gradient of groundwater flow towards the river" (Wahaab *et al.*, 2019). As water percolates through the aquifer sediments towards the production wells, it creates several natural treatment processes, including filtration, biodegradation, adsorption, chemical precipitation, and water quality improvement (Singh *et al.*, 2016). Three major blocks are required for such a vital groundwater ecosystem that supports self-natural groundwater treatment to be established, including the geologic substratum. Groundwater and living organisms (diverse micro-, meio- and macro-organisms) play distinct roles in recycling organic matter transported by water and redistributing energy and matter (Danielopol *et al.*, 2003). RBF is quite simple and cheaper compared to conventional treatment systems and can be used in rural areas of developing countries.

In mining, the principle of water management is grounded on balancing between long term supply and demand. Before mining, effective management requires being aware of groundwater quantities and quality for planning and instituted effective management processes. This should be accompanied by continuous monitoring to ascertain future problems and mitigation measures. Focused attention should be given to groundwater exploitation and critical areas. This should be aided by rain harvest and aquifer recharge by protecting water bodies and aquifer recharge areas (Raghavendra and Deka, 2015). Rejuvenating and deepening of wells is also a requisite. These should be supported by pieces of legislation and policies that should be adhered to. Awareness of all key stakeholders on the importance of groundwater is necessary (Smith *et al.*, 2016).

The borehole is one of the major methods used worldwide to extract clean and quality groundwater from the subsurface. Xu *et al.* (2019) indicated that water quality in boreholes could be achieved by packing well-graded gravel between casing pipes and ground surfaces to provide natural treatment and sealing on top with a sanitary seal. The installation of a sanitary seal must be mandatory for the water supply borehole to prevent groundwater pollution from septic tanks and toilets; hence the depth of the sanitary seal is of great importance to water quality. The recommended minimum depth is 5 m as most surrounding on-site sanitation infrastructure are less than 4m depth. The sanitary seal should rest on a

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good gravel pack. Boreholes drilled on an unconfined or semi-unconfined aquifer should be provided with a competent sanitary seal to prevent material separation. A well-graded gravel pack should be used on boreholes drilled on a semi-confined or confined aquifer up 5 m above the surface which should be sealed with a sanitary seal.

Borehole Safe distance – a borehole should be well sited, protected from surrounding potential contaminate and provided with the right pump size. A minimum distance of about 10 – 50m has been recommended to be a safe or optimum distance from any potential contamination sources to a drinking water borehole (Soulsby, 2010). For a latrine or a septic and sock way tank, the optimal distance should be guided by the following factors: the water table's depth, the soil's composition, and the aquifer's characteristics. Other specific sites optimal distances should be guided by aquifer properties such as thickness and porosity and hydraulic properties such as slope, average pumping rate and duration. The minimum distance is cardinal to provide adequate time to decode degradable contaminants like bacteria and viruses and dilute the encroachment of non-degradable contaminants.

The zoning approach protects the Wellhead Protection Area (WHPA) region contributing to water to the well. This process entails identifying the land of influence to manage it to prevent potential groundwater contamination. WHPA should depend on the aquifers hydrogeological properties and the intention and operational properties of the boreholes. Such hydraulic structure management measures should be extended to fractured rock aquifers, the major groundwater supplier in Africa (Xu *et al.*, 2019).

South Africa has utilised a spring box to protect spring water and improve quality further. The box is filled with well-graded gravel for filtration and treatment purposes. The layout of different earth layers is shown in figure 1.1. Strings of casing and screens packed with gravel filers, pump selection and sealing of boreholes are the major consideration required during borehole construction and recommended (Soulsby, 2010).

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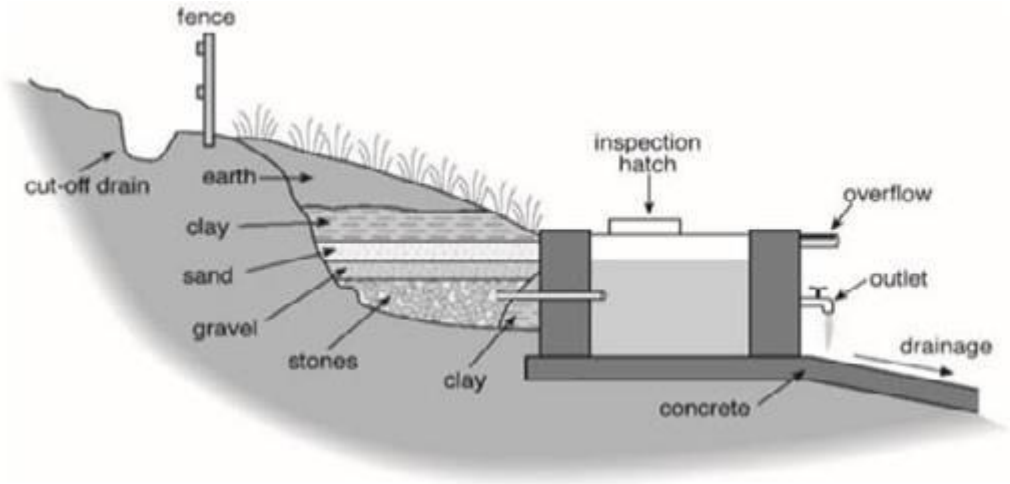

Figure 1.1: Spring Box Model

Source: Soulsby, 2010

In Zambia, groundwater remains one of the major water supplies for domestic use, agriculture and industrial constituting and, in many cases supplying 100% of the demand (Nkhuwa, 2018). Water resources management (ground and surface) falls under the Water Resource Management Agency (WARMA). The agency was established under the Water Resources Management Act (WARM) No. 21 of 2011 to manage, develop, conserve, protect, and preserve ground and surface water resources and their ecosystems. Except for international water bodies, regulation of its abstraction, allocation, use, development, and sustainable water management. One of the challenges is that most of the main aquifers supplying groundwater are sitting on significant settlements. An increase in population, joined with challenges of inadequately planned city expansions, inadequate sanitation services, and human activities, have made the aquifers vulnerable to pollution (Nkhuwa, 2018). This is due to failure by service providers to service this settlement to a point where most households have resorted to the use of boreholes and septic tanks for water supply and wastewater treatment, respectively (Phiri *et al.,* 2019). This scenario requires integrating sustainable on-site groundwater and wastewater management to conserve and protect exiting aquifers locally at the household level (Ahmad *et al.*,2005). This is in line with the WARM, which identifies and protects potential sources of fresh water supply through developing

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tools, standards, guidelines, and best practices for water resource management. The act provides for WARMA to collaborate with Appropriate Authorities to establish sustainable water resource management principles. In line with this, it is also supported by the following pieces of legislation;

The Local Government Act No. 2, 2019 gives authority to Councils to provide government services at the districts level. Sanitation is among some of the services offered by the council. Section 17 (b) of the act allows the councils to join with other authorities to enhance efficiency and effectiveness in its service provision. Inadequate collaboration between authorities and cooperating partners have created gaps in water resource management. Due to limited human and technical resources, authorities mandated to manage water resources have only performed less than required, hence an integrated water resource management approach (Mbolela *et al.*, 2016).

The Solid Waste Regulation and Management Act No. 20 of 2018 gives authority to protect the environment and human health through sustainable management of waste.

The Urban and Regional Planning Act No. 3, 2015 provides planning authorities whose main responsibilities are preparing, approving, and revocating development plans. It also provides for the control of catchment land.

The Public Health Act gives authority to regulate all matters related to public health to prevent and suppress diseases in the country.

The Environmental Management Act No 12 of 2011 is an umbrella and principal law that stands over all other environmental legislation in Zambia. The Act is mandated to ensure the sustainable management of natural resources and protection of the environment to provide for human health and the environment. The act is supported by three regulations that govern licensing, management of toxic substances and approaches to conducting environmental impact assessment.

Regulations related to mines and minerals can be found in the Mines, and Minerals Development Acts No. 11 of 2015 provide sustainable mineral resource management. The Act stipulates regulations in acquiring prospection and exploration rights. It also deals with environmental issues of prospecting and exploration regarding environmental impact assessment study before any prospecting rights are granted. This is supported by the Mines and Minerals Environmental Protection Fund Regulations (SI 102 of 1998).

There is a need for onsite sustainable water usage and household wastewater treatment to safeguard water resources,

Therefore, this study aims to identify sustainable water resource management methods to help overcome water resource and waste water management issues and devise and propose

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an appropriate sustainable onsite infrastructure water resource management mechanism for adoption by authorities and communities.

The study is important as it supports sustainable water and wastewater management strategies to help reduce climate change, human activities and mining on water resources. It also contributes to attaining some sustainable development goals, including; goals no. 11 and 17, as shown in figure 1.2. Further, the study creates new knowledge in onsite water resource management, particularly in new and old residential areas. Furthermore, the study helps to mitigate impacts of climates change and human activities such as mining, agriculture, industrialisation, among others, on water resources.

Figure 1.2: Sustainable Development Goals

Source: www. SDG's.com

2. Research Methodology

The study adopted qualitative and quantitative methods known as the Mixed Method (MM) because of its ability to alleviate the weaknesses and provide richness and details otherwise unavailable if each method were pursued separately. Questionnaires, guided interviews and observation were used in the study.

2.1. Research Approach

The research was achieved by targeting the Water Resource Management Agency (WARMA) representative in the Shibuyunji district. WARMA is an institution tasked to provide for the management, development, conservation, protection and preservation of ground and surface water resources and their ecosystems through regulation of its abstraction, allocation, use, development and sustainable water management except for international water bodies. WARM was purposely chosen to perform a benchmark study regarding water resource management. The basic objective of obtaining information from

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WARMA was to understand the current water resource management strategies to devise solutions to water resource issues. Shibuyunji District Water and Sanitation Hygiene Education Committee (D-WASHE) and drilling companies were used to confirm solutions and establish onsite infrastructure for sustainable water resource management.

2.2 Sampling Technique

The study adopted purposive and convenient sampling techniques, which falls under Non-probability sampling because of financial and time factor limits. The two sampling techniques are well articulated by (Banda 2016; Taherdoost, 2016).

2.3 Research Approach

The study adopted the following approaches to achieve its two objectives.

i. Objective 1: Identification of sustainable water resource management methods to help overcome water resource and wastewater management issues was obtained from the Shibuyunji District Water and Sanitation Hygiene Education Committee (D-WASHE), which comprises social, scientist and engineering experts from different government ministries, including; Health, Local Government, Education, Community Development and Social Welfare and Water Development, Sanitation and Environmental Protection, private sector and NGO's operating within the district. Interviews were conveniently conducted among 20 (Twenty) participants (5 Engineers, 2 Technologists, three planners, 5 Health inspectors and five social scientists). Information obtained through the interview was implemented at the household level to manage water and wastewater sustainably. The information was analyzed using SPSS into a presentable form to deduce methods implemented at the household level to manage water and wastewater sustainably.

Objectives 2: Information on designing a sustainable fresh and wastewater infrastructure for onsite water resource management/treatment for residential areas were obtained from 5 engineers from the D-WASHE committee and 15 borehole drilling and exploration companies from the Lusaka district. The participants were purposely chosen because of their knowledge and technical understanding of groundwater, wastewater and construction. Information was obtained through interviews coupled with graphical demonstrations aimed at improving the construction of the septic tank, soakaway pits and drilling of boreholes. Information obtained was logically and technically compiled to design a sustainable fresh and wastewater infrastructure for onsite water resource management for residential areas.

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3. Results and Discussion

This chapter presents an analysis of all the data gathered by the approach of the methodological framework discussed in section 2. It discusses the research findings and answers questions posed in section 1.

The section presents findings from analysed questionnaires by discussing identified sustainable water resource management approaches to help overcome water resource issues and wastewater management at the residential level. The results are divided into three categories: sustainable disposal of residential solid waste to zero harm, sustainable management of grey and black water, and sustainable management of stormwater. The Section ends by presenting the recommendations on improving construction/drilling of a standard septic tank, soakaway pits and borehole drilling for sustainable onsite freshwater resource and wastewater management in residential areas.

3.1. Responses from Questionnaires

Table I shows the detailed response rate from the questionnaires submitted to D-WASHE. Out of 20 questionnaires submitted, 19 responded, representing a 95% response rate.

Table I: Number of respondents in Shibuyunji district

Description	**Parameter**
Questionnaires Submitted	20
Questionnaires Responded to	19
% Response Rate	**95%**

3.2.1 Sustainable Disposal of Residential Solid Waste to Zero Harm

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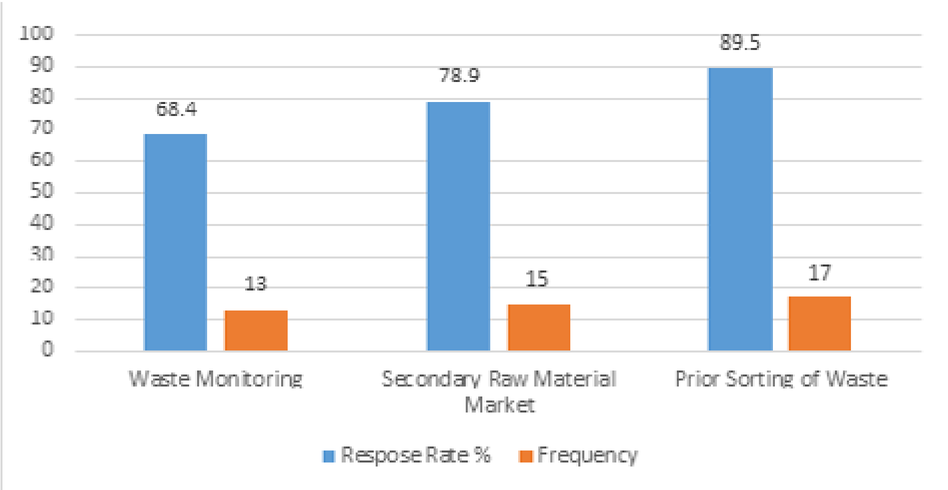

Figure 3.1: Recommended sustainable solid waste management techniques

Residential areas have continued to pollute surface and groundwater through inconsiderate disposal of solid waste. Figure 3.1 highlights the response rate and frequency of three (3) identified techniques for sustainable disposal of residential solid waste that may be implemented in residential areas to avoid continuous pilling up of waste. This is to a point where it degrades the environment, pollutes the soil and water bodies near it and causes outbreaks of diseases. 68.4% of the respondents transcending to a frequency of 13 confirmed that waste monitoring is one of the key techniques to sustainable disposal of residential solid waste. The basic arm of this exercise is that each residence should examine its raw data, uncover a hidden pattern in waste disposal/management, any connections and other insight. The importance of this process is to assist waste management utilities and the local authority to predict, describe, and improve operations by understanding the different categories of waste streams and how they should be treated. One of the greatest challenges in waste management in a developing country like Zambia is its incapacity to predict and describe waste type, quantities, locations where waste is generated most and waste generation behaviour due to monitoring data and other information. As confirmed by 89.5% response rate (frequency of 17) need pre-sorting (characterisation) of waste material before disposal at the landfill as the first step in sustainable disposal of solid waste to zero harm. This can be achieved through waste monitoring, which is the basis for formulating feasible, sustainable waste disposal management policies and strategies to capture all categories of waste streams. Prior sorting of waste by consumers according to physical, chemical and thermal properties does not only help create a healthy environment and social-economic benefits. This is supported by the 78.9% respondents transcending to a frequency of 15, which recommended secondary raw material market. The respondents predicted that there are two types of streams

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of raw materials, (i) those that have no further use (no alternative use) and (ii) those that can be engineered invaluable products for reuse (processed and sell to secondary raw material market). Materials with no further use will involve management strategies such as; landfill monitoring, landfill engineering to enhance waste management (offer a proper sanitary location for residues) and landfill natural endowment. These materials with alternative uses can be improved through recycled and converted into assorted products depending on their chemical, physical or thermal properties and these includes; energy, recycled construction materials, composts and extraction of rare earth minerals.

Residential waste will mainly consist of organic waste, polythene bags and plastic, paper and construction waste but comparing this to what is trending on the ground today, residential waste consists more than that hence the limit of this article but from the four major classes of waste highlighted above, here are some of the management strategies;

i. **Organic Waste,** Adeniran, 89.5% of respondents that identified characterisation of waste further recommended three major secondary uses of organic waste: used as soil nutrients, used for composite production, and energy production. This paper does not state how composite can be produced but instead connects to a secondary raw material market for farmers in the agriculture sector. The biogas can be generated from biodigesters fed using household waste. This gas can be used for cooking, space heating, water and space heating.

ii. **Polythene and Plastic,** despite the respondents recommending recycling of polythene and plastic product but not giving details of how they can be recycled and what the process recycling requires. The respondents further recommended reducing use in the Environmental Management (Extended Producer Responsibility) Regulations, 2018.

iii. **Paper,** Because of IT technological advancement, paper use has drastically reduced as most people prefer to use soft copy data instead of hard copy. The respondents also recommended recycling but never gave the details of the process. Reforestation with a concept of 1 paper = 1 tree was also recommended as an additional policy that responsible government ministries may adopt with support from cooperating partners.

iv. **Construction and Demolition Waste**: the respondents identified cement, sand, water, and admixtures as significant components in concrete production but somewhat limited this study because production and transportation of these materials are assumed to be a unique process. The fact remains that the use of recycled aggregates from construction and demolition waste may harm the environment (land transformation and depletion of natural resources) due to the high demand for cement, whose production in the study has been assumed to be a unique process and continuous sourcing of sand from the exact location. To avoid further environmental transformation and resource degradation, the respondent recommended that the most sustainable way of managing recycled aggregates from construction and demolition waste is to use them in highway construction and unbound

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material instead of concrete production due to adverse environmental effects cement production and sand requirement.

v. Metals, Ceramic and Glass, the respondents recommend that such materials be used in secondary manning, especially metals. Secondary mining will provide a process for recovering these elements from the environment and reengineering them into useful components.

3.2.2. Sustainable management of Grey and Blackwater

Grey is relatively clean wastewater generated from baths, kitchens, sinks and washing machines without faecal contamination, while Blackwater (waste), wastewater containing faeces, urine, and flush water from flush toilets. Figure 3.2 shows that 94.7% of respondents transcending to a frequency of 18 recommended greywater reuse for irrigation and cleaning purposes. Greywater can effectively be treated using the filtration process consisting of peat, charcoal and well-packed gravel. This type of greywater treatment relies on natural microorganisms to treat the water to a very high standard to be safely re-used. The reuse of greywater keeps it out of the sewer or septic system, thereby reducing the chance of polluting groundwater through infiltration and flowing to local water bodies. It also reduces the need for freshwater. Saving on freshwater use can significantly reduce household water bills and has a broader community benefit in reducing demands on public water supply. A frequency of 14, the response rate of 73.7% recommended separation of grey and black water sewer networks. Wastewater from the flushable toilet and kitchen sinks, which contains fats, can be channelled directly to the septic tanks. In contrast, wastewater from the household can be channelled to a filtration treatment channel for treatment and reuse.

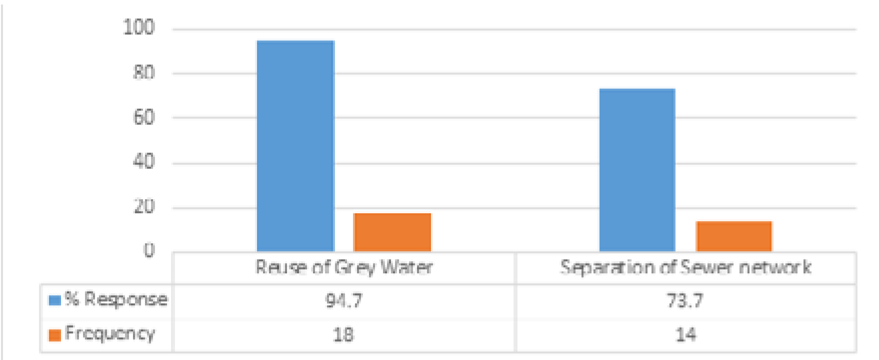

Figure 3.2: identified techniques for treatment of grey and black water

3.2.3 Sustainable Management of Storm Water

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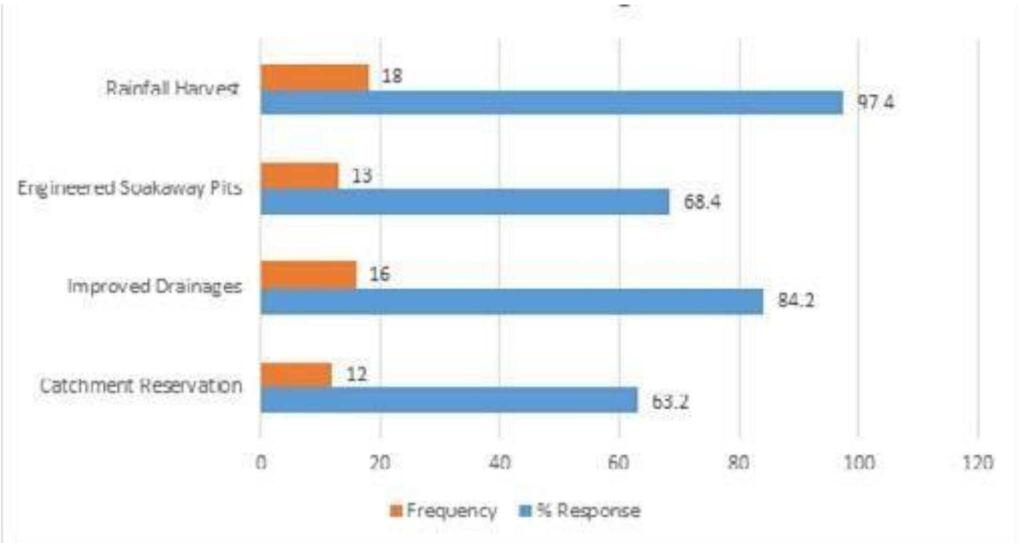

Figure 3.3: Identified Sustainable Techniques to Manage Storm Water

Figure 3.3 has identified rainfall harvest, construction of engineered soakaway pits, improved drainage and reservation of catchment areas as some of the sustainable approaches to manage stormwater. 94.7% of the respondents, transcending to a frequency of 18, recommended rainfall harvest as one of the sustainable techniques to manage stormwater. Rainfall harvest is collecting the runoff from structures other impervious surfaces to store it for later use. Runoff water from structures and impervious surfaces can be channelled through installed continuous gutters or spoon drains passing through rainwater filters into surface or underground water tanks. The water can then be pumped to elevated tanks (gardening, cleaning, toilets and baths). One of the advantages of rainwater harvest is reducing surface and groundwater contamination with pesticides, sediment, metals, fertilizers, and other hazardous wastes. It also reduces stormwater runoff volumes in drainages, streams, and rivers, reducing potential streambank erosion and flooding. Engineered soakaway pits should support rainfall harvest with a response rate of 68.4% and a frequency of 13. Excess stormwater above the capacity of rainfall harvest storage tanks should be directed to the soakaway pits for effective infiltration into the groundwater table with minimal or zero contamination. The well-packed rocks and gravel pack should create several natural treatment processes, including filtration, biodegradation, adsorption, chemical precipitation, and water quality improvement. Surplus water from the soakaway pits should be directed to some well continuous defined drainages as indicated by a response rate of 84.2% and a frequency of 16. Local authorities should ensure that plots are fully serviced before

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developing. Most township drainage cannot collect and discharge stormwater accordingly but instead act as storage rest areas. 63.2% of the respondents represent a frequency of 12 recommended reservations of catchment areas, which can act as discharge areas to improve township drainage systems. A catchment provides a geographical area in which rainwater naturally drains into a water resource and from which the water resource receives surface or ground flow.

3.3. Designed Sustainable Groundwater and Waste Water Infrastructure for Onsite Water Resource Management/treatment for Residential Areas

3.3.1 Sustainable Borehole

From the 15 drillers interviewed, figure 3.4 shows the four primary parameters identified as part of a successful borehole. This was in line with the specification stipulated in subsection 5 of the water resource management (groundwater & borehole) regulation, 2018.

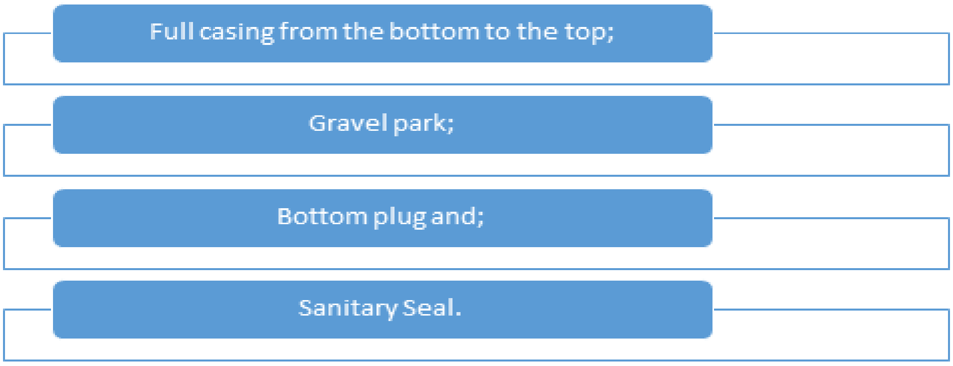

Figure 3.4: List of parameters to be installed to a successful borehole

The respondents recommended a borehole casing with polyvinyl chloride (PVC) instead of steel sitting PVC are more durable than steel. The casing will also prevent and support the borehole from collapsing. The bottom plug is also important to prevent pollution from settled fine particles. Gravel pack promotes the natural treatment of filtrating groundwater through the perforated section of a casing known as a screen at the bottom of a borehole. The well-graded gravel pack, uniform, clean and round shape, creates natural treatment processes detailed in subsection 3.2.3. The gravel pack should be filled from the bottom of the borehole to about 5 – 7 meters above ground level. The sanitary seal, which should cover from the bottom of the gravel pack at 5 – 7 meters’ depth to the top, is meant to prevent contamination of the borehole from nearby sanitary structures such as toilets pits, waste pits and human activities at the ground surfaces. The seal should be made from workable screed or concrete.

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Further, it was observed that there had not been much compliance during the drilling and installation of successful boreholes due to the lack of technical and human resource capacity by WARMA to supervise and monitor these activities throughout the country. As provided in the water resource management act, No. 1 of 2011, it was recommended that integration of Local Authorities in supervision and monitoring of borehole drilling and equipping through its engineering/works departments and their established District Water and Sanitation Hygiene Education Committees (D-WASHE) and Area Pump Minders (APMs) would improve compliance, supervision and monitoring of these activities in all the 116 districts of Zambia.

3.3.2 Designed Waste Water Infrastructure for Onsite treatment

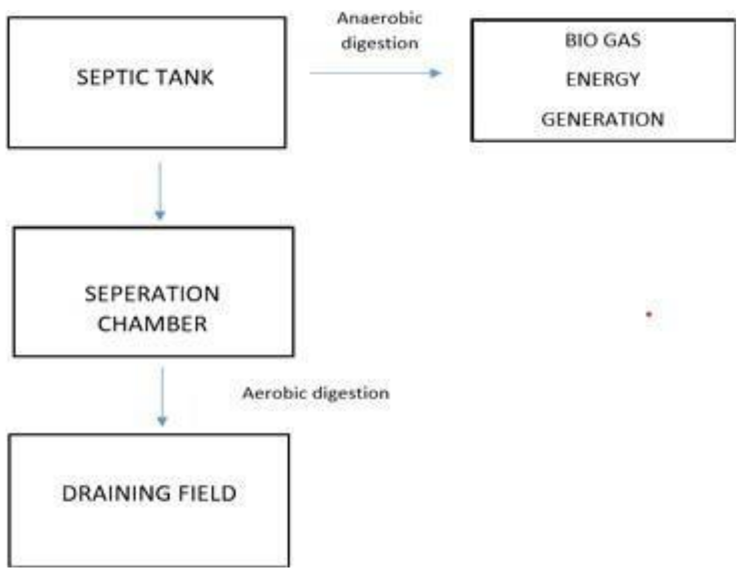

Figure 3.4: Proposed Engineered Septic Tank Components

Figure 3.4 shows the proposed engineered septic tank component whose main objective is to treat sewer water as it filtrates into the ground. The design has three major components, which are the septic tank, separation chamber and drain fields. As per tradition, the septic tank receives wastewater from a household. The tank separates solids, known as sludge which settles to the bottom from wastewater. The lighter solid known as scum floats on top of the water. The trapped solid components of the waste in the tank have to be pumped out periodically. The solid is further broken down and reduced in size through anaerobic digestion, whose off products are helpful in bioenergy production and are outside the scope of this study.

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The liquid component of the sewage water known as effluent flows into the separation chamber, whose major function is to distribute effluent into the draining field. The draining area, also known as tile or leach, is a series of pipe works buried in gravel trenches, usually under growing grass. The pipes will have holes that will allow effluent to flow into the gravel. The pipe network should be laid on a layer of sand that sits on top of a layer of gravel underneath a layer of stone. Hence, as to effectively natural filter to remove bacteria's and provide a medium through which formed microorganism breakdown dissolved impurities. The soil returns some nutrients leaving filtered water flowing into groundwater.

4. Conclusion

Statistics have shown that the polar ice caps and glaciers contain 68% of freshwater, inaccessible for public use, while 30% is found underground. Only 1.2% is found in streams and lakes hence the need to implement measures that mitigate threats to groundwater and promote sustainable use. The first step in sustainable groundwater management is to upscale regulations and policies that protect and conserve groundwater and promote an integrated approach in water resources by both government and private sector through realignment of their mandate, objectives and goals. Respondents scored waste monitoring – 68.4%, secondary raw material market – 78,9% and prior sorting of waste as some of the approaches for sustainable disposal of residential solid waste. Greywater can also be sustainably managed through reuse and separation of sewer networks. Rain harvest -97.4%, improved drainages – 84.2%, engineered soakaway pits – 68.4% and catchment reservation – 63.2% were recommended for sustainable management of stormwater.

Further, full casing, bottom plug, gravel pack and sanitary seal should be installed for any successfully drilled borehole for sustainable groundwater management and protection. Furthermore, the draining field should replace soakaway pits in a domestic sewer treatment structure to provide effective natural filtering and remove impurities from sewer water before it infiltrates into groundwater. These sustainable water resource management systems play an important role in providing utilisation water for human activities, plant growth and soil formation, and contributing to social-economic development.

5. Acknowledgements

I am grateful to Water Resource Management Agency (WARMA) representative in Shibuyunji and Shibuyunji District Water and Sanitation Hygiene Education Committee (D-WASHE) for the opportunity and help rendered to me during the collection of information. Special thanks also go to Shibuyunji Town Council management for allowing me to undertake this study.

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DII

Proceedings of the DII-2021 International Conference: “Building Smart, Resilient and Sustainable Infrastructure in Developing Countries”

DII-2021-027

Sustainability Awareness for Architectural, Engineering and Construction Professionals in Zimbabwe

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Abstract

Sustainability-related challenges are evident in the construction industry. Therefore, a contextual interrogation of sustainability awareness for the determination of knowledge-based improvement strategies is supported. This study reports on a survey that pursued sustainability awareness needs for construction professionals and evaluated statistically significant variances due to gender, designation, educational levels, and respondents’ experience. A web-based questionnaire survey was administered to built environment professionals, and the collected numerical data were analysed through descriptive and non-parametric statistical methods. Factor analysis determined six (6) significant components, with the most essential being cultural diversity and evolution and futures thinking. These are the broad learning objectives within which sustainability instruction should be implemented. Significant variances due to the selected demographic variables were non-existent, indicating consensus on the required sustainability learning objectives. However, a few individual sustainability learning objectives had statistically significant differences that require intervention for Architects and Engineers and those with degrees and MSc educational levels. Determining sustainability learning objectives establishes curriculum re-design, continuous professional development, and improvement for built environment professionals. However, due to the exploratory nature of the study, the insights of clients were not considered. Further studies should aim to establish the context-specific sustainability learning objectives for each designation. The derivation of sustainability awareness needs for architectural; engineering and construction professionals enables operationalization of remedial strategies within the construction companies and professionals’ bodies.

Keywords: Sustainability, Construction professionals, Construction, Continuous professional development

1. Introduction

Sustainability concerns have dominated construction industries in recent years. Despite the construction industry contributing significantly to national economies, it has contributed substantially to economic, social, and environmental sustainability challenges. Performance inefficiencies (Chigara and Moyo, 2014a), construction on wetlands and sustainability challenges (Mhlanga, 2018), infrastructure inadequacies (Mhlanga, 2019), and construction workers’ well-being shortcomings (Moyo *et al.*, 2021) have been widespread. In addition, health and safety insufficiencies (Chigara and Moyo, 2014b; Chirazeni and Chigonda, 2018),

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corporate social responsibility insufficiencies (Uzhenyu and Marisa, 2017; Moyo *et al.*, 2019a) and decent work concerns (Moyo *et al.*, 2019b) have inundated the construction industry. Among other contributing causes, the lack of sustainability awareness amongst the built environment professionals and a necessity to raise sustainability literacy levels have been identified as critical (Cotgrave and Kokkarinen, 2010; Brennan and Cotgrave, 2014; Higham and Thomson, 2015). More so, for developing countries like Zimbabwe, sustainability in construction has been hampered by a lack of knowledge. Thus, any effective resolutions to these challenges require the provision of adequate sustainability knowledge and skills. Viertel (2010) bemoans arguments on widespread inequalities, environmental damage, climate change, dwindling resources, and the consequent need for stronger education on sustainable development. In support, United Nations Education Science and Cultural Organization (UNESCO, 2017) advocates strengthening Education for Sustainable Development (ESD) by implementing substantial training changes that incorporate critical issues such as climate change, biodiversity, disaster risk reduction, and sustainable consumption and production. However, Blewitt (2010) justifies the lack of sustainability within the training curriculum due to suspicion that the concept is inexact, unique to different situations and the general scarcity of knowledge. Despotovic *et al.* (2015) also assert that economic competitiveness should be amply assimilated with environmental and social sustainability. However, clarity lacks in explaining the complex phenomenon of these mechanisms.

Therefore, this study aims to determine the sustainability awareness for construction professionals in Zimbabwe through factor analysis. The Government of Zimbabwe's (2014: 25) prerogative is "the provision of relevant skills to individuals for sustainable economic development and self-fulfilment through a system which is accessible, equitable, inclusive, financially sustainable, and responsive to technological developments, includes entrepreneurship and involves all stakeholders". Therefore, resolutions can be achieved through developing sustainability literacy which informs our behaviour and attitude to technological advancements in the industry. Further to this, an examination of any significant variances in perceptions due to gender, designation, educational levels and experience was undertaken. Wan and Ng (2016) emphasize that construction sustainability approaches by developed and developing countries are not mutually adaptable; hence a country-specific approach is inevitable. The next section of the study presents the theoretical and conceptual framework of the study.

Sustainability in Construction

World Commission on Environment and Development (WCED, 1987: 24) defines sustainability as humanity's ability to "ensure that it meets the needs of the present without compromising the ability of future generations to meet their own". It is concerned with issues

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of continuity and endurance and sets a methodology to remedy social, economic and environmental challenges that face mankind (Murray and Cotgrave, 2007). However, the execution of sustainable development is inundated with complexities and conflicts the world over. Ratiu and Anderson (2015) decry that a clear understanding of sustainability continues to elude academics though there is an upsurge in attention and use of this notion. Sustainability in the built environment focuses on ways the sector can add to the earth's sustainability (Halliday, 2008). Sustainable construction concerns construction projects that promote environmental, social and economic gains today and tomorrow (Suliman and Abdelnaser, 2009). Since the built environment has a significant impact on the community, it faces scrutiny from various stakeholders (Siew *et al.*, 2013). Innovative sustainability solutions are dependent on firms fostering 'sustainability cultures' to produce evident objectives for the environment and society (Galpin *et al.*, 2015). As such, construction should enhance social, economic and environmental sustainability through motivating for considerable sustainability literacy (Murray and Cotgrave, 2007). This is due to sustainability having transformed into a considered authority (Galpin *et al.*, 2015). Several academics, including Murray and Cotgrave (2007), El-Zein *et al.* (2008), Blewit (2010), agree that education is essential to making changes to the industry to improve sustainability. However, Kagawa (2007) relays that academics have decided that there is no single context and acceptance of sustainability; hence there is a need for alignment to country-specific challenges. Training is crucial in promoting attitudinal change (Cotgrave and Kokkarinen, 2010). Therefore, realising how sustainability can be incorporated into curricula is pertinent (Wyness *et al.*, 2015). Changing the thought process and perceptions of the workforce is vital to achieving sustainable development (Brennan and Cotgrave, 2014). Suffice to say, sustainable construction principles are achievable if and when construction professionals attain the expected levels of sustainability literacy (Kibert, 2002).

Demographic variables are pertinent in effectively resolving sustainability challenges. Limitations of women in the Zimbabwean construction industry are significant (Infrastructure development bank of Zimbabwe, 2019). Alkhaddar *et al.* (2012) expose the deep learning approach effectiveness on sustainability improvement differences between office-based and site-based construction workers. Robotham (2003) interprets the importance of education by highlighting that effective training to achieve competent learners is borne out of consideration of their learning ability. Desha and Hargroves (2014) intimate that key professionals lack critical knowledge and skills to bring about sustainable solutions. Also, differences in professional roles were significant towards how sustainable construction could be enshrined in projects. Cumulatively, Viertel (2010) concurs that competent transition to achieving sustainability is vital and can be realized through general awareness and applied research. Achieving sustainable development is entrenched in equipping professionals and skilled individuals in literacy (Murray and Cotgrave, 2007).

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Sustainability literacy

Literacy involves a wide range of knowledge to empower people to achieve their objectives, advance their awareness, and contribute to their societies (UNESCO, 2017). Achieving sustainability literacy is understanding global macro-problems and tackling these problems at all societal levels within irregular settings (Dale and Newman, 2005). Sustainability literacy is foundational and is based on construction professionals being instructed in sustainability learning to advance the sustainability development drive. As construction professionals are the drivers of construction projects, they can lead towards sustainability through good learning objectives. However, to accomplish this, they need to be equipped with the relevant knowledge during their training or/and as part of their professional development. Competencies in sustainability permit effective job performance associated with sustainability risks. With key competencies of sustainable development goals being envisioning, systemic thinking, critical thinking and reflection, participation in decision-making, and building partnerships (Osman et al., 2017), most learning objectives are captured. Rieckmann (2012) determined key sustainable development competencies as analysis and responsibility, management of processes, cooperation and communication, handling of differences and conflicts, critical reflection on and involvement with the world, and handling complexity and future developments. Steiner (2013) also developed competencies to resolve difficulties, including personal competence, socio-cultural (collaborative) competence, professional domain competence, creativity competence and systemic competence. Related to these, the current study considered converging competencies of systems thinking, strategic thinking (or action-oriented), values thinking (or normative), futures thinking (or anticipatory) and collaboration (or interpersonal) as suggested by various authors (Wiek *et al.,* 2011; Frisk and Larson 2011). However, Glasser's competencies of affinity for life, state of the planet knowledge, wise decision making, modelling sustainable behaviour and transformative social change had more excellent agreement than those proposed by Wiek *et al.* (2016) (Glasser and Hirsch, 2016). Therefore, the sustainability learning objectives emphasized hereafter, as suggested by Glasser and Hirsch (2016), were subjectively selected considering the infancy of sustainability within the study area. This is due to the suggested competencies not being as explicit as learning objectives, as these accentuate the context within which advances are to be incorporated. Dale and Newman (2005) argue that learning objectives for sustainable development education are processed-based in addition to facts-based, in which the structures under study are composite, dynamic, and varied. Further, gaining a set of skills and implementing those skills in a dynamic environment is pertinent. Hence, the learning objectives within these competencies were interrogated, as shown in Table I.

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Table I: Conceptual framework for the study.

Key competence	**Sustainability learning objectives**
Affinity for life	SL01- Biophilia Integration SL02- understanding of how life on planet Earth coevolved SL03- Cultural diversity appreciation SL04- Biological diversity appreciation
State of the planet knowledge	SL05- Deep understanding of how nature sustains life SL06- Understanding current, widely-held state of the planet perceptions and their limits SL07- Understanding of climate change SL08- Understanding of biological and cultural diversity loss rates SL09- Facility to foster a state of the planet knowledge recalibration SL10- Understanding linear and non-linear growth rates and consequences
Modelling sustainable behaviour	SL11- Being the change one wants to see in the world SL12- Incorporating a deep understanding of the state of the planet into policies and actions SL13- Acting in accordance with long-term goals (Sustainability Development Goals) SL14- Responding to maladaptive forces effectively SL15- Creating policy incentives to encourage the behaviour we seek SL16- Prioritizing high-level values when tradeoffs arise
Transformative social change	SL17- Social learning for sustainability leadership and collaboration SL18- Recognition of motivational variables and consequences of action SL19- Facility to inspire collective change for sustainability SL20- Openness to the views and concerns of others SL21- Facility to perform action research

Learning objectives associated with an affinity for life include biophilia integration (Niu Jiang and Li, 2010; Dmochowski *et al.*, 2016), understanding of how life on planet earth co-evolved (Dmochowski *et al.*, 2016), cultural diversity appreciation (Du Plessis, 2007; Svanstrom *et al.*, 2008; Dmochowski *et al.*,2016; Hill and Wang, 2018) and biological diversity appreciation (Svanstrom *et al.*,2008; Dmochowski *et al.*,2016). Obiozo and Smallwood (2014) support the “green” interventions on construction sites as a tactic to improve workers well-being and performance. Goldswain and Smallwood (2013) also mention health, safety and ergonomics being caused by inadequacies in designs. The state of the planet knowledge includes deep understanding of how nature sustains life (Wiek *et al.*, 2011; Hill and Wang, 2018), understanding current, widely-held state of the planet perceptions and their limits (Hill and Wang, 2018), understanding of climate change (Du Plessis, 2007; Blewitt, 2010; Dmochowski *et al.*, 2016; Osman *et al.*, 2017), understanding of biological and cultural diversity loss rates (Du Plessis, 2007; Svanstrom *et al.*, 2008; Blewitt, 2010; Hill and Wang, 2018), facility to foster a state of the planet knowledge recalibration (Hill and Wang, 2018), and understanding linear and non-linear growth rates and consequences (Du Plessis, 2007; Hill and Wang, 2018). Will (2008) suggest that

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corporate sustainability potentially enhances the competitiveness of companies by exploiting opportunities and reducing risks associated with current global trends like climate change. Cruickshank and Fenner (2012) support instruction in climate change as pertinent for transforming the current working conditions regime.

The competence of modelling sustainable behaviour includes being the change one wants to see in the world (Murray and Cotgrave, 2007; Gaard *et al.*, 2017), incorporating a deep understanding of the state of the planet into policies and actions (Du Plessis, 2007; Sivapalan, 2017), acting under long-term goals (Murray and Cotgrave, 2007; Osman *et al.*, 2017), responding to maladaptive forces effectively (Svanstrom *et al.*, 2008; Niu *et al.*, 2010; Osman *et al.*, 2017), creating policy incentives to encourage the behaviour we seek (Murray and Cotgrave, 2007; Niu *et al.*, 2010; Kokkarinen and Cotgrave, 2013), prioritizing high-level values when tradeoffs arise (Du Plessis, 2007; Murray and Cotgrave, 2007; Kokkarinen and Cotgrave, 2013; Sivapalan, 2017). UNESCO (2017) remarks that ESD can develop learning objectives that are specific to a particular sustainability development goal (SDGs) and relevant to all seventeen (17) sustainability development goals. To improve the efficiency of the built environment, key construction players need to be trained on drivers of such sustainability objectives (Sfakianski, 2015). Learning objectives associated with transformative social change include social learning for sustainability leadership and collaboration (Steiner and Posch, 2006; Murray and Cotgrave, 2007; Svanstrom *et al.*, 2008; Niu *et al.*, 2010; Gaard *et al.*, 2017; Sivapalan, 2017), recognition of motivational variables and consequences of action (Gaard *et al.*, 2017), facility to inspire collective change for sustainability (Svanstrom *et al.*, 2008; Gaard *et al.*, 2017), openness to the views and concerns of others (Dmochowski *et al.*, 2016) and facility to perform action research (Steiner and Posch, 2006; Du Plessis, 2007; Svanstrom *et al.*, 2008; Niu *et al.*, 2010; Osman *et al.*, 2017; Hill and Wang, 2018). Priest (2008: 3) supports the social capital concept comprising linkages, shared principles and considerations that enable clusters and entities to depend on each other and work together.

The focus of this study, on sustainability learning objectives for construction professionals in Zimbabwe, is predicated on the demographic background of respondents, as alluded to in the previous section. Twenty-one (21) sustainability learning objectives from Table I were selected for the survey. The methodology is outlined in the next section.

2. Methodology

The study's exploratory nature utilized a web-based questionnaire survey strategy supported by Cotgrave and Kokkarinen (2011) and Gaard *et al.* (2017). Although Cotgrave and Kokkarinen (2011) used built environment students to establish sustainability learning objectives, this study collected numerical data from construction professionals to promote

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awareness of sustainability learning. All the eighty-three (83) construction companies' situated in Harare and Bulawayo and registered with the Construction Industry Federation of Zimbabwe were considered for the built environment professional's selection. Harare and Bulawayo are inhabited by 90% of construction and consultancy firms (Mhlanga, 2019), with 202 firms eligible for participation in the study.

The web-based questionnaires included two (2) sections. The first (1st) section invited demographic data on age, designation, educational levels, experience, gender and profession. The second (2nd) section requested the respondents to score on the importance of sustainability learning objectives: 1- not important, 2- of little importance, 3- somewhat important, 4- important and 5- very important. The Statistical Package for Social Science (SPSS) version 25 was utilized to aid in the determination of important learning objectives within demographic variables considerations. The reliability of the data collection instrument was ensured through a Cronbach-alpha reliability test. Taherdoost (2016) defines this test as the degree to which the instrument provides constant and dependable results, and it showed a very good reliability of 0.897. Normality was determined by the Shapiro-Wilk test, which is reliable for samples of more than fifty (50). This had a significant value of 0.000 which is less than 0.05, indicating abnormally distributed data (Ghasemi and Zahediasl, 2012) and consequent use of non-parametric tests.

Importance was evaluated through the relative importance index (RII). As adapted from Perera *et al.*, (2007) the response evaluation scales were ordered as follows: 'not important' < 0.2; $0.2<$ 'of little importance' ≤ 0.4; $0.4<$ 'somewhat important' ≤ 0.6; $0.6<$ 'important' ≤ 0.8; $0.8<$ 'very important' ≤ 1. Importance was considered from RII ≥ 0.6. Statistically significant variances due to demographic variables were evaluated utilizing the Mann-Whitney U test and the Kruskal-Wallis test, where the significance level was $p < 0.05$. The Mann-Whitney U test was used for matching the central tendency of the two (2) gender independent samples (Blumberg *et al.*, 2008). The Kruskal-Wallis test was used to test the null hypothesis that more than two (2) independent random samples (in the case of designation, educational levels and experience) come from undistinguishable populations against the alternative hypothesis that their means are not equal (Kothari, 2009). A post-hoc Mann-Whitney U test analysis was used, where individual learning objectives had statistically significant variances, where the effect size scale to measure the strength of the relationship; $r = 0.10$ (small effect); $r = 0.30$ (medium effect); $r = 0.50$ (large effect) was used to determine practical significance (Field, 2014).

Factor analysis was utilised to expose sets of underlying factors by considering the interrelationship among the variables (Field, 2014). The Kaiser-Meyer-Olkin (KMO) was used to measure the sampling adequacy for validity, with a measured value of 0.820 being acceptable for conducting factor analysis as it was > 0.5 (George and Mallery, 2003). Bartlett's test for Sphericity had a significant value of 0.000, which was < 0.05, signifying a

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suitably multivariate normal and acceptable data for factor analysis (Field, 2014). Components from the analysis were extracted using the principal component analysis with varimax rotation due to its advantage in maximizing variance for each factor (Kaiser, 1958; Benson and Nasser, 1998), with those with eigenvalues greater-than-one being noteworthy. Those with values being < 1 were disregarded, as supported by Ather and Balasundaram (2009). The baseline for loadings was set at 0.4, which was considered stable for utilization (Guadagnoli and Velicer, 1988). The components were titled from consideration of their constituent factors as held by Rieckmann (2012). Factor scores were used to rank the components of learning objectives (Ather and Balasundaram, 2009).

3. Results and Discussion

This segment will elucidate the demographics of respondents, the importance of the learning objectives, statistically significant variances due to demographic variables and factor analysis.

Demographics of respondents

The response rate was 54.5%, represented by one hundred and ten (110) respondents from a population size of two hundred and two (202), and this was adequate. It conforms to Baruch (1999)'s recommended 60% (+/- 20%) response rate for populaces of professionals. The designations were represented as follows; Quantity surveyors (34%), Project Managers (31%), Engineers (21%) and Architects (14%). Table II shows the other demographics of respondents.

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Table II: Demographics of respondents

Respondent group	**Architects' Firms**	**Construction companies**	**Civil engineering firms**	**Quantity surveying Firms**
Population	54	83	43	22
Responses	19	59	23	14
Response rate	35%	71%	54%	64%
Gender	**Males**	**Females**		
Response rate	83%	17%		
Educational levels	**Diplomas**	**Degrees**	**Post-graduate degree**	
Response rate	7%	45%	47%	
Experience	**0-5 years**	**6-10 years**	**11-15 years**	**More than 15 years**
Response rate	41%	25%	21%	13%

The gender-biased nature of the construction industry is evident with a skew in favour of males (Infrastructure Development Bank of Zimbabwe, 2019). All the educational levels are well embodied, representing acceptable aptitude levels. Also, the work experience results indicate a slight skew towards the less experienced. However, the more experienced professionals also had their insights included.

Relative importance of sustainability learning objectives

Respondents contributed their insights on sustainability learning objectives for construction professionals, and the results are as shown in Table III. This analysis shows the importance of the individual sustainability learning objectives for construction professionals for directed corrective action. According to the evaluation scale, for overall ranking and that of Engineers, Project managers and Quantity surveyors, all twenty-one (21) sustainability learning objectives for construction professionals were measured as being important with RII $\geq$ 0.6 (Perera *et al.*, 2007). This supports the need to enrich all the construction professionals with sustainability learning. However, the learning objectives of 'facility to foster a state of the planet knowledge recalibration' and 'understanding linear and non-linear growth rates and consequences' were considered not important by Architects. The top three (3) overall important sustainability learning

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objectives for construction professionals include: Understanding climate change (RII= 0,867), Acting by long-term goals (SDGs) (RII= 0,860) and Openness to perform to the views and concerns of others (RII= 0,840). All these learning objectives are fundamental towards enhancing sustainable construction principles through addressing the social, economic, environmental, technical and cultural aspects of construction-related activities (Steiner and Posch, 2006; Du Plessis, 2007; Murray and Cotgrave, 2007; Svanstrom *et al.*, 2008; Niu *et al.*, 2010; Svanstrom *et al.*, 2008; Dmochowski *et al.*, 2016; Gaard *et al.*, 2017; Sivapalan, 2017; Hill and Wang, 2018). Climate change is topical the world over and has also affected the construction sector. More so, where a need for resilient infrastructure and adequate health and safety of workers is fundamental. Construction professionals have the prerogative to ensure that all aspects of the design and execution of construction projects align with climate change requirements, as supported by Will (2008) and Cruickshank and Fenner (2012). Acting by long term goals (SDGs) is also relevant. With most countries ratifying the Sustainable development plan, construction professionals inevitably act towards its achievement. However, a clear understanding of sustainability continues to elude academics and professionals (Ratiu and Anderson, 2015). This is reflected by the construction professionals' insights and supports the integration of sustainability learning in undergraduate, postgraduate and continuous professional development programmes.

Table III: Ranking of sustainability learning objectives

Sustainability learning objectives	**Overall**		**Project Managers**		**Architects**		**Engineers**		**Quantity Surveyors**	
	RII	**Rank**	**RII**	**Rank**	**RII**	**Rank**	**RII**	**Rank**	**RII**	**Rank**
SL07- Understanding of climate change	0,867	1	0,859	2	0.863	1	0,861	1	0,881	1
SL13- Acting in accordance with long-term goals	0,860	2	0,865	1	0.850	3	0,835	2	0,881	1
SL20- Openness to the views and concerns of others	0,840	3	0,853	3	0.863	1	0,774	9	0,859	3
SL05- Deep understanding of how nature sustains life	0,815	4	0,812	6	0.775	7	0,791	5	0,849	5
SL03- Cultural diversity appreciation	0,811	5	0,818	5	0.763	8	0,835	2	0,811	7

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SL19- Facility to inspire collective change for sustainability	0,798	6	0,800	8	0.663	16	0,791	5	0,859	3
SL17- Social learning for sustainability leadership and collaboration	0,796	7	0,847	4	0.725	11	0,757	12	0,805	9
SL21- Facility to perform action research	0,796	7	0,812	6	0.825	5	0,765	11	0,805	9
SL12- Incorporating deep understanding of the state of the planet into policies and actions	0,789	9	0,782	10	0.725	11	0,826	4	0,800	11
SL15- Creating policy incentives to encourage the behavior we seek	0,787	10	0,759	12	0.725	11	0,791	5	0,838	6
SL11- Being the change one wants to see in the world	0,760	11	0,741	14	0.763	8	0,774	9	0,784	13
SL04- Biological diversity appreciation	0,758	12	0,776	11	0.738	10	0,783	8	0,741	16
SL18- Recognition of motivational variables and consequences of action	0,758	12	0,794	9	0.838	4	0,730	15	0,789	12
SL16- Prioritizing high-level values when tradeoffs arise	0,753	14	0,735	17	0.663	16	0,748	13	0,811	7
SL08- Understanding of biological and cultural diversity loss rates	0,751	15	0,741	14	0.713	14	0,739	14	0,784	13
SL06- Understanding current, widely-held state of the planet perceptions and their limits	0,738	16	0,747	13	0.800	6	0,696	17	0,730	18

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SL14- Responding to maladaptive forces effectively	0,698	17	0,741	14	0.638	18	0,678	18	0,697	20
SL01- Biophilia Integration	0,691	18	0,688	18	0.613	19	0,722	16	0,724	19
SL02- Understanding of how life on planet Earth coevolved	0,685	19	0,671	20	0.675	15	0,626	19	0,741	16
SL09- Facility to foster state of the planet knowledge recalibration	0,660	20	0,688	18	0.563	20	0,626	19	0,697	20
SL10- Understanding linear and non-linear growth rates and consequences	0,658	21	0,635	21	0.550	21	0,609	21	0,757	15

Statistically significant variances due to demographic variables. As shown in Table IV, the Mann-Whitney U and Kruskal-Wallis tests show that there was no statistically significant variance in the aggregated sustainability learning objectives concerning gender (0.305), designation (0.120), educational levels (0.09) and experience (0.668) since their p-values were > 0.05.

Table IV: Summary of results for sustainability learning objectives

Sustainability learning objectives	**Gender (sig.)**	**Designation (Sig.)**	**Educational level (Sig.)**	**Experience (Sig.)**
SL01- Biophilia Integration	0.227	0.279	0.119	0.165
SL02- Understanding of how life on planet Earth coevolved	0.760	0.344	0.364	0.726
SL03- Cultural diversity appreciation	0.282	0.908	0.203	0.860
SL04- Biological diversity appreciation	0.262	0.664	0.071	0.408
SL05- Deep understanding of how nature sustains life	0.635	0.364	0.033*	0.819
SL06- Understanding current, widely-held state of the planet perceptions and their limit	0.388	0.612	0.468	0.554
SL07- Understanding of climate change	0.708	0.810	0.751	0.778

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SL08- Understanding of biological and cultural diversity loss rates	0.960	0.763	0.538	0.838
SL09- Facility to foster state of the planet knowledge recalibration	0.215	0.252	0.401	0.803
SL10- Understanding linear and non-linear growth rates and consequences	0.420	0.040*	0.028*	0.846
SL11- Being the change one wants to see in the world	0.386	0.708	0.127	0.148
SL12- Incorporating deep understanding of the state of the planet into policies and actions	0.360	0.298	0.467	0.743
SL13- Acting in accordance with long-term goals (Sustainability Development Goals)	0.696	0.407	0.165	0.288
SL14- Responding to maladaptive forces effectively	0.344	0.555	0.483	0.814
SL15- Creating policy incentives to encourage the behavior we seek	0.916	0.244	0.031*	0.520
SL16- Prioritizing high-level values when tradeoffs arise	0.587	0.024*	0.106	0.901
SL17- Social learning for sustainability leadership and collaboration	0.095	0.112	0.601	0.828
SL18- Recognition of motivational variables and consequences of action	0.234	0.075	0.017*	0.950
SL19- Facility to inspire collective change for sustainability	0.384	0.011*	0.108	0.539
SL20- Openness to the views and concerns of others	0.195	0.466	0.692	0.409
SL21- Facility to perform action research	0.395	0.870	0.728	0.828
Aggregated	**0.305**	**0.120**	**0.090**	**0.668**

Holistic resolutions are reinforced by the results, showing consistent perceptions from respondents regardless of their demographic variances. Despite sustainability being in its early stages in the Zimbabwean construction industry, all the construction professionals generally agree on its appreciation.

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The gender imbalance and experience of professionals in the construction industry has not shown any significant differences, even in the individual learning objectives. However, individual learning objectives have demonstrated significant differences with p-values of < 0.05 for the demographic variables of designation and educational levels. These are discussed hereafter with consideration of the post hoc Mann Whitney U test to ascertain the existence of the actual statistically significant differences, as shown in Table V-IX.

Table V: Post-hoc Mann-Whitney U test results for designations

Learning objectives	**Designation Groups**	**Mann-Whitney U**	**Wilcoxon W**	**Z**	**r**	**Asymp. Sig. (2-tailed)**
Understanding linear and non-linear growth rates and consequences	Architects & Quantity surveyors	172.00	308.00	-2.509	0.119	0.012
	Engineers & Quantity surveyors	292.500	568.500	-2.100	0.099	0.036
Prioritizing high-level values when tradeoffs arise	Architects & Quantity surveyors	174.00	310.00	-2.503	0.247	0.012
	Engineer & Quantity surveyors	287.000	563.000	-2.252	0.157	0.024
	Project managers & Quantity Surveyors	458.500	1053.500	-2.077	0.076	0.038
Facility to inspire collective change for sustainability	Architects & Quantity surveyors	146.00	282.00	-3.122	0.193	0.002
	Architects & Project managers	182.00	318.00	-2.097	0.312	0.036

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For designation, as shown in Table V and VI, the posthoc tests showed results for the learning objectives of Understanding linear and non-linear growth rates and consequences, Prioritizing high-level values when tradeoffs arise and Facility to inspire collective change for sustainability. However, the practical significance of these differences is low except for that which exists for Architects & Project managers for the Facility to inspire collective change for sustainability learning objectives. Table VI shows that Quantity surveyors and Project managers perceive these learning objectives as being more critical as compared to Architects and Engineers, and this is opposed to views by Du Plessis (2007), Murray and Cotgrave (2007), Kokkarinen and Cotgrave (2013), Gaard *et al.*, (2017) and Sivapalan (2017).

Viertel's (2010) and Desha and Hargroves (2014) views on key professionals' lack of critical knowledge and skills are evident in these learning objectives. Competent transition to achieving sustainability is vital and can be realized through general awareness and applied research. From the results, Engineers and Architects should value these learning objectives more since they are the originators of designs that are supposed to initiate sustainable provisions. This difference likely emanates from deficiencies in sustainability learning within the curricula of these two professions.

Table VI: Ranking of learning objectives

Learning objectives	Designation	N	Mean Rank	Sum of Ranks
Understanding linear and non-linear growth rates and consequences	Engineers	23	24.72	568.50
	Quantity surveyors	37	34.09	1261.50
	Total	60		
	Architects	16	19.25	308.00
	Quantity surveyors	37	30.35	1123.00
	Total	53		
Prioritizing high-level values when tradeoffs arise	Architects	16	19.38	210.00
	Quantity surveyors	37	30.30	1121.00
	Total	53		
	Engineers	23	24.48	563.00
	Quantity surveyors	37	34.24	1267.00

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	Total	60		
	Project managers	34	30.99	1053.50
	Quantity surveyors	37	40.61	1502.50
	Total	71		
	Architects	16	17.63	282.00
Facility to inspire collective change for sustainability	Quantity surveyors	37	31.05	1149.00
	Total	53		
	Architects	16	19.88	318.00
	Project managers	34	28.15	957.00
	Total	50		

For educational levels, as shown in Table VII and VII, the posthoc tests showed results for the learning objectives of deep understanding of how nature sustains life, Understanding linear and non-linear growth rates and consequences, creating policy incentives to encourage the behaviour we seek and recognition of motivational variables and consequences of the action. These showed significant differences since the p-values were < 0.05. However, the practical significance of these differences is low except for that which exists for Diploma & Degree professionals for the Recognition of motivational variables and consequences of the action.

Table VII: Post-hoc Mann-Whitney U test results for educational levels

Learning objectives	Education Groups	Mann-Whitney U	Wilcoxon W	Z	r	Asymp. Sig. (2-tailed)
Deep understanding of how nature sustains life	Diploma & MSc	101.500	1479.500	-2.462	0.068	0.014
	Diploma & Degree	111.500	1386.500	-2.170	0.229	0.030
Understanding linear and non-linear growth rates and consequences	Diploma & MSc	100.000	1478.000	-2.450	0.087	0.014
	Diploma & Degree	86.000	1361.000	-2.689	0.143	0.007

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Creating policy incentives to encourage the behaviour we seek	Diploma & MSc	122.000	1500.000	-1.959	0.029	0.049
Recognition of motivational variables and consequences of action	Diploma & MSc	91.500	1469.500	-2.754	0.188	0.006
	Diploma & Degree	91.500	1366.500	-2.684	0.331	0.007

Table VIII shows that those with diplomas perceive these learning objectives as more important than those with degrees and MSc educational levels. Diploma graduates’ value on these learning objectives is evidence of a gap requiring remedial action through academic and professional interventions. These interventions can include curricula re-designs and professional short courses for integration of these learning objectives. These results support Wan and Ng (2016)’s assertion on the need for country-specific interventions. Further, Robotham (2003)’s consideration of abilities of various educational levels needs critical analysis for sustainable resolutions. However, sustainability has become pertinent such that all professionals of different academic levels need its instruction. More so on a deep understanding of how nature sustains life, understanding linear and non-linear growth rates and consequences, creating policy incentives to encourage the behaviour we seek and recognition of motivational variables and outcomes of the action.

Table VIII: Ranking of learning objectives

Learning objectives	**Educational groups**	**N**	**Mean Rank**	**Sum of Ranks**
Deep understanding of how nature sustains life	Diploma	8	43.81	350.50
	MSc	52	28.45	1479.50
	Total	60		
	Diploma	8	40.56	324.50
	Degree	50	27.73	1386.50
	Total	58		

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Understanding linear and non-linear growth rates and consequences	Diploma	8	44.00	352.00
	MSc	52	28.42	1478.00
	Total	60		
	Diploma	8	43.75	350.00
	Degree	50	27.22	1361.00
	Total	58		
Creating policy incentives to encourage the behaviour we seek	Diploma	8	41.25	330.00
	MSc	52	28.85	1500.00
	Total	60		
	Diploma	8	45.06	360.50
Recognition of motivational variables and consequences of action	MSc	52	28.26	1469.50
	Total	60		
	Diploma	8	43.06	344.50
	Degree	50	27.33	1366.50
	Total	58		

Relationships amongst sustainability learning objectives

Six (6) groups of learning objectives were revealed from the factor analysis having eigenvalues of ≥ 1, which explained 67.017% of the total variance with factor loadings ranging from 0.799 to 0.473. Each group of learning objectives was discussed here-after and named according to the constituent learning objectives, as shown in Table XI.

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Table XI: Factor analysis results

Factor score and (Rank)	Sustainability learning objectives	Components					
		1	2	3	4	5	6
1,945	SL17- Social learning for sustainability leadership and collaboration	0.728					
	SL18- Recognition of motivational variables and consequences of action	0.713					
	SL19- Facility to inspire collective change for sustainability	0.701					
	SL08- Understanding of biological and cultural diversity loss rates	0.671					
	SL15- Creating policy incentives to encourage the behaviour we seek	0.657					
	SL16- Prioritizing high-level values when tradeoffs arise	0.581					
	SL04- Biological diversity appreciation	0.537					
2,340	SL09- Facility to foster state of the planet knowledge recalibration		.799				
	SL10- Understanding linear and non-linear growth rates and consequences		0.709				
	SL01- Biophilia integration		0.626				
	SL14- Responding to maladaptive forces effectively		0.501				
	SL12- Incorporating deep understanding of the state		0.473				

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	of the planet into policies and actions						
2,781	SL05- Deep understanding of how nature sustains life			0.795			
	SL06- Understanding current, widely-held state of the planet perceptions and their limits			0.658			
	SL11- Being the change one wants to see in the world			0.640			
3,010	SL20- Openness to the views and concerns of others				0.791		
	SL21- Facility to perform action research				0.741		
3,540	SL07- Understanding of climate change					0.759	
	SL13- Acting in accordance with long-term goals					0.499	
3,800	SL03- Cultural diversity appreciation						0.759
	SL02- understanding of how life on planet Earth coevolve						.617
	Eigen value	7.317	1.730	1.347	1.318	1.229	1.132
	Proportion of variance (%)	34.843	8.238	6.415	6.276	5.854	5.391
	Cumulative variance (%)	34.843	43.081	49.496	55.772	61.626	67.017
	Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 10 iterations.						

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Component 1- Sustainability leadership and value prioritization

The first (1st) component was named "sustainability leadership and value prioritization" and accounts for 7.317 eigenvalues with a variance of 34.843 %. The sustainability learning objectives included in this component are Social learning for sustainability leadership and collaboration (sig.= 0.728), Recognition of motivational variables and consequences of action (sig.= 0.713), Facility to inspire collective change for sustainability (sig.= 0.701), Understanding of biological and cultural diversity loss rates (sig.= 0.671), Creating policy incentives to encourage the behaviour we seek (sig.= 0.657), Prioritizing high-level values when trade-offs arise (sig.= 0.581), and Biological diversity appreciation (sig.= 0.537). This component was ranked sixth (6th) with a factor score of 1.945. This component has diverse learning objectives. However, they all resolve towards effective sustainability leadership and adding value to the sustainability development drive. Objectives of social learning, motivational variables, collective change, understanding loss rates, policy incentives, prioritizing high-level values, and appreciation of biological diversity enrich construction professionals towards improving their focus on sustainability. As Galpin et al. (2015) supported, sustainability cultures that seek to enhance value thinking are paramount. Construction professionals need to be equipped with these learning objectives through continuous professional development and curricula re-development for undergraduate and postgraduate programmes.

Component 2- Strategic planning for co-existence

The second (2nd) component was titled "strategic planning for co-existence" and accounts for 1.730 eigenvalues with a variance of 8.238%. The sustainability learning objectives incorporated in this component are Facility to foster state of the planet knowledge recalibration (sig. = 0.799), Understanding linear and non-linear growth rates and consequences (sig. = 0.709), Biophilia integration (the urge to affiliate with other forms of life) (sig. = 0.626), Responding to maladaptive forces effectively (sig. = 0.501), and Incorporating deep understanding of the state of the planet into policies and actions (sig. = 0.473). This component was ranked fifth (5th) with a factor score of 2.340. Strategic thinking allows for long-term objectives that will bring about the necessary change in the construction industry. The learning objectives within this component enable the construction professionals to achieve or implement sustainable development within and through their designations. Objectives of planetary knowledge recalibration, understanding growth rates and consequences, biophilia integration, responding to maladaptive forces and enacting appropriate policies and actions are all paramount products of essentially equipped professionals as supported by Svanstrom *et al.* (2008), Niu *et al.* (2010) and Osman *et al.*, (2017). However, training constructional professionals on these objectives requires complementary efforts from instructors in other professions

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and industries. This implies the need to integrate sustainability learning objectives as multi-disciplinary functions.

Component 3- Planetary knowledge and behaviour

The third (3rd) component was titled "planetary knowledge and behaviour" and accounts for 1.347 eigenvalues with a variance of 6.415%. The sustainability learning objectives incorporated in this component are Deep understanding of how nature sustains life (sig. = 0.795), Understanding the current, widely-held state of the planet perception and their limits (sig. = 0.658) and being the change one wants to see in the world (sig. = 0.640). This component was ranked fourth (4th), with a factor score of 2.781. Critical thinkers are essential for the attainment of the sustainable development agenda. The deep understanding of the relationship between nature and life and the state and limits of the planet (Dmochowski *et al.*, 2016) are fundamental objectives of critical thinkers. These are supported by the resolve to be the change one wants to see in the world. For construction professionals to achieve these objectives, they must be exposed to the broader planetary issues and affect the change required from a holistic perspective.

Component 4- Social inclusivity and evidence-based problem-solving

The fourth (4th) component, titled "social inclusivity and evidence-based problem-solving, " accounts for 1.318 eigenvalues with a variance of 5.854%. The sustainability learning objectives incorporated in this component are Openness to perform to the views and concerns of others (sig. = 0.791) and Facility to conduct action research (sig. = 0.741). This component was ranked third (3rd), with a factor score of 3.010. The learning objectives within this component are concerned with the ability and capacity of construction professionals to solve problems in the construction industry. The objectives of 'openness to perform to the views and concerns of others' and 'facility to perform action research' enable construction professionals to identify sustainability inadequacies within their construction projects and broader communities. Consequent to identification, the construction professionals can undertake competent inquiries that culminate in viable solutions and be exported to similar communities. Failure to equip construction professionals in this regard will have disastrous consequences, as opined by Viertel (2010) and Alkhaddar *et al.* (2012).

Component 5- Futures thinking

The fifth (5th) component, titled "futures thinking, " accounts for 1.229 eigenvalues with a variance of 4.446%. The sustainability learning objectives incorporated in this component are: Understanding climate change (sig. = 0.759) and Acting in accordance with long-term goals (SDGs) (sig. = 0.499). This component ranked second (2nd), with a factor score of 3.540. Issues of climate change and acting according to the long-term goals (SDGs) are universal and are a real threat to the future of mankind. Thus, the component

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title is appropriate as it highlights the learning needs that will assist in securing future generations' existence. However, the attention on these pertinent objectives has not been equally met with sufficient instruction in tertiary institutions (Kokkarinen and Cotgrave, 2013). Professional bodies have not adequately taken remedial action towards its incorporation in construction-related policies. The existent gap needs redress if the tenets of the sustainable development agenda are to be achieved (Despotovic *et al.*, 2015). It is incumbent upon the construction industry organizations, academics and associated professional bodies to enhance the knowledge of construction professionals in these aspects.

Component 6- Cultural diversity and evolution

The sixth (6th) component, titled "Cultural diversity and evolution, " accounts for 1.132 eigenvalues with a variance of 5.391%. The sustainability learning objectives incorporated in this component are Cultural diversity appreciation (sig. = 0.759) and Understanding of how life on Earth co-evolved (sig. = 0.617). This component was ranked highest, with a factor score of 3.800. Globalization has contributed to the opening up of borders, bringing about considerable advantages and disadvantages. Multinational construction companies have a strong presence in the Zimbabwean construction industry, and this has inevitably brought about cultural variances on social and environmental aspects. Decent work and workers' well-being concerns (Moyo *et al.*, 2019; Moyo *et al.*, 2021) are borne from a lack of cultural diversity appreciation. Thus, as construction professionals are effectively instructed in such apprehensions, they will ably administer construction projects sustainably. As supported by Dmochowski *et al.* (2016), 'understanding how life on planet Earth co-evolved is an important learning objective. Long term future planning needs an in-depth understanding of how the planet has co-evolved. This enables an understanding of how evolution will likely progress and enables effective strategic planning and policy formulation of construction professionals. Issues of construction on wetlands (Mhlanga, 2018) and infrastructure inadequacies (Mhlanga, 2019) can be efficiently dealt with if construction professionals attain such instruction.

The six (6) significant groups of sustainability learning objectives show the depth of construction professionals' current knowledge. It is apparent that much needs to be done to improve the learning of construction professionals concerning cultural, social and environmental concerns. Contrariwise, economic concerns are inconspicuous. The results are supported by Wiek *et al*. (2015) and Glasser and Hirsch (2016), although the thrust of the groups' broader learning objectives is different. Hence, the implementation, in accordance with the importance of the learning groups, also differs. The results have various implications. There is a need to enhance sustainability education in the construction industry for those in training and those already in professional capacities. Ratifying global initiatives is not enough if this is not supported by remedial action within

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the training of professionals. Enacting sustainability policies should be supported by knowledge enhancement within the construction industry, and appropriate performance measures should be operationalized.

4. Conclusion

Sustainability-related challenges of performance, workers well-being and social responsibility issues are common in Zimbabwe. While advocating for sustainable construction seems an excellent resolution, however, sustainability instruction of architectural, engineering and construction professionals is inadequate. This research aimed to determine sustainability awareness needs for construction professionals and evaluate statistically significant variances due to gender, designation, educational levels, and respondents' experience concerning their ranking. The relative importance analysis results show that all sustainability learning objectives are important with understanding climate change, acting per long-term goals (SDGs), and openness to perform to the views and concerns of others being the top three (3) learning objectives. The results confirm the dearth in construction professionals’ sustainability learning. Construction professionals need support from universities and relevant professional bodies to bridge the evident gap. The need for policies that support sustainable construction is emphasized. No statistically significant aggregated sustainability learning objectives variances were due to gender, designations, educational levels, and experience signifying uniformity in perceptions. However, interventions for Architects, Engineers and those with degrees and MSc academic levels are supported for individual sustainability learning objectives, although these differences' practical significance was generally low. There is consensus from the construction professionals on the sustainability learning needs.

Factor analysis exposed related and significant components of sustainability learning objectives. It generated six (6) essential groups. These comprised, from highest importance: cultural diversity and evolution, futures thinking, social inclusivity and evidence-based problem-solving, planetary knowledge and behaviour, strategic planning for co-existence and sustainability leadership and value prioritization. These sustainability learning objectives will inevitably resolve the sustainability-related challenges affecting the construction industry. However, the major challenge is potentially in equipping construction professionals with this knowledge. An integrative and multi-disciplinary approach is most suited. This entails an extensive sustainability education drive through academic institutions and professional bodies. Regulatory authorities can also be proactive in shaping the sustainability agenda by insisting on adherence to sustainability enhancement proposals. The study had limitations on failing to incorporate the views of clients as initiators of built environment projects. However, project managers represented their views to a great extent. Future studies can consider the derivation and

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contextualization of sustainability learning objectives to develop continuous professional development programmes within the various construction-related professions.

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Proceedings of the DII-2021 International Conference: “Building Smart, Resilient and Sustainable Infrastructure in Developing Countries”

DII-2021-031

People, People, everywhere; The Architectural Design Response for Enugu City, Nigeria

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Abstract

Overpopulation is a serious global problem, and it is predicted to get worse in future if unchecked; coupled with this is the threat of dwindling resources. The steady increase in the population of many Nigerian cities and its effect on the housing sector are surfacing as a clog in the wheel of efforts to reduce the nation’s housing deficits. This research aims to investigate how urban life can continue to thrive in the face of existing housing issues in the colonial city of Enugu. It utilized a qualitative research method of survey, participant observation, and literature review in which primary and secondary data were collected and analysed based on thematic content analysis. Employing the convenience sampling technique, the sample size involved the three local government areas that make up the Metropolis. The research results highlight gross housing deficit, increased housing rent, emergence and expansion of squatter settlement, Land use conversion, poor infrastructure and slum conditions as some effects of rapid population growth due to urbanization and rural-urban drift in the city. Statistics of public housing provision from 1999-2020, was observed to be skewed away from low-income earners who make up a significant proportion population. It recommends that architects’ intervention in the housing sector be strategic, holistic, and proactive and encourage local building materials, vertical development, dry construction, and stakeholders’ participation in the housing delivery process. It concludes that futuristic architecture holds the key to ensure humanity’s continued stewardship on earth and sustainable housing delivery for the teeming population.

Keywords: Population, Settlements, Housing Deficits, Architecture, Enugu

1. Introduction

Concerns about the overpopulation issue have continued to rise and have assumed a global dimension. To better appreciate the crisis our planet is subjected to. It is crucial to understand overpopulation. It is a condition where the total number of humans in a particular geographical area (often a city, country or continent) is too high for the environment and its available resources to sustain them. Globally, overpopulation is a situation in which the earth's resources used by the world's population cannot be regenerated by the earth each year.

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Since the 1970s, this trend has persisted with each successive year causing more harm with increasing damaging effects.

Currently, the global population is about 7.6 billion. Experts anticipate growth increase to 9.8 billion in 2050 and 11.2 billion by 2100 (See figure 1), with more than half of us living in cities (Robert, 2020).

This rapid escalating human population is mounting pressure on the earth's natural resources and consequently changing its climate at an alarming rate—fears and doubts about access to adequate food, housing, water etc., for all these people.

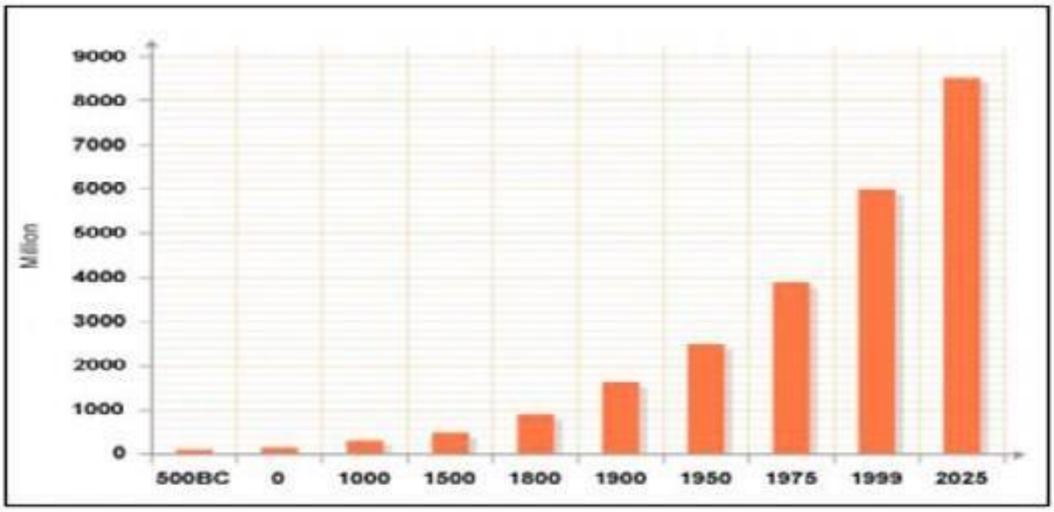

Figure 1: World population growth 500BC-2025 Source: BBC UK, 2017.

From figure 1, for the global population to reach only one billion inhabitants, it took hundreds of years, however in a little over two centuries, this figure multiplied exponentially and spun towards overpopulation. In the history of the human species, there has always been a balance between birth and death rates, and it has maintained a sustainable population growth rate (Rinkesh, 2020). Evidence in the literature suggests that there has been a constant population increase since the Bubonic Plague in the 1400s. The plague and the 21st century period have witnessed several wars, natural disasters, and man-made hazards. However, none of these made a dent in the human population (Rinkesh, 2020). The tipping point was generally

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accepted to be the fourth Industrial Revolution. However, numerous smaller revolutions have contributed to population take-off and have resulted in the current dangerous overpopulation of the planet (UNPF, 2021). Developing nations face the problem of overpopulation more than developed countries, but it affects most of the earth as of now. Available statistics show that Nigeria (Africa), China (Asia) and India (Asia) are three countries whose total population over the next decade will amount to 40% of global demographic growth (Muggah, 2016). This reveals an impending global population explosion if not controlled. However, it indicates vast opportunities in these rapidly developing settings and unsettling risks related to the development.

Since the end of the Nigerian civil war in 1970, no aspect of society has aroused the passionate concern of reforms more constantly than the massive population increase, the housing condition, and the urban poor's living standard. These profound changes have led to the proliferation of modern-day slums (Okeke, 2021). According to United Nations Development Programme (UNDP, 2010), Africa has the largest slum population globally, amounting to 61% of its urban residents, approximately 195.5 million people. On the other hand, Nigeria has an urban population that ranks 9th largest globally and accommodates some of the largest slums in Africa (Okeke *et al.,* 2020). Huge population increase mainly due to the effect of galloping urbanization and massive rural exodus encourages thousands of rural people who daily flock to urban areas where they think there are 'green urban pastures' to seek education and employment. However, very little thought has been paid to its effects, and no strategic architectural mitigating measures have been instigated to accommodate the expanding human population within cities in developing countries like Nigeria.

The growth of the colonial city of Enugu has been tremendous from its initial size as a coal miners camp (the present-day coal camp residential neighbourhood) within an area of 151 miles (243 km) and a population of about 3,170 people by 1921 to a projected population of over 1,125,467 in 2020. This has grievous implications for urban housing delivery in the city. Current and previous public housing provision in Enugu has not contributed to alleviating the housing deficit experienced by the teeming city population. Therefore, the research aims to investigate existing housing issues in the colonial city of Enugu due to the population explosion and formulate a theoretical framework that is architecturally based on mitigating the effects of the emerging overpopulation problems experienced in the study area. The specific objectives pursued in this study include; (i) to understand the concept of housing and the environment of the earth, (ii) to determine population growth of the study area (iii) to highlight the Urban Public Housing provision in Enugu from 1999-2020. It is pertinent to note that discourse on overpopulation issues, especially in a typical African setting like Nigeria, can quickly become provocative because of many unravelling questions; whose

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fault, what is the origin, and who do we evict from the environment to maintain the balance. It, therefore, draws to attention that the research focuses on accommodating the already exacerbating issue that has come to stay. The findings of this study are instructive in noting that to achieve a balance between environment and human population, architects and other building design professionals should endeavour to give adequate attention to the sociological aspect of environmental design.

According to Koslow (2017), overpopulation can influence how we think about architecture more than any other problem we face. Thus, architecture needs to respond accordingly to accommodate the newfound city’s change that is still threatened by supplemental challenges like climate change, global warming, and biodiversity loss—forcing cities to undertake a holistic and sustainable transformation of their previous models and invariably driving city governments under pressure to provide more housing and workspaces to avert the populace from living and working in poorly designed or low-quality buildings. This research is valuable to the current discourse on managing the growing urban population in developing cities and improving the housing condition of urban areas in the Global South by revealing and projecting the rate of population increase due to urbanisation and suggesting possible control measures for urban areas housing issues. Thus, these research findings are expected to build on the existing knowledge base and inform building designers, town planners, and policymakers on tackling the growing condition of a housing shortage due to demographic surge in urban residential neighbourhoods through futuristic architecture and adoption of measures to mitigate its effects in Nigeria effectively.

1.1 Context of the Study

Enugu, a city that emerged as a result of the discovery of coal deposit by 1915, is situated between latitude 06°21°N and 06°30°N and longitude 07°26° E and 07°37°E (see figure 2) within an estimated land area covering a total of 215mi^2 equivalent to 556 km^2 (Okeke *et al.*, 2020) and fondly called the coal city was named after “Enugwu Ngwo”. It is a hill settlement of the Ngwo people of the Igbo tribe of Nigeria and owns its origin from coal mining activities of the colonial era.

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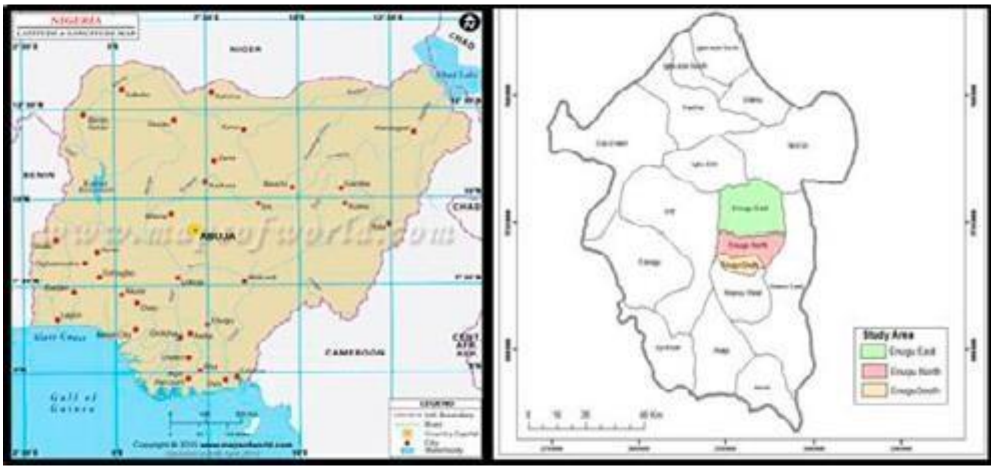

Figure 2: Map of Nigeria Showing Enugu State; Map of Enugu State Showing the study area

Source: Ministry of Lands Survey, Enugu State, 2018.

The incidence of rapid urbanization and an increasing rate of rural-urban migration into the city would be better appreciated with insight into the city's historical development during the colonial coal mining era and the present-day status. Enugu is the Capital city of Enugu State. It is located in the South-Eastern geopolitical zone of Nigeria. The town grew and expanded into other indigenous inhabitants like Ngwo, Nike, Amaechi, among other communities within the vicinity. Since 1929 as Capital of the Southern Provinces, Enugu has remained an administrative headquarter in various capacities and is presently the capital of Enugu State from 1991. Although coal mining activities no longer thrive in the city, Enugu is still regarded as the “Coal City”.

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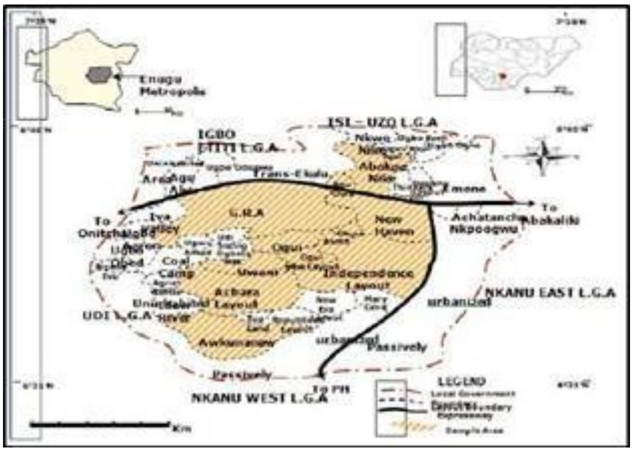

Figure 3: Map of Enugu Metropolis

Source: Google Map, 2014

Enugu has developed as the rallying point of many people and cultures of the hinterlands and naturally assumed the headquarters of Eastern Nigeria since the early 1960s till date. As an administrative capital city of Enugu state, the government's presence is dominant. Enugu is internationally ranked as the 553rd city in the world. The city is dotted by many tertiary educational institutions, industries, financial houses, commercial centres and health institutions, and infrastructure and basic amenities, among other characteristics. All these attractions pull people to the city from far and near, especially from surrounding rural communities. The town has grown rapidly over the past 50-years, at a population growth rate ranging from 2.553% to 2.85% (NPC, 2006) and net migration rate of -0.22 migrant(s)/1,000 populations. Most government institutions have no housing scheme for their employees, who are mostly low and medium-income earners. The housing situation is further worsened because existing decent- housing units in Enugu are inadequate, expensive, and unaffordable to most of these employees. Many housing programs in Enugu have failed because; the housing problem is seen as a mere shortage of houses. Consequently, most proffered solutions have been ad-hoc in nature, as attempts were made to provide as many housing units as possible within the shortest possible time. This has led to poor targeting, haphazard development, lack of planning and implementation.

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2. Literature Review

Fewer than 800 million people populated the earth in the mid-18th Century. Today, barely 250 years later, the number is more than 7.7 billion and will continue growing until 2050 by at least another 2 billion. Scholarship in the literature shows that debate about overpopulation is controversial because of different researchers' diverse views, opinions, and perceptions. Many questions bordering around overpopulation have remained unanswered. For instance, who is the problem source? How did we get to this sorry state? What should be done about it? Who do we evict from earth? Who have the right to live?

Considering that human beings appeared on earth more than four million years ago, the cause of the exponential growth in the number of people in recent history has been astonishing and unanticipated. The industrial revolution was widely regarded as the defining moment. However, numerous minor revolutions have aided current global alarming overpopulation: medical, technological, agricultural, financial, transport and demographical, among others.

Every human being is entitled to a fair share of the earth’s finite resources. However, with a total population reaching 8.1 billion, everybody adopts a comparatively low material lifestyle like Papua New Guinea. The world will still be pushed to an ecological breaking point because an average person consumes over 50% above the sustainable level. Amazingly in the United States, under ideal conditions, an average individual consumes five times greater than the planet’s sustainable yield. To help temper this wildly unsustainable condition, we need to understand what exacerbates overpopulation and overconsumption. We also need to know how these trends affect everything from climate change to socio-political unrest. The rapid exponential growth of the global human population is overwhelming; therefore, it is necessary to understand its root cause. Some factors contributing to overpopulation include:

- Increased birth rate
- declined death rate
- Agricultural advancements
- Urbanization
- Better medical facilities and technological advancement in fertility treatment
- Rural-urban migration
- Lack of Family Planning and Poor Contraceptives Use
- Child Labour
- Religious ideologies etc

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2.1 Effects of Overpopulation

Since the beginning of human civilisation, people have strived to create a beneficial built environment. However, human population growth and mass migrations are putting the infrastructure of many cities under strain, especially in developing nations. It is surfacing as an age-old problem that has caused headaches amongst urban planners and city officials for decades. Below are some of the effects of overpopulation.

- Rapid climate change
- Environmental degradation
- Depletion of natural resources
- Increased cost of living
- Unemployment surge
- Malnutrition, starvation and famine
- Increased intensive farming
- Extinction of biodiversity
- Breeds conflicts and wars
- Water shortage
- Epidemics and pandemics
- Decreased life expectancy

2.2 Structure of the earth environment

Earth is a planet in the solar system that supports life, with about 70% of its surface covered with water and only 30% dry land. It envelopes (or spheres) the atmosphere, hydrosphere, lithosphere, and biosphere and are closely linked by the flow of matter and energy, which integrate them into specific systems. According to Glazovsky (2007), two large integrated systems are the geographical envelope and the biosphere. The basic components of the environment are atmosphere or the air, lithosphere or the rocks and soil, hydrosphere or the water, and the living element in the background or the biosphere.

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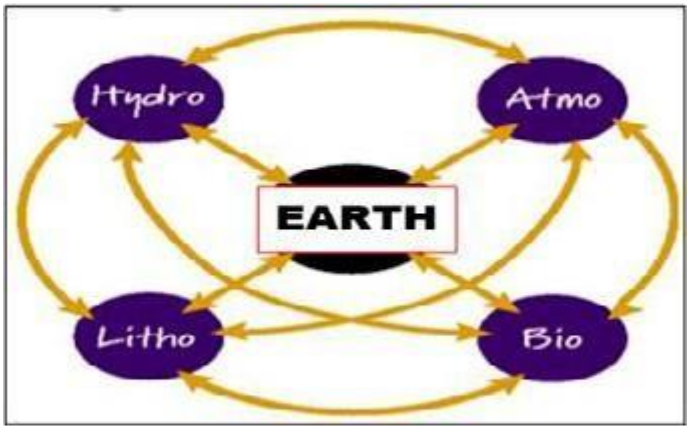

Figure 4: Structure of the earth environment

Source: author, 2021

The atmosphere: the mass of air surrounding the Earth like a transparent wrapping. It spreads up to 300 km. above the earth’s surface. The lithosphere: the solid outer crust of rocks about 80km thick, which is the outermost solid shell of the planet body. This also includes the pedosphere, where the soils are present, and the soil-forming processes occur.

The hydrosphere: the water portion of Earth. This part of the environment also includes the cryosphere, a part of the Earth’s predominantly frozen body and mainly consists of different ice forms.

The biosphere is the planet's life zone that permeates all the above as life is widely spread around the planet.

Architecture is a field of study for planning and ordering the built environment by ensuring design safety and functionality (Okeke et al., 2019). It beholds architects to plan the atmosphere, hydrosphere, and lithosphere to provide housing for the continual existence of the biosphere.

2.3 Concept of housing and assumptions of Public Housing Policy

The concept of housing has received scholarly attention in recent times. It can be seen as providing a large number of residential buildings permanently with adequate physical

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infrastructure and social services in planned, decent, safe and sanitary neighbourhoods to meet the basic and special needs of the population. (Osuide, 2004; Mba, 1992). Housing in all its ramification is more than mere shelter since it embraces all infrastructure, social services and utility that make a community or neighbourhood a livable environment. It is also an aggregation of human settlements around facilities and resources that support and provide a livelihood.

It has been observed that some constant assumptions herald urban public housing policies. These assumptions by Policymakers were captured by Graham (2015) from work on five African National Urban Housing Profiles of Malawi, Ghana, Zambia, Liberia and Lesotho, and some work in Sierra Leone and Ethiopia. He stated that some constant assumptions springing in part from several shared circumstances seem to rule policymaking but are far from being true. These assumptions were as follows

(i) Urban land and housing are expensive and more unaffordable than in the past.
(ii) Rents are too high and skyrocketing.
(iii) The solution to the housing problem is to build housing more cheaply.
(iv) Mortgages for more/poorer households are a large part of the solution.
(v) Affordable housing is possible through formal sector private investments.
(vi) Establishment of a National Housing Trust Fund will help many households own their own home.
(vii) Housing affordability depends upon household income.
(viii) Land registration is the solution to non-bankable land.
(ix) New supply policy should be based on single household villas on serviced plots.
(x) Every household should become an owner of housing.

Judging from recent experience in seven countries in the region, he argues that these are generally untrue and work against the effective provision of appropriate housing affordable by the majority of households in Sub-Saharan Africa (Graham, 2015). In the light of the above, the burden of poor urban housing delivery could be blamed on the ill-conceived opinion of Policy-Makers about the socio-economic constituents of the urban populace and hence, the inability of Governments to deliver on the housing needs of all categories of urban residents vis a vis high, middle and low-income classes. By this misconception, the high-income groups seem to be most favoured. While whatever consideration is left is meted on tile middle income groups, the real urban low-income groups are relegate to the background and left to cater for their housing needs in their own way. This explains the inevitable and sporadic emergence of squatter settlements in most developing and even some developed countries.

***2.4** Urbanization and housing issues in Enugu urban*

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As one of the major Nigerian cities, Enugu lacks adequate infrastructure for housing and has had its fair share of urban population upsurge, a significant feature of cities of third world economies. Aka (1993) assert that it is due to the land-use planning statute that encompasses the evolving functions and responsibilities of urban areas, as numerous Nigerian research studies have documented. Although, according to Ononugbo *et al.* (2010), from the 1960s through 1989, rapid urbanization and industrialization in Enugu, Nigeria, resulted in two housing-related issues. The first was a scarcity of low-income housing, and the second was the rising cost of decent living accommodation. The shortage of affordable housing, along with the increasing cost of available units, made it increasingly difficult for low-income households in Enugu to maintain an acceptable quality of urban life, compelling them to live in slums where they wreaked havoc on the environment (Okeke *et al.*, 2020). Environmental problems escalate when and where there is a significant increase in urban population with little or no regard for the ecological repercussions. Anecdotal evidence and previous authors (Egbenta, 2009; Ononugbo *et al.*, 2010; Chukwu, 2015; Emodi and Udechukwu, 2021) suggests a high level of land-use conversions in the city. Residential districts have been converted to commercial uses, and industrial areas turned into residential areas. Development of residential accommodation has moved to recreation parks and open spaces, among other visible abuses. Several incompatible land uses have emerged, resulting in health hazards, environmental deterioration and chaotic traffic situations in the city.

3. Research Methodology

The study emanated from observable difficulties experienced by residents in securing decent accommodation experienced within the metropolis. The research methodology adopted was a review of the literature. It followed a qualitative research approach and utilized both secondary and primary data. The study population involved 19 neighbourhoods within the city. The primary data were derived from anecdotal evidence. They used techniques of participant observation, survey with the author's previous research works on sustainable urban development in the 21st century to provide a holistic representation depicting the current situation of the study area. The secondary data was derived from a literature review of published research relevant to the study, identified from various sources, including journals, workshops and conference papers. Papers reviewed were identified via searchers on online databases such as Google scholar, United Nations database, and Science Direct. Population and housing survey of the National Population Commission and the official gazette of Enugu State Housing Development Authority formed a significant source of secondary data. Statistics of the human population for Enugu metropolis was projected from 1991 to 2040, applying Thomas Malthus' Exponential Model. The data were subjected to thematic content analysis. The results are presented using tables and text. Based on the results, inferences were made regarding the rising urban population and the contribution of

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Urbanization and rural-urban migration in Nigerian cities on urban public housing delivery issues in the Enugu metropolis.

4. Results and Discussions

Table I: population trend in Enugu (1991-2021)

Sn	Neighbourhood	Area (ha)	Density	1991 Population	2006 Population	2020 Population	2040 Population
1	Abakpa	50.2	High	90,619	137,124	201,846	350656
2	Asata	45.0	High	21,828	33,030	48,619	84465
3	Iva valley	50.3	High	8,891	13,453	19,804	34404
4	Akwuke	16.6	High	3,326	5,033	7,408	12522
5	Coal camp/Ogbete	34.0	High	25,994	39,334	57,900	100586
6	Ogui new Layout	44.3	High	41,237	62,400	91,852	159569
7	Emene	53.5	High	79,033	119,593	176,039	305823
8	Gariki	98.7	High	19,662	29,753	43,795	76083
9	Obiagu	43.0	High	5,487	8,303	12,222	21232
10	Amechi Awkunanaw.	67.47	High	13,441	20,339	29,939	52011
11	Nike	138.2	High	34,501	52,207	76,848	133504
12	Achara Layout	955.0	Medium	50,427	76,306	112,321	195131
13	Maryland	40.4	Medium	4,666	7,061	10,393	18055
14	Uwani	61	Medium	31,875	48,233	70,999	123342
15	New haven	48	Medium	18,753	28,377	41,770	72566
16	Idaw river	750	Medium	3,138	4,748	6,990	12143
17	GRA	233.3	Low	19,600	29,659	43,657	75843
18	Independence Layout	30.5	Low	24,466	37,022	54,496	94673
19	Trans Ekulu	103.9	Low	11,474	17,358	25,557	44,399
	TOTAL	**251346**		**505,280**	**722,664**	**1,125, 467**	**1,955,216**

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Source; National Population Commission (1991) projected to 2020 by the researcher

The decision of individuals to migrate represents some form of collective wisdom because the migration trend is mainly prompted by economic reasons and a better standard of living, and such opportunities are presumed to be high in urban areas. However, housing availability and provision have not been commensurate surfaces as an urban issue; hence, overpopulation and resultant overcrowding in the built environment becomes inevitable. Thus, the speed and magnitude of population movement as supported by literature (Okonkwo, 2003; Ibem, 2011; Nnaemeka-Okeke 2016; Okeke *et al.*, 2020; Adewale *et al.*, 2020) and evident in the city of Enugu has not equated government's ability to cope with the added burdens of the human need for housing and several serious. Hydra-headed problems of housing have emerged in the city.

The proliferation of tertiary institutions and establishing industries such as food, pharmaceuticals, automobile, plastics, beverages, mineral water, and breweries around the Enugu metropolis contribute to rural-urban drift. As given by the 1991 population census figure, the population of Enugu was 505,280 at an annual growth rate of 2.5 percent. The 2006 national population census indicated a population of 722,664 inhabitants at a yearly growth rate of 2.85 percent. Presently, the people of the city is projected to be over 1,125,467 people. It can be observed that within the interval of 15years (1991-2006) Enugu population figure rose by 217,384 inhabitants.

Consequently, within the span of another 14years (2006-2020), it had an incremental change with 402,803 new people, approximately 90% growth. This suggests that city is going through the proverbial roof, set to surpass 2 million by 2040, just like many third world cities. This finding tends to provide support to the study of Wei and Yuzhe (2020). They posit that in Chongqing, China, the housing condition keeps declining amidst geometrically progressing population figures resulting in urban slum and blighted conditions. As projected, the population growth change also indicates that the government and stakeholders should double their effort to tackle the rising demand.

Furthermore, the population distribution across the neighbourhoods in Enugu, according to the National Population and Housing survey of the National Population Commission, as shown in Table I, did not capture the squatter settlements. The implications of the population trend in Enugu, as depicted in table I, is that the city has exploded to the extent of creating an imbalance between the rate of population growth and housing provisions, thus putting strain on the city's natural resources to attain the increasing demands. It has also occasioned the growth and extension of low-income unplanned settlements on the city outskirts. Workers

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from those areas are putting further stress on the already inefficient public transportation system and urban infrastructure. This aligns with the study result of Kuddus *et al*. (2020), who attributed urban decay and declining public health in both developed and developing cities to the effects of galloping urbanization. The list of Urban Public Housing provisions in Enugu from 1999-2020 was perused to better understand the housing and population imbalance.

Table II: Urban Public Housing provision in Enugu (1999-2020)

Sn	Housing Provision	Density	Housing Type
1	Ebe-Ano	Low density	5 bedroom duplex with boys quarters
2	Golf course	Low density	5 bedroom duplex with boys quarters
3	Harmony	Medium density	2 bedroom flat
4	Maryland estate	Medium density	2 bedroom flat
5	Zoo estate	Low density	5 bedroom duplex with boys quarters
6	Liberty estate	Low density	5 bedroom duplex with boys quarters
7	Trans ekulu housing	Medium density	5 bedroom duplex and 4 bedroom bungalow with boys quarters
8	Coal city estate	Low density	5 bedroom duplex with boys quarters
9	New abakiliki road	Medium density	5 bedroom bungalow with boys quarters
10	Transparency	Low density	Block of 4-bedroom flat
11	WTC	Medium density	Block of 2-bedroom flat (4 housing unit)
12	Rangers 1	Low density	3-bedroom bungalow
13	Rangers 2	Medium density	3-bedroom semidetached bungalow
14	Citadel estate phase 1	Low density	Block of 4 flat terrace
15	Citadel estate phase 2	Low density	Block of 4 flat terrace
16	Victory housing	Low density	Block of 4 flat terrace
17	Trinity	Low density	Block of 4 flat terrace
18	Sand view	Medium density	1- and 2-bedroom flat/ 3 suspended floor semi-detached
19	Coal city view	High density	3-bedroom semidetached bungalow
20	Valley	High-Medium/Low density	4 housing units per plot

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21	Valley 2	High density	4 housing units per plot
22	Fidelity estate	Low density	4-bedroom duplex
23	Liberty phase 1	Low density	5-bedroom duplex with boys quarters
24	Liberty phase 2	Low density	5-bedroom duplex with boys quarters

Source: Enugu State Housing Development Authority (2020)

Recent public housing provision in the city of Enugu from 1999-2020 was skewed away from low-income earners who still dominate a significant proportion of the urban population in the city. The data in Table II shows that the state government chose to pay more attention to housing development for high-income earners in the most recent years. There is an indication of various housing schemes planned for low and middle-income groups, but their reality is almost inexistent in the present housing provision in the city. The present Ebeano and Golf Course Housing Estates were designed exclusively for high-income earners. Harmony Estates which was intended to take care of the low, medium and high-income earners, was observed to have been hijacked by the high-income groups, thereby leaving the urban poor housing problems unaddressed. Out of 24 Urban Public Housing projects embarked on by the government in the metropolis from 1999-2020, only about three targeted the low-income earners. Existing evidence revealed that it was futile as medium and high-income earners presently enjoy those facilities. Consequently, the cost of building materials in Enugu was also very high and kept on increasing. This inhibits low-income housing provision in Enugu and, thus, the call to pursue more sustainable options of locally available building materials.

Another development trend within the city is gentrification, whereby low-income earners are displaced from their settlement in the city centres by affluent individuals. This has left many resident itinerants. However, gentrification is the process whereby the character of a poor urban area is changed by wealthier people moving in, improving housing and attracting new businesses. The ill effects of displacing the current inhabitant, usually the urban poor in the process, have not been adequately considered in the study area. Instead, many of the efforts of housing providers aim at quick profits and returns on investments on a short term basis has led to fixing and increasing exorbitant rental fees for new development within those areas adding to the shortage in housing supply for the urban poor.

Furthermore, as population figures keep rising with the influx of migrants to the city, the residential property stock is decreasing to accommodate commercial use, mainly along the major roads and streets (Agbani Road, Zik Avenue, Nike road, Okpara Avenue, Ogui road,

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Chime Avenue, Market road, Abakaliki road among others) in metropolis contributing to hike in rent on the available housing in other locations. Contravention of planning standards due to unapproved land development, increasing traffic congestion, urban sprawl, and massive pressure on available infrastructure within the significant road as districts transform into a commercial zone. These findings support the previous works of Egbenta (2009) and Echendu *et al.* (2020), who noted that shrinkage of residential stock of housing, Land use conversion and traffic issues as some of the significant imprints of rural-urban drift and population growth in the city of Enugu.

4.1 Architectural response to accommodate the expanding population

Humanity is inextricably moving to cities, and by 2050, 2 out of 3 people are expected to live in the town (UNDESA, 2018). With cities becoming a place of residence for most of the earth's population, their architecture, structure and ecology are bound to exert considerable impact on inhabitants. As a result, architects must reflect on previous experience and offer solutions following modern requirements while designing new spaces and cities. Shelter, constituting the architectural building, is one of the three necessities of life after food and clothing; that is why its absence or inadequacy is viewed with serious concern (Okeke, 2021). Buildings provide the infrastructure for a functioning city and allow for many opportunities to demonstrate a commitment to sustainability. According to Chendo (1990), the architect has solutions to every problem relating to the environment by nature of training acquired. Thus he has a role to play in addressing overpopulation issues in the background. The literature has established that the environment consists of the atmosphere hydrosphere, biosphere, and lithosphere. From time immemorial, man has continually utilized the land, and it is getting overpopulated. Therefore, the model below illustrates new areas architecture needs to harness. These interventions, through theoretical, will aid lessen the mammoth burdens felt by conurbations.

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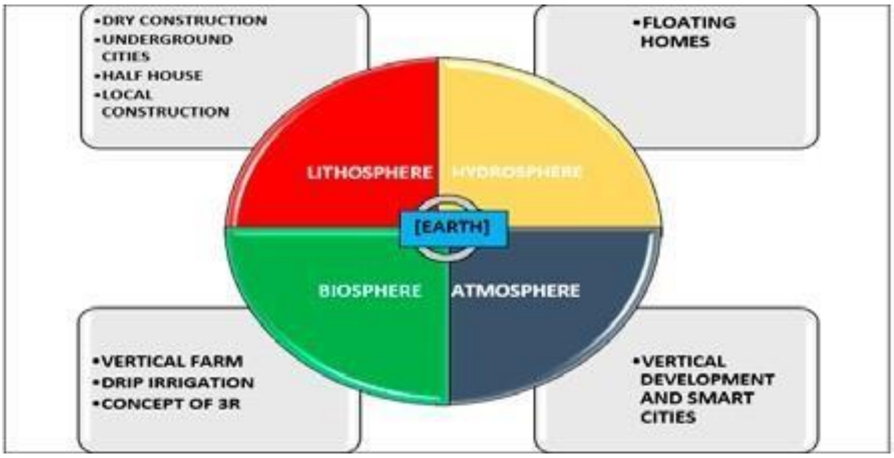

Figure 5: Architectural model to mitigate the effects of overpopulation

Source; author, (2021)

4.2 Atmosphere

Vertical development

To tackle overpopulation, architects should look to the sky in search of an escape route. High-rise construction will serve as a powerful incentive for the further development of mega-high-rise clusters, in which people can stay for a long time with no need to leave it. The concept of the development of vertical cities is to build upwards as a substitute for outward (horizontal) development as the city housing development in Enugu. This can afford an insignificant area of space for a large population. Furthermore, vertical towers help conserve the environment rather than clearing forests to build cities, resulting in biodiversity and deforestation.

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Figure 6: Vertical development of high rise cluster

Source: Samson (2018)

4.3 Lithosphere

Dry construction

It is a construction technique in which core building components are fabricated offsite, and the finished products are assembled on the construction site in dry condition without mortar in use (Adegboye, 2015). Such systems comprise two essential construction elements – load-bearing construction and lining, which, when put together, form a static, functional and aesthetic unit. Plywood and gypsum board are used in dry buildings instead of concrete and bricks. According to Adegbenga and Kamaldeen (2021), this offers moisture resistance, reduction in construction time, fire safety, thermal and sound insulation and ease of installation. Quality performance, quick and dry assembly, which does not require any additional time for drying the construction, are essential factors in this day and time, characterised by an increased pace of living and working. An example is a single storey office building at Chevron Lekki, Lagos. Built entirely by Kalsi dry construction (a division of Nigerite), the structure has a 60 sqm footprint and is completely framed with light gauge steel sitting on a concrete raft foundation

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Figure 7. DCT office building at Chevron Lekki, Lagos
Source; Cromrite 2020

Underground cities

If the early man could live and survive in caves, why don't we think cities could be built underground because the earth's surface gradually reaches its limit. Like we have vertical development upwards, architects can design and build habitable structures that grow downwards in cities with large populations that cannot expand horizontally because of their location. An example of an underground project includes (i) Rascasuelos in Mexico. The design stage is expected to extend beneath Mexico City with about 65 levels for housing accommodation, offices complex, and commercial shops. Though currently in the study phase, the studio responsible for its design is BNKR architecture. The concept of an inverted pyramid form is used to ensure natural daylight all through its 300m length underground (see figure below). An estimated thousand of city population will reside and work in rascasuelos, below the 57000sqm (240m x 240m) of the Zócalo, in the city of Mexico

Figure 8: Rascasuelos in Mexico (underground city)
Source: AmatImmo, 2018

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(ii) HELSINKI; another world lies below the metropolis of Helsinki. Approximately 10,000,000m^3 of space was constructed underground, comprising running tracks, shopping malls, and swimming pools enabled by the city's strata of granite subsoil. In the capital of Finland, during the winter, when temperatures drop to -20 degrees Celsius, it is preferable to be below the earth rather than on the surface. (iii) Underground city of Beijing; people in Beijing are already residing underground. In the capital city of China with a large population, a network of anti-aircraft accommodations converted to housing is hidden due to high market demand price, and approximately a million citizens live underneath the ground

Half house construction

This is an adaptable architectural design that accommodates change in need. Building half a good house is a futurist housing plan for new suburbs that utilises elementary skills as the need arises; occupants can readjust and construct the remaining half over time depending on their financial capacity—Example Quinta Monroy housing in Chile.

Figure 9: Image of the Half–Building

Source: archdaily.com 2019

Use of local building material

Architects should pursue the adoption and promotion of local building materials as a sustainable option through the involvement of both the public and private housing development sectors. One of the impediments to sustainable housing programs in Nigeria identified in the literature is the frequent shortage and increasing cost of building materials such as Portland cement, reinforcement iron bars, roofing sheet, plumbing and electrical fittings etc. The adaption of local building materials which are naturally available, cheap and eco-friendly should be encouraged. Special enlightenment campaign to erase the perception

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about traditional architecture in Nigeria as being 'backwards and primitive" even though it is cheap, practical, sustainable, attractive, environmentally responsive, readily available and abundant everywhere, especially in the rural areas where land is still generally available for its excavation should be re-evaluated.

4.4 Hydrosphere

Floating building

The impact of rising sea levels due to climate change resulting in flooding and loss of properties and lives in most waterfront and coastal communities in Nigeria (Okeke *et al*., 2019) has necessitated the need to find a sustainable solution. Floating building concepts are becoming a strong and intriguing alternative around the globe. It represents a new architectural paradigm compared to the traditional notion of building only on the ground and will help accommodate people close to water bodies instead of moving to dry land. An example is the Makoko Floating school building project.

Figure 10: Image of the Half–Building
Source: Okeke *et al*., 2019

4.5 Biosphere

Vertical Farms

As the global population rises, urban and rural areas will require more food to survive in the coming decades. Therefore architects are to key into Vertical Farming. It is a hydroponic farming system within high rise dwellings. Despommier Dickson of the University of Columbia advocated for this concept which discharges a small proportion of pollution compared to traditional farming methods and requires a reduced amount of energy. Its farming technique is indoor with a technology regulated agricultural environment integrating renewable energy sources like solar and biomass. Also, within limited space in the city,

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corporations can stack used shipping containers furnished with innate climate controls, LED lights with vertical hydroponics for food crop production.

Figure 11:Vertical Farming system

Source: Samson, 2018

Dripping Irrigation

This irrigation method allows water to drop gradually to the plant’s root, thereby minimizing evaporation. It has the water-saving advantage as nutrients are placed directly by slow dripping to the root region. Operating farms for agriculture to feed a sizeable rising population comes with substantial running costs and exercise. Therefore drip irrigation is the most practical technique to irrigate food crops. Research has shown that it has 30 – 50% water saving potential, and food production is twice the amount of conventional methods.

Figure 12; Drip irrigation system
Source; Samson, 2018

Concept of 3r

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Municipalities have pursued the 3-R idea of Reduction, Reuse, and Recycling in various ways towards a sustainable environment, particularly in production and consumption. The principle of reducing waste, reusing and recycling resources and products should be the target of architects in the built environment.

5. Conclusion and Recommendation

Human overpopulation is one vital issue the society must resolve to ensure a good quality of urban life for the future. Cities having greater populaces are at an advantage and better equipped to deliver urban services, educational facilities, mobility infrastructure, energy provision and healthcare. However, the side-effect and tipping point is when rising demographic overgrowth creates an imbalances situation that puts cities to a halt. The study discovered that the housing problem, which is already acute in Nigeria, has been intensified in Enugu city by massive migration from rural to urban areas, evident in the city's rising population figure. The government urban housing provision in Enugu has not matched the demographic increase. Its effects in the city include; gross housing shortage, increased housing rent, and high land value. This results in the emergence and expansion of many squatter settlements at the city's periphery, land-use conversion, poor infrastructure and facilities, and slum conditions. Urban planning and architecture, which have addressed the prevailing condition in its environment, has a significant role in mitigating the effects of overpopulation. It is recommended that sustainable housing solutions like vertical development, underground cities, dry construction, half house construction, vertical farms, floating buildings, and 3r concepts will be viable alternatives and response to the growing population, especially within the city rapidly congesting spaces.

Conflicts of Interest

The authors declare no conflict of interest.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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DII-2021-034

Data Sharing in the Construction Industry: Exploring the Willingness of Industry Stakeholders In South Africa

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Abstract

This study evaluated the attitude of South African project and construction professionals towards sharing construction data, assessed the level of satisfaction with construction data sharing and the level of willingness towards the creation of a database for construction data. The study adopted a closed-ended questionnaire served on project and construction professionals through an online survey platform. The respondents were reached through the South African Council for the Project and Construction Management Professions (SACPCMP). From a total of 2062 professionals contacted for participation in the survey, 134 responses were obtained. This represents 6.50% of the total population. The responses were analysed using frequencies, percentages, mean rating, ANOVA and correlation analysis. The results of the stratified study show that while most respondents supported data sharing, the level of support received from other practitioners was low. The findings also revealed that practitioners are mostly dissatisfied with data sharing among professionals in the industry. Though the results indicate some measure of willingness on the part of the practitioners to transfer data at a fee, more experienced practitioners and large/multinational firms supported creating a central database. Further, the result shows that professional affiliation positively impacted the level of willingness to share data. The study will further deepen insight into professionals’ characteristics that could influence construction data sharing and assemblage. The study explores the relationship between professionals’ characteristics and the willingness to share data. The study presents insights from industry professionals on the level of satisfaction with construction data sharing, especially where issues of construction data pose significant challenges to project and construction professionals.

Keywords: construction data, databank, fourth industrial revolution, open data sharing, practitioners, satisfaction.

1. Introduction

There has been a tremendous digital switch over the last couple of decades, and this has named this the fourth industrial revolution (4IR). This rapid-paced technological shift has opened up markets, led to rapid industrialization in most economies, influenced operations across industries and impacted existing models of interactions and business operations

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(World Economic Forum, 2016). Globally, sectors are beginning to brace up for the transformations accompanying the 4thIR. Though the extent of its impact may not be fully understood, the anticipated response must be integrated and comprehensive (Schwab, 2015). A major characteristic of the 4thIR is its underlying digital and automated influence on all activities across sectors and industries. The construction industry operations are not exempted from these influences. This presupposes that construction industry professionals need to be strategically ready for the resultant disruptions accompanying these technological trends. Towards achieving the transformation drive of the construction industry, there is the need for increasing awareness about the need to maximize data sharing. The use of digital technologies collaboratively enhances data sharing among professionals. It might thus be surmised that with the 4thIR and its attendant technological advances, data sharing among construction professionals will be encouraged at an increased level. Though the construction industry is often heavy-footed in responding to changes, innovative technologies and methods (Ostravik, 2015; World Economic Forum, 2016), the industry appears slow-paced in the integration of innovative technologies when compared with other sectors (Oesterreich and Teuteberg, 2016; RICS Insight, 2018). There is a need for the construction industry to keep pace with these emerging technological innovations and embrace automation and digitalization. It might suffice to note that the adoption of building information modelling (BIM), augmented/virtual reality, artificial intelligence (AI), cloud/mobile computing, robotics and data analytics are an important first step towards automation and digitalization in the industry.

Arising from the growing uptake of automation and digitalisation in the industry, the need and use of data cannot be overemphasized. This suggests that maximizing the use of data in the construction industry is a major factor underpinning the transformation and evolution associated with the 4thIR (World Economic Forum, 2018; Ayodele and Kajimo-Shakantu, 2020). Aibinu (2017) aptly noted that data is the fulcrum upon which the digitalization trends in the industry rest. The increasing use of advanced digital technology and automated processes will increase the potential gains of data sharing (Aibinu, 2017; Ayodele and Kajimo-Shakantu, 2020). Unless data sharing is encouraged among the professionals in the construction industry, it will be difficult to harness the gains afforded by the digitalization and automation trends. Extant studies have submitted that digital and automated technologies will open up a whole new level of data exchanges in the construction industry. However, concerns remain, particularly among researchers and construction professionals, especially in emerging markets, as to the readiness of practitioners to share data (Serwadda *et al.*, 2018). Thus, to ensure increased uptake of digital technologies, the biases of practitioners towards data sharing, perhaps stimulated by their characteristics, must be evaluated.

To this end, this study evaluated the attitude of South African construction professionals towards data sharing, assessed the level of satisfaction with data sharing and the level of

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willingness towards the creation of a central database. The remainder of this study is sectioned into four. Following the introductory section, section 2 presents the review of extant literature. Section 3 examines the methodology adopted for the study. Presented in section 4 is the discussion of findings, while section 5 focuses on the conclusions and implications derivable from the study.

2. Literature Review

The literature review discusses the construction industry and its data needs in the first subsection. The challenges to data sharing among industry professionals and the benefits derivable by industry professionals from data sharing are discussed in the second and third subsections, respectively.

2.1. The Construction Industry and its Data Needs

Construction projects are data-intensive and data-driven (Sarkar and Thakkar, 2018). A large amount of data is generated and exchanged between different professionals during the various phases of the construction process (Collinge *et al.*,2009). The professionals create, access and interpret different data daily. These include architectural plans, construction programs, BOQ, progress reports, specifications, comparative cost data, quality assessment and others such as spatial and locational data, design parameters and market data. These are used in various ways, and they must be complete and undistorted to ensure satisfactory project outcomes. However, the data generated are often not put to maximum use because the industry is characterized by inconsistency in the way data is produced, shared and used. Thus, the unstructured data becomes a challenge to data availability needed for policy and decision making (Childerhouse *et al.*, 2003). The foregoing presupposes that the nature of the industry could also serve as a barrier to data sharing. The construction industry is project-based, where companies form a temporary multi-disciplinary alliance to execute projects with specified contract terms. However, after project completion, the contractual relationships are often terminated. This often leads to ineffectiveness in managing project data. Data becomes lost owing to failure to share, keep good records or aggregate individual data collected in silos during the project (Zhang and Fai Ng, 2012). Most often, professionals within the organisation fail to conform to the standard approach in data collection during the construction process. Thus, most of the data collated are incompatible with other databases, thereby raising data compatibility and interoperability (World Economic Forum, 2017). Ruddock (2002) submitted that data on construction has been erratic, inconsistent in content and often unusable by other users. Supporting this view, RICS Insight (2019) opined that most data sets in the industry have been unstructured and often difficult to understand. The challenge of data compatibility is compounded because currently, there are no generally acceptable frameworks for collating consistent cost data. The incompatibility of data

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undermines its usefulness to others. Inaccessibility to data or an unsystematic means of assemblage can adversely affect cost management issues, the construction industry's competitiveness, and financial decisions, among others (World Economic Forum, 2017; Ayodele and Kajimo-Shakantu, 2020).

2.2 Challenges Impeding Data Sharing among Construction Professionals

Data sharing issues are beginning to form a centrepiece across different sectors and industries, and the construction industry is not left out (RICS Insight, 2019). Investors often perceive the lack of data as a major risk factor for investment decisions. Aibinu (2017) noted that data must be leveraged to provide value-added services to clients. Hence, data could be regarded as the lifeblood of the construction industry. Data is a valuable asset to professionals and firms in the construction industry (Vo-Tran and Kanjanabootra, 2013). It is synonymous with power, with which firms and professionals seek to retain their market position. Data is often regarded as a factor that provides market competitiveness over others. More often, these perceptions often inhibit data sharing among construction professionals. Thus, where data is regarded as a competitive business input (Ahiaga-Dagbuinand Smith, 2014), the thought of gaining a competitive advantage could detract from and serve as a debacle towards data sharing (Leppikorpi, 2018).

Perhaps from a psychological perspective, studies such as (Ahmed *et al.*, 2018; Che-Ibrahim *et al.*, 2019) noted that data sharing could also be dependent on organisational behaviour and professionals' collaborative inclinations. Evidence suggests that the level of collaboration among professionals concerning data sharing has long been a source of concern (Collinge *et al.*, 2009). The personal gains of data often dominate the perception of the industry benefits and interest obtainable. The construction industry is diverse, with various professionals and clients having different interests and stakes regarding construction data (World Economic Forum, 2017). A recent study by RICS Insight (2018) revealed that contractors saw fewer benefits to themselves from data sharing than clients and consultants. Maskey *et al.*, (2019) noted that due to inadequate motivation, incentives and perceived personal benefits, professionals most times refuse to disclose data. Hence, it presupposes that the willingness to share data might be intricately dependent on the level of perceived benefits to the professionals. However, beyond the concerns of personal benefits, there is an array of challenges impeding meeting the data needs of the industry. One such challenge is the complexity of the supply chain because of the multiplicity of contractors, consultants and other project actors (Sawhney *et al.*, 2004). RICS Insight (2018) noted that consultants, clients and other professionals in the construction industry are finding it increasingly difficult to access detailed and accurate data relating to pricing and construction costs which are largely embedded in the supply chain.

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Furthermore, the data challenge becomes more amplified when viewed through the lens of the fragmented nature of the industry, diversity and silo thinking, the reluctance of professionals to share data owing to perceived individual benefits, issues of data compatibility and inadequate collaboration among professionals (Ahmad *et al.*, 1995; World Economic Forum, 2016; Ayodele and Kajimo-Shakantu, 2020). Other barriers such as inconsistent conventions for data generation, closed systems, lack of standards for data exchange and concerns about intellectual property rights are often considered as major obstacles to data sharing and assemblage. For instance, RICS Insight (2018) noted a corresponding challenge in gathering construction data due to decreasing use of BOQs, increasing cost of collating and assembling data, lack of generally accepted standard of cost break-down and the inability to realize the gains of sharing data. Other areas of concern arise from "who owns the data", the need for confidentiality of clients' data and the increasing market value of data (RICS Insight, 2019). At the same time, Von-Tran and Kanjanabootra (2013) observed that data sharing, organisational culture, degree of common perspective of professionals, level of trust and absorptive capacity were identified as major factors that often influence data sharing among construction professionals. Che-Ibrahim *et al.* (2019) identified behavioural factors that influence data sharing, including trust, leadership, reciprocity, accountability, communication, culture, and commitment.

Despite the challenges to data sharing at the individual and industry level, with the pace of recent technological advances, construction data must be available, accessible and useable (RICS Insight, 2018). Data constitutes significantly to the activities of construction professionals, and without removing the biases in the perception of professionals regarding data sharing, the industry will not optimally benefit from the automation and digitalization processes triggered by the 4thIR. To improve industry professionals' perception of data sharing practices, such as enchaining internal capacities, enlightenment about the gains of sharing data and encouraging adequate alliance among industry professionals must be intensified upon.

2.3 Benefits Derivable by Industry Professionals from Data Sharing

The issue of data and reliability of estimates are fundamental causes of cost and time overruns (Ahiaga-Dagbuin and Smith, 2014). Thus, the success of construction projects and the actualization of investors' goals largely depend on accessibility to data and up-to-date data management (Martínez-Rojas *et al.*, 2016). Issues of reliability and robustness of data presuppose that the data is available and accessible. Data will have no value and lead to spurious outcomes where it is not reliable and robust. It results in risky financial decisions. Thus, construction data must be valid, reliable, current, clear and transparent concerning known limitations and comparable through advanced international standards (Ruddock, 2002). WEF (2017) submitted that professionals' confidence in the construction industry can

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be strengthened when data is updated, appropriate, accessible and stored in a compatible format.

Other benefits as widely recognized in the literature include benchmarking and improving the accuracy of cost estimation (RICS Insight, 2018). Also, the use of data goes beyond a tool for risk reduction. It could serve as a strategic input to minimize cost and gain a competitive advantage (Jones, 2012). The data generated in silos would be more meaningful if aggregated and transformed into intelligence for the use of other industry professionals (Aibinu, 2017). Where these data are applied in silos during cost management, the usefulness becomes limited, and the outcome could be spurious. Thus, it might be expected that, where silo operations are reduced, and there is more collaboration among industry professionals, there will be an increased level of data exchanges, benchmarking, and best practice sharing (World Economic Forum, 2016; Ayodele and Kajimo-Shakantu, 2020).

The foregoing review suggests that several studies have examined the factors militating against the data exchanges in the construction industry, the benefits to data sharing, and factors influencing professionals' readiness to share construction data. However, there is the need to examine the willingness and perception of the professionals to data sharing based on their characteristics/profile. It might be argued that the individual perception, profile and firms' idiosyncrasies will present significant influences/biases regarding data exchanges among practitioners in the construction industry. Thus, an analysis of the practitioners' characteristics will engender a better understanding of the personal and firms' idiosyncrasies impacting the data sharing in the construction industry. Towards this end, this study examines professionals' willingness in the South African construction industry towards data sharing. This study addressed the following research questions;

i. What is the level of support of construction professionals for open data sharing?

ii. What is the level of satisfaction of professionals with data sharing in the industry?

iii. What is the level of support towards creating a central database at a fee?

3. Research Method

To achieve a national spread, the study was based on an online survey approach. The study adopted a quantitative research approach. Data was gathered employing a closed-ended questionnaire administered to construction professionals in South Africa. Two academic professionals evaluated the survey instrument, and institutional ethical clearance was subsequently obtained to conduct the research. The respondents were reached through The South African Council for the Project and Construction Management Professions (SACPCMP) and personally through referrals. From a total

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of 2062 professionals contacted for participation in the survey via an email link, a total of 134 responses were obtained, and all were found suitable for analysis. This represents 6.50% of the total population. While online surveys are characteristically low in terms of responses (Oppenheim, 1992), the reticent attitude of the respondents might have also been caused by the global pandemic and the resultant economic slowdown that pervaded the construction industry during the time of the survey. Nonetheless, the responses obtained could provide professionals with information on the South African construction industry. Also, given the national coverage, the information obtained could provide a sufficient representation of the perspectives of construction professionals in the South African Construction industry.

Except otherwise stated, the data for the study were collected from March to August 2020. A 5-point Likert scale was adopted for the study, and these responses were analysed using frequencies, percentages, mean rating, ANOVA and correlation analysis.

In analyzing the level of satisfaction with data sharing and the support for creating a database at a fee, the authors conceptualized the level of satisfaction and support based on a 5-point Likert scale. The study adopted the mid-point of 3.0 as the benchmark mean, and scores lower than the midpoint were regarded as “not satisfied” or “not supported”.

$5.00 \geq x \geq 4.50$ = very highly satisfied/supported

$4.49 \geq x \geq 3.50$ = very satisfied/supported

$3.49 \geq x \geq 3.00$ = somewhat satisfied/supported

$2.99 \geq x \geq 1.00$ = not satisfied/supported

4. Analysis and Discussion of Results

4.1 Respondents Profile

As presented in Table I, the respondents' profile shows that 49.3% had Honours while 20.9 and 6.0% had MSc and PhD degrees, respectively. Regarding the years of experience in the construction industry, the results revealed that 29.9% had industry experience spanning up to 10 years, and 59.7% had years of experience spanning from 11 to 40 years. A total of 7.5% have over 40 years of experience in the construction industry. An examination of the management cadre showed that 14.9% are lower-level employees, 25.4% are mid-level employees, 19.4% are senior-level employees, and 40.3% are firm executives. The professional affiliation of the respondents showed

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that 80.6% of the respondents are affiliated to a professional body, and 19.4% are not members of any professional organisation. These show that a greater percentage of the respondents’ have at least a first degree with a substantial number of years in the industry. Also, the respondents are in the top hierarchy of the firms. Consequently, they would be familiar with the practices of the organisations and the industry at large.

An examination of the type of organisations in which the respondents' work showed that 42.5% are consulting firms, 38.8 are contractors, 4.5% are client organisations, and 14.2% are government agencies. The analysis of the size of the firms showed that 23.9% of respondents are small firms, while 10.4% and 38.8% are micro and medium-sized firms, respectively. A total of 19.4% and 6.7% are large and multinational firms, respectively. The result of the firms’ years of existence showed that while 9.7% have been in existence for up to 5 years, 23.1% were established between 6 to 15 years. A total of 67.2% have over 15 years of organisational existence.

Table I: Respondents’ Profile

Profile		Frequency	Percentage
Academic Qualification	Matric	15	11.2
	Honours	66	49.3
	MSc	28	20.9
	PhD	8	6.0
	Others	17	12.7
	Total	*134*	*100.0*
Years of Experience in the Construction Industry	10 years and below	40	29.9
	11 to 20 years	33	24.6
	21 to 30 years	28	20.9
	31 to 40 years	19	14.2
	more than 40 years	10	7.5

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	No Response	4	3.0
	Total	*134*	*100.0*
Management Cadre	Lower Level	20	14.9
	Middle Level	34	25.4
	Senior Level	26	19.4
	Executive	54	40.3
	Total	*134*	*100.0*
Professional Affiliations	YES	108	80.6
	NO	26	19.4
	Total	*134*	*100.0*
Organizations Employed	Consulting Firm	57	42.5
	Contractor	52	38.8
	Client Organisation	6	4.5
	Government Agency	19	14.2
	Total	*134*	*100.0*
Firm's Size	Small Firm	32	23.9
	Micro Firm	14	10.4
	Medium Sized Firm	52	38.8
	Large Firm	26	19.4
	Multinational Firm	9	6.7
	No Response	1	0.7
	Total	*134*	*100.0*
Years of Organization Existence	5 years and below	13	9.7
	6 to 10 years	20	14.9
	11 to 15 years	11	8.2
	above 15 years	90	67.2
	Total	*134*	*100.0*

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4.2 Attitude towards Open Data Sharing

Based on the analysis of the respondents’ and firms’ profiles, the following a-priori expectations are set forth relating to respondents’ attitude towards open data sharing:

i. Higher academic qualifications would positively influence respondent’s willingness to share data
ii. The higher the years of industry experience, the lesser the willingness to share data
iii. Senior and executive-level employees will not be favourably disposed to data sharing owing to the need for the firm to maintain market dominance
iv. Respondents with professional affiliations would show more willingness and level of support for data sharing, especially among affiliate professional members.
v. Contracting and consulting firms will be less favourable to data sharing
vi. Large and multinational firms will be significantly averse to data sharing owing to the need to maintain industry dominance
vii. Older firms; that is, firms being established over 15 years, will be significantly averse to data sharing owing to the increasing volume of in-house data and extensive professional networks

Table II presents the analysis of the respondents’ perception of open data sharing. This was examined in two directions. The first examined the respondents’ level of support for open data sharing in the industry. The second analysed the respondents’ perceived level of support of other industry practitioners towards data sharing.

Table II: Mean Score Table of Respondents Perception towards Open Data Sharing

		Individual Level of Support for Open Data Sharing			Level of Support of other Industry Practitioners towards Open Data Sharing		
Profile		Mean	rank	Std. Dev.	Mean	rank	Std. Dev.
Academic Qualification	Matric	3.47	5	1.302	2.47	5	1.302
	Honours	3.89	3	.914	2.98	3	1.088
	MSc	4.14	2	.848	3.39	1	.994

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	PhD	4.38	1	.744	2.88	4	.641
	Others	3.71	4	1.312	3.35	2	1.367
	F	1.731			2.110		
	Sig.	.147			**.083****		
Years of Experience in the Construction Industry	10 years and below	3.95	3	.876	3.30	1	.992
	11 to 20 years	4.12	1	1.111	3.30	2	1.287
	21 to 30 years	3.46	5	1.232	2.71	4	1.049
	31 to 40 years	3.84	4	.688	2.79	3	1.032
	more than 40 years	4.00	2	.816	2.50	5	1.179
	F	1.783			2.469		
	Sig.	.136			**.048***		
Management Cadre	Lower Level	3.80	3	.894	3.40	1	.995
	Middle Level	4.24	1	.855	3.21	3	1.067
	Senior Level	4.23	2	.908	3.27	2	1.079
	Executive	3.57	4	1.092	2.72	4	1.188
	F	4.435			2.791		
	Sig.	**.005***			**.043***		
Professional Affiliations	YES	4.01	1	.912	3.11	1	1.097
	NO	3.46	2	1.272	2.81	2	1.266
	F	6.410			1.509		
	Sig.	**.013***			.221		
Organizations Employed	Consulting Firm	3.93	3	.799	2.98	3	1.157
	Contractors	3.69	4	1.213	2.92	4	1.218
	Client Organisation	4.50	1	.837	3.33	2	.516
	Government Agency	4.21	2	.918	3.53	1	.841

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	F	2.104			1.549		
	Sig.	.103			.205		
Firm's Size	Small Firm	3.94	3	.878	2.88	5	1.100
	Micro	3.79	4	1.051	2.93	4	1.385
	Medium Sized	3.69	5	1.058	2.96	3	1.047
	Large	4.15	2	1.047	3.50	1	1.241
	Multinational	4.33	1	.866	3.11	2	.928
	F	1.450			1.347		
	Sig.	.221			.256		
Years of Organization Existence	5 years and below	4.08	3	.862	3.46	1	1.127
	6 to 10 years	4.15	1	.933	3.40	2	1.273
	11 to 15 years	4.09	2	.831	3.27	3	1.272
	above 15 years	3.80	4	1.062	2.89	4	1.065
	F	.965			2.001		
	Sig.	.411			.117		
Overall		3.90		1.010	3.05		1.133

* *p*-value significant at $p < 0.05$

** *p*-value significant at $p < 0.1$

Regarding the respondents' level of support for data sharing, the analysis shows that based on academic qualifications, with an additional academic qualification, there is an increased preference for open data sharing. This perhaps might owe to the increasing understanding of the importance of data to construction activities and research. However, based on experience, practitioners with 11 to 20 years of industry experience had the highest support for open data sharing *(mean – 4.12)*, followed by respondents with over 40 years of experience *(mean – 4.00)*. The respondents having 21 to 30 years of industry experience had the least mean rating of 3.46. The inconsistencies in the pattern of the responses across the years of industry

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experience might owe to other factors such as the firm's policies and personal biases. The level of support for data sharing vis-a-vis the management cadre of the respondents showed an inverted u-shape with mid-level employees being the most supportive of open data sharing *(mean – 4.24)*, followed by senior-level employees *(mean – 4.23)*. Lower-level employees and executives had the least support for open data sharing *(mean – 3.80 and 3.57, respectively)*. The result affirms the *a-priori* expectations that executive-level employees will be averse to data sharing due to the need to maintain the market dominance of firms. The analysis of the professional affiliation showed that practitioners with professional affiliations had a higher level of support *(mean – 4.01)* than respondents with no professional affiliation *(mean – 3.46)*, thereby corroborating the *a-priori* expectation.

Analysis of the results based on the firm's profile shows that client organisations; with a mean score of 4.50, and government firms *(mean – 4.21)* are more supportive of data sharing as opposed to consulting firms and contractors. These have mean scores of 3.93 and 3.69, respectively. Regarding the size of the firms, the result reveals that large firms and multinational companies had a higher level of support for data sharing *(mean scores of 4.15 and 4.33, respectively)* than small firms, micro firms and medium-sized firms. These have a respective mean rating of 3.94, 3.79 and 3.69. The level of support based on years of firm's existence showed an inverted u-shape, with firms being established 6 to 10 years and 11 to 15 years being more supportive of data sharing *(mean – 4.15 and 4.09 respectively)* than firms established 5 years and below *(mean – 4.08)* and above 15 years *(mean – 3.80)*. Overall, the statistical significance analysis showed that there were no statistically significant differences regarding the level of support for data sharing except for management cadre and professional affiliation across most of the variables. These were significant at $p = 0.005$ and $p = 0.013$ respectively.

Examining the respondent's perception of the level of perceived support received from other industry professionals regarding data sharing showed lower mean scores across all of the items compared to the level of individual support for open data sharing. The lower mean scores might owe to the observed apathy, and reluctance practitioners usually exhibit towards data-sharing issues. An examination of the item-by-item analysis starting with academic qualification showed that practitioners with a master's degree have the highest level of support *(mean – 3.39)*. Practitioners with up to 20 years of industry experience were perceived to have a higher level of support for data sharing (mean – 3.30) compared to practitioners with over 40 years of industry experience *(mean – 2.50)*. Regarding the respondent's management cadre, lower, senior and mid-level employees are perceived to have a higher level of support for data sharing, with respective mean values of 3.40, 3.27 and 3.21, as opposed to firms' executives *(mean – 2.72)*. The mean scores of the perception on the level of support received from practitioners based on professional affiliation showed that

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professionals registered with professional bodies had a higher level of support for data sharing *(mean – 3.11)* than those without professional affiliation. Analysis based on the organisational profile showed that practitioners in client organisations and government agencies were perceived to have a higher level of support; mean scores – 3.33 and 3.53 respectively, than those in the employment of consulting firms *(mean – 2.98)* and contractors *(mean – 2.92)*. Also, regarding the size of the firms, large firms and multinational companies are rated to have higher support for data sharing *(mean – 3.50 and 3.11 respectively)* than small, micro and medium-sized firms. These have mean scores of 2.88, 2.93 and 2.96, respectively. The results of the years of organisations existence showed that the level of perceived support diminishes with increasing years of organisational existence; 5 years and below, mean – 3.46 and above 15 years, mean – 2.89. This perhaps owes to the increased networks and build-up of an in-house database. An examination of the statistical variations showed that years of experience in the industry and management cadre were the only statistically significant variables at $p < 0.05$. Academic qualification had a p-value of 0.083, significant at $p < 0.1$ level. Overall, the mean scores showed a higher level of individual support for data sharing while indicating lower perceived support from other industry practitioners.

4.3 Level of Satisfaction with Data Sharing in the Construction Industry

After examining the practitioners' attitudes and perceptions towards data sharing, the study further examined the respondents' satisfaction with data sharing in the construction industry. This was disaggregated and evaluated based on the respondents' and firms' profiles (See Table III). Following the respondents' ratings on the level of support received from other industry practitioners regarding data sharing, the *a-priori* expectation is that the respondents will be dissatisfied with the level of data sharing and assemblage.

Table III: Level of Satisfaction with Data Sharing

Profile		Satisfaction with Data Sharing			Level of Satisfaction
		Mean	**Rank**	**Std. Dev.**	
Academic Qualification	Matric	2.53	5	1.246	not satisfied
	Honours	2.77	4	1.005	not satisfied
	MSc	3.07	1	.900	somewhat satisfied
	PhD	2.86	3	.900	not satisfied
	Others	3.06	2	1.088	somewhat satisfied

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	F	.966			
	Sig.	.429			
Years of Experience in the Construction Industry	10 years and below	3.08	1	1.047	somewhat satisfied
	11 to 20 years	2.94	2	1.162	not satisfied
	21 to 30 years	2.79	3	.995	not satisfied
	31 to 40 years	2.63	5	.761	not satisfied
	more than 40 years	2.70	4	.675	not satisfied
	F	.830			
	Sig.	.509			
Management Cadre	Lower Level	3.05	1	.999	somewhat satisfied
	Middle Level	2.94	3	1.059	not satisfied
	Senior Level	3.00	2	1.131	somewhat satisfied
	Executive	2.65	4	.935	not satisfied
	F	1.243			
	Sig.	.297			
Professional Affiliations	YES	2.93	1	1.012	not satisfied
	NO	2.50	2	.990	not satisfied
	F	3.890			
	Sig.	**.050***			
Organizations Employed	Consulting Firm	2.79	3	.959	not satisfied
	Contractors	2.75	4	1.074	not satisfied
	Client Organisation	3.50	1	.837	very satisfied
	Government Agency	3.11	2	1.049	somewhat satisfied
	F	1.475			
	Sig.	.224			
Firm's Size	Small Firm	2.68	5	1.137	not satisfied

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	Micro	2.93	3	.730	not satisfied
	Medium Sized	2.71	4	.915	not satisfied
	Large	3.12	2	1.143	somewhat satisfied
	Multinational	3.33	1	1.118	somewhat satisfied
	F	1.439			
	Sig.	.225			
Years of Organization Existence	5 years and below	2.85	3	1.068	not satisfied
	6 to 10 years	3.32	1	1.250	somewhat satisfied
	11 to 15 years	3.09	2	1.136	somewhat satisfied
	above 15 years	2.72	4	.924	not satisfied
	F	2.049			
	Sig.	.110			
Overall		2.85		1.019	not satisfied

* *p*-value significant at $p < 0.05$

Based on respondents' academic qualifications, the results showed that MSc holders had a mean satisfaction score of 3.07; and are somewhat satisfied, the respondents having Matric and Honours were the most dissatisfied with the level of data sharing *(mean – 2.53 and 2.77 respectively; "not satisfied")*. Based on the years of experience in the construction industry, the level of satisfaction is a u-shaped curve. Respondents with 10 years below have the highest mean score of 3.08 (somewhat satisfied), while those with 31 to 40 years' experience have the least mean score of 2.63 (not satisfied). This suggests that more experienced practitioners expect a higher level of data sharing within the industry, and they are dissatisfied with the level of data sharing among industry practitioners. Furthermore, while lower-level employees were somewhat satisfied *(mean – 3.05)*, followed by senior-level employees *(mean – 3.00; somewhat satisfied)*, mid-level and executive-level employees were the least satisfied *(mean – 2.91 and 2.65 respectively;* not satisfied*)* with the level of data sharing in the construction industry. Respondents having professional affiliations had a mean score of– 2.93, while those who were not members of any professional body had a mean score of 2.50; though the mean rating of both groups fall into the category of "not satisfied". Perhaps being a member of professional associations influenced data accessibility, hence, the

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somewhat higher level of satisfaction relative to those who are not members of any professional body.

Assessing the level of satisfaction based on the type of organisation shows that client organisations and government firms rated a higher level of satisfaction *(mean – 3.50; very satisfied, and 3.11; somewhat satisfied, respectively),* relative to consulting firms and contractors *(mean – 2.79 and 2.75 respectively; "not satisfied")*. The size of the firms showed that multinational companies and large firms also had a higher level of satisfaction with the level of data sharing in the construction industry. These had mean scores of 3.33 and 3.12, respectively (somewhat satisfied). Assessing the level of satisfaction based on years of organisational existence showed an inverted u-shape. Recently established firms; 5 years and below, had the least mean rating of 2.85 *(not satisfied)*, while firms established between 6 to 10 years had the highest mean score of 3.32 (somewhat satisfied). Examining the statistical differences across the different stratification showed that only profession affiliation was significant with the level of satisfaction at $p = 0.05$ level.

Summarily, the results showed that the mean scores for the respondents' level of satisfaction in most instances were in the band of "not satisfied". Only client organisations had a marginal mean score of 3.50 (very satisfied). The aggregate mean score of 2.85 showed that satisfaction is lower than the 3.00 benchmark mean value. This indicates that practitioners are dissatisfied with the level of data sharing and assemblage in the construction industry. Perhaps creating a central and accessible database might be highly prized among the respondents. Towards this end, the study further examined practitioners' willingness or support towards creating a central database at a fee to the public and professional members only.

4.4 Creating a database at a Fee

Table IV presents the stratified analysis of the respondents' willingness to make data available to a central database at a fee to the public or professional members only. The results showed that while respondents with PhD and Matric showed a greater level of support towards making construction data available at a fee to both the public and professional members, respondents with Honours and MSc were less supportive of releasing data. Regarding the years of experience, the analysis reveals that respondents with over 40 years' experience were willing to release data at a fee to either the public or professional members. Respondents with 11 to 20 years of industry experience have a higher preference for releasing data to the general public *(mean – 3.73)* than practitioners alone *(mean – 3.61)*. The level of support based on the management cadre showed that the middle and senior-level employees rated a higher level of support for making data available at a fee to a central database available to the public and members of the professional bodies instead of lower executive-

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level employees. The professional membership showed that respondents’ belonging to professional organisations support data availability at a fee to both the public (3.72) and professional members (3.81).

Table IV: Level of Support for Creating a database at a Fee

Profile		Data Base accessible to the Public				Database accessible to Professional Members only			
		Mean	**rank**	**Std. Dev.**	**Level of Support**	**Mean**	**rank**	**Std. Dev.**	**Level of Support**
Academic Qualification	Matric	4.00	2	1.195	*VS*	3.87	2	1.246	*VS*
	Honours	3.56	5	1.025	*VS*	3.74	3	1.057	*VS*
	MSc	3.61	4	1.066	*VS*	3.71	4	1.150	*VS*
	PhD	4.25	1	.463	*VS*	4.25	1	.707	*VS*
	Others	3.71	3	1.263	*VS*	3.71	5	1.263	*VS*
	F	1.157				.443			
	Sig.	.333				.777			
Years of Experience in the Construction Industry	10 years and below	3.60	3	1.008	*VS*	3.85	2	1.027	*VS*
	11 to 20 years	3.73	2	1.232	*VS*	3.61	5	1.298	*VS*
	21 to 30 years	3.57	4	1.168	*VS*	3.82	3	1.124	*VS*
	31 to 40 years	3.47	5	.697	*SS*	3.63	4	.895	*VS*
	more than 40 years	4.20	1	.919	*VS*	3.90	1	1.101	*VS*
	F	.903				.347			
	Sig.	.465				.845			
Management Cadre	Lower Level	3.65	3	1.089	*VS*	3.65	3	1.182	*VS*
	Middle Level	3.76	2	1.017	*VS*	4.00	1	1.044	*VS*
	Senior Level	3.85	1	1.047	*VS*	4.00	2	1.166	*VS*
	Executive	3.56	4	1.110	*VS*	3.57	4	1.057	*VS*

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	F	.527				1.539			
	Sig.	.665				.208			
Professional Affiliations	YES	3.72	1	1.003	*VS*	3.81	1	1.089	*VS*
	NO	3.50	2	1.304	*VS*	3.65	2	1.164	*VS*
	F	.910				.396			
	Sig.	.342				.530			
Organizations Employed	Consulting Firm	3.88	1	1.157	*VS*	3.96	2	1.034	*VS*
	Contractor	3.44	4	1.211	*SS*	3.54	4	1.163	*VS*
	Client Organisations	3.83	2	.753	*VS*	4.17	1	.983	*VS*
	Government Agency	3.68	3	1.057	*VS*	3.74	3	1.098	*VS*
	F	1.573				1.649			
	Sig.	.199				.181			
Firm's Size	Small Firm	3.97	1	.999	*VS*	3.88	3	1.040	*VS*
	Micro	3.29	5	1.267	*SS*	3.29	5	1.383	*SS*
	Medium Sized	3.44	4	1.127	*SS*	3.63	4	1.155	*VS*
	Large	3.96	2	.871	*VS*	4.04	2	.916	*VS*
	Multinational	3.78	3	.833	*VS*	4.22	1	.833	*VS*
	F	2.250				1.737			
	Sig.	**.067****				.146			
Years of Organization Existence	5 years and below	3.92	1	1.038	*VS*	3.92	1	.862	*VS*
	6 to 10 years	3.90	2	1.119	*VS*	3.75	3	1.209	*VS*
	11 to 15 years	3.45	4	1.128	*SS*	3.64	4	1.286	*VS*
	above 15 years	3.62	3	1.056	*VS*	3.78	2	1.099	*VS*
	F	.757				.137			
	Sig.	.520				.938			

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Overall		3.68		1.066	*VS*	3.78		1.101	*VS*

** *p*-value significant at $p < 0.1$; VS – very supported; SS – somewhat supported

The organisation employed showed that consulting firms and client organisations supported making data available at a fee to a central database to both the public and professional members. Concerning the size of the firms', data availability at a fee to the public and members of professional associations were favourably supported by large and multinational firms and small firms. However, micro and medium-sized firms had the least mean rating across both categories. Based on the years of firms' existence, the results show decreasing support to release data to a central database at a fee to the public. However, firms with up to 10 years and firms with over 15 years have a higher level of support for creating a central database at a fee to professional members.

The results show a high level of support across the stratified groups and on an overall basis. Most of the mean scores were in the “very supported” band, and only very few were in the “somewhat supported” range. The interest in creating databases at a fee might stem from the dearth of data and the benefits derivable from the creation and accessibility to construction data. Perhaps given that there will be monetary considerations for the release of data, especially where data is seen as a competitive advantage among practitioners, there will be some measure of interest. It thus appears that practitioners appear willing where data is shared with some consideration passing between parties.

On an aggregated basis, the mean scores show a higher level of support for creating a central database at a fee to members of professional bodies. This had a higher mean score (3.78) when compared to making data accessible to the public at a fee (3.68). The result of the statistical differencing showed that there were no statistically significant differences at $p < 0.05$ across all the different strata. However, at a 10% significance level, the size of the firm and the level of support to make data available at a fee to the public was significant at $p = 0.067$.

4.5 Correlation Analysis

The study examined the correlation between the constructs used in assessing the willingness of respondents to data sharing. This was done to ascertain the existence and extent of the

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relationship between the variables. As presented in Table V, the results showed that the R-values are statistically significant at $p < 0.05$, and the R-values are positively correlated. The results suggest that the variables have a significant influence on one another. For instance, the correlations between the individual level of support for open data and the willingness to release data to a central database accessible to the public at a fee ($r = 0.508$) and to make data available to professional members at a fee ($r = 0.440$) were statistically significant at $p < 0.01$. This suggests that respondents' willingness significantly influences the level of support to create a database accessible to the public or the professional members at a fee.

Table V: Correlation Analysis between the Variables

	Individual Level of Support for Open Data Sharing	Perceived Level of Support of Industry Practitioners to Open Data Sharing	Satisfaction with Level of Data Sharing	Support for DataBase accessible to the Public	Support for DataBase accessible to Professional Members only
Individual-level of Support for Open Data Sharing	1				
Perceived Level of Support of Industry Practitioners for Open Data Sharing	.405**	1			
Satisfaction with level of Data Sharing	.272**	.487**	1		
Support for Data Base accessible to the Public	.508**	.251**	.129	1	
Support for Data Base accessible to only Professional Members	.440**	.196*	.192*	.732**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed)

5. Conclusion

The construction industry contributes substantially to fiscal and economic growth and the development of economies. However, to ensure continuous expansion and increased contribution of the construction industry to economic growth and development, the professionals' must align their interests on data sharing and assemblage. The data-sharing debacle could be overcome where professionals are willing to assemble data and create a

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central database. The availability and use of data within the industry can only be optimized when the willingness and perceptions interest of professionals' is sufficiently evaluated and stimulated towards the benefits of data sharing. The stratified analysis shows that practitioners are mostly unsatisfied with data sharing among professionals in the industry. The results showed that most respondents showed a conservative attitude, perhaps owing to the industry's slow response to change. However, when professionals are aware of the common benefits instead of individual gains, the conservative perception of respondents could become eliminated. The increasing use of digital and automated technologies in construction activities exacerbates the need to embrace data sharing through collaborative means by construction practitioners.

Though the findings reveal some measure of willingness on the part of the practitioners to share data at a fee, the results show that more experienced practitioners and large/multinational firms supported creating a central database. This finding disproves the a-priori expectations that these categories of respondents will be averse to creating databases owing to the need to maintain market dominance and a significant amount of networking capacities enjoyed by long-standing practitioners in the industry. The low level of support noted by other industry practitioners might owe to confidentiality issues of data and the firm's policy. Further, the result shows that professional affiliation positively impacted the level of willingness to share data. The influence of professional membership might be further emphasized for practitioners to achieve the goal of data sharing and assemblage. The respondents' higher preference for data availability to professional members might owe to benefits of reciprocity, where data could be shared and collated at a central database by all professional members. This is opposed to public members who might be unable to add inputs to the databases yet have access to the database, though at a fee.

Though most of the results show no statistically significant relationships, perhaps owing to the low response rate, the results could still afford some preliminary insights into the influence of practitioners'/firms' demographics on their perception of data sharing and assemblage in the construction industry. The study has evaluated the attitude of South African construction professionals towards data sharing. Further studies could compare data sharing in the construction industry with data sharing in other sectors. This will help in benchmarking the practices in the industry.

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Proceedings of the DII-2021 International Conference: "Building Smart, Resilient and Sustainable Infrastructure in Developing Countries"

DII-2021-006

Poor management and maintenance of municipal infrastructure on socio-economic development

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Abstract

Municipal infrastructure management plays a critical role in the country's socio-economic development and provides essential community services. Albeit, much attention is usually given to the development aspect, disregarding post-development management. This study explores the impact of poor management of municipal infrastructure in South Africa. A qualitative approach was adopted; thus, fifteen (15) senior municipal workers, local organizations, and forums in Ngqushwa Municipality in Eastern Cape were interviewed. Common themes and frequencies were generated from the data using thematic content analysis. The study's findings revealed that the municipal infrastructure is poorly managed due to limited funding, lack of synergy, insufficient budgets, one-sided focus, and skilled personnel. Consequently, these have negatively impacted various aspects of municipal social and economic development, including revenue generation, investment attraction, job creation, political/community instability, poverty levels, and tourism. Although only one municipality was used for the study, the same approach may apply to other South African municipalities with similar settings. For municipalities to ensure efficient infrastructure management and enhance service delivery to the communities and the general public to curtail rampant service delivery protests, the municipalities should urgently redirect their infrastructure development policies by focusing on post-construction management. The provincial government must assist the municipalities with funding for infrastructure management and a qualified and adequate personnel engagement. The study gives insight into the effects of ineffective management of the municipalities' facilities; thus, guiding the municipalities and the authorities on infrastructural management strategies for effective service delivery and revenue generation

Keywords: Infrastructure, impact, municipality, management, maintenance, South Africa

1. Introduction

With the evolvement of local government and sections 28(1) of schedules 6 and 239 of the South African Constitution of 1996 (as amended), municipalities across the country post-1994 inherited very limited resources. These include immovable infrastructure facilities, assets, and properties they rely upon to service delivery within their jurisdiction and ensure

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sustainable social and economic development (Department of Planning, Monitoring, and Evaluation: Republic of South Africa, 2014).

Infrastructure development and management form a central part of the government's commitment to providing essential services to communities. However, much focus has been placed on the development aspect, with very little focus and investment in management and maintenance (Department of Planning, Monitoring, and Evaluation: Republic of South Africa, 2014). As a result, this leaves the authors with a question of the associated impacts on socio-economic development. Amoah (2018) wrote on evaluating the need for implementing agents in Public Infrastructural Delivery in KwaZulu Natal with a specific focus on Durban. His research highlights the importance of municipal/public infrastructure delivery and its relation to socio-economic development. For this research, the municipal infrastructure that will be explored is an immovable property that includes land needed for infrastructure and development, buildings, roads, and bridges. The main question is whether these properties are used and appropriately managed to ensure effective and efficient service delivery (Amoah, 2018). This question is often not answered or answered with hesitation by those that are responsible. Miller (1997) emphasizes the vital role of public infrastructure in socio-economic development and that without proper management, social and economic growth is negatively affected.

In most cases, when immovable property is not well managed, it threatens sustainable socio-economic development in society. The Republic of South African government's immovable asset management policy (2005) states that when assets are appropriately managed, it will benefit the government by creating an environment that enables recreational and local economic development. It also attracts investment, and most importantly, provide access to land for the security of tenure. Dlomo and Tseane-Gumbi (2017) highlight that the government uses the money to provide services to the communities and manage their assets. Further, they argue that over the years, less attention has been given to the effective use of government-owned assets, except for those owned by public enterprises.

Ngqushwa, like many municipalities around the country, owns various types of immovable properties within their jurisdiction. However, as indicated above, it also faces many challenges, especially on socio-economic development. This leaves the same question of whether they use their resources effectively and efficiently to ensure sustainable socio-economic development. The service delivery actions that face the municipality somehow indicate the challenges of poor socio-economic development within the jurisdiction. Therefore, this research study explores how poor municipal infrastructure management impacts sustainable socio-economic development and how municipalities can best address

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this problem for socio-economically improved service delivery and sustainable growth. The Ngqushwa Local Municipality, one of the six municipalities that form part of Amathole District Municipality, located within the Eastern Cape Provinces. The municipality was selected because it is very relevant as it is a significant tourism centre among the six municipalities. The main economic activity in the municipality is agriculture and tourism. However, in recent years, the municipality has faced ongoing service delivery protests like many municipalities across the country, resulting from poor service delivery, hence, the interest in exploring the study area.

2. Literature Review

2.1 Public infrastructure management and maintenance

As Halfawy (2008) articulated, most municipalities are under mounting pressure to optimize interdepartmental operational and renewal decisions by ensuring integrated and coordinated infrastructure management processes. The only threat to achieving sustainable asset management is the fragmentation of work processes and asset data. Halfawy (2008) highlights three critical interventions: incorporating and prioritizing infrastructure management and maintenance in budgeting and strategic planning to help address this persistent problem. Secondly, the capacity building for management and maintenance personnel must also be the main priority for the municipalities to succeed. Thirdly, adopting information technology as a strategic tool has been well accepted internationally as the key in addressing the management and maintenance of infrastructure. The South African Department for Provincial and Local Government (DPLG) (2019) emphasizes a plan of action that integrates planning, sector coordination, and life cycle sustainability of all infrastructure assets to ensure municipalities deliver sustainable services.

Boshof *et al.* (2015) suggest that one of the common arguments regarding infrastructure challenges is that the full scope of municipal asset management is not adequately encompassed in the current legislation when looking at the best practices internationally. Due to the latter, South African municipalities are not doing well on asset management practices. They have no roadmap to plan, budget, and spend on maintenance and renewal of infrastructure (Boshof *et al.*, 2015). The 2006 report by Construction Industry Development Board (CIDB) on the South African municipal infrastructure state, operation, and maintenance have revealed areas with inadequate infrastructure and service delivery in South Africa. Equally and more significantly, the rural municipalities face plenty of poor-quality services and deteriorating infrastructure. The following were highlighted as the significant

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challenges on infrastructure management and maintenance by authors, including Boshof *et al.* (2015), Republic of South Africa (2018), and CIDB (2006):

- **Budgeting** – their findings reveal under-budgeting and spending on municipal infrastructure management and maintenance.
- **Asset valuation/auditing -** methods are not consistent with international practices.
- **Prioritization** – infrastructure management and maintenance are often not prioritized, but more priority is given to new infrastructure construction.
- **Capacity** – lack of champions/dedicated sections responsible for management and maintenance of infrastructure. Another issue is the loss of qualified technical staff and their replacement with less qualified staff or non-replacement.

According to CIDB (2006), the above issues relate to policy shortcomings in budgeting and prioritization of sustainable infrastructure management and maintenance on a longer-term basis. The organization proposes that whenever the treasury provides capital to municipalities, such must be accompanied by compelling conditions that force the municipalities to utilize a portion of the funding for management and maintenance. Municipalities should take centre stage and adopt policies and systems to manage, maintain, and safeguard the state assets legislated under their jurisdiction and custody. Isaacs (2014) also suggests that there seems to be a consensus to adopt integrated multidisciplinary approaches to achieve a pro-active, efficient, and sustainable asset management program. According to Gaal and Afrah (2017), over time, most municipalities and governments worldwide have started introducing and developing integrated systems for infrastructure construction and maintenance.

Buys and Mavasa (2007) argue that best practice asset management depends on integrating experience on assets contribution to business planning (e.g., looking at workplace strategies, acquisitions, refurbishments, and disposals), knowledge, and understanding of the system as a whole. According to Buys and Mavasa (2007), the first essential component, the Immovable Asset Management Plan (IAMP), serves as a guiding tool for planning, acquisition, operation, maintenance, and disposal of assets. The second being the asset register is meant to record all immovable assets regarding their status and condition. The third and last one is the performance management system, which deals with asset performance to ensure municipal goals. The latter is critical, especially when dealing with infrastructure that plays a crucial role in the municipality's social and economic development needs. Both the Republic of South Africa (2006-2009) and Buys and Mavasa (2007) emphasize that the most crucial component of the asset management system is a good

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infrastructure management policy. Both studies point out that the policy would serve as the framework guideline reflecting the methodology and procedures for the management, maintenance, disposal, leasing, and letting of various infrastructure and properties. This is to ensure the availability of municipal vast economic opportunities for socio-economic development to attract inward investment. According to Wilson (1999), corporate and production knowledge, future operational needs, asset plan appreciation, property lifecycle thorough understanding, and keeping up with policy and regulatory development affect infrastructure management efficiency. The overall asset objectives remain the critical success factors when developing asset strategy.

2.2 Socio-economic impacts of poor management and maintenance of municipal infrastructure

According to UN-Habitat (2011), the Southern African region is under considerable strain due to the rapid rate of urbanization resulting from inadequate investment in basic infrastructure development in rural areas. This directly impacts the region's socio-economic development. Much investment and economic growth of any area heavily rely on its quality infrastructure to support the socio-economic needs. Foster (2008) stressed the critical role infrastructure plays in the economy in diagnosing the African infrastructure. Wherein infrastructure played a critical role in the turnaround of Africa's economy around the late 1990s to 2005. He further cautions of the more significant role it still needed to play going forward to reach the development targets of the continent. However, investors and developers seldom consider areas dilapidated or lack proper infrastructure due to investment risk. Boshof (2009) summarized the impacts of poor/failures of municipal infrastructure and argued that they adversely affect individuals and organized formations: social, economic, financial, political, and environmental.

The South Africa Department of Provincial and Local Government Guidelines on Sustainable Municipal Infrastructure Provision and Service Delivery emphasized that local provision of an essential household infrastructure is the local government's central contribution to social and economic development (Boshof, 2009). Koma (2014) also highlights that Public Infrastructure Investment and Service Delivery have a high potential to shape socio-economic development, especially for disadvantaged communities, when government plans are implemented in an integrated and consistent manner. Boshof (2009) and Foster (2008) argue that poor municipal infrastructure management and maintenance fail socio-economic development because they result in no employment opportunities, recreation activities, social cohesion, and no inward investment to grow the local economy. The South

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African Local Municipal Finance Management Act (Act 32 of 2003) mandates municipalities to use their local resources, including infrastructure, to promote local economic growth and improve communities' lives (Republic of South Africa, 2003). UN-Habitat (2011) also shared that the latter views also emphasize both the policy and academic realms. There is a long-standing view that the infrastructure services adequate supply is essential to ensure that poverty is reduced and sustainable economic development. This is also backed by Ayoola *et al.* (2016). They also emphasize that the connection between infrastructure and economic growth has long been recognized by municipality benchmark best practices for municipal infrastructure management with other municipalities or organizations in public economics.

There is a complex relationship between economic growth and infrastructure municipalities benchmark the best practices for municipal infrastructure management with other municipalities or organizations. It is also argued by The National Asset Management Steering Group (NAMSG) (2006) that infrastructure represents a significant investment in many developed countries that were built over the decades. The latter and other work like that of the UN-Habitat (2011) and Boshof (2009) indicate that the role of infrastructure in economic development is significant. NAMSG (2006) suggests that for the economies of developing countries to start nourishing, they need basic infrastructure as a foundation for services to be distributed efficiently. According to Bello and Osinibu (2017), there remains controversy around the numerical magnitude of the importance or significance of infrastructure. The NAMSG (2006) in the international infrastructure management manual articulates the link between infrastructure and the socio-economic environment by arguing that infrastructure represents a considerable investment to support the modern-day living fabric of our communities backed by both the public and private sector organizations.

Because of this perceived link/relationship, eminent implications come with the failure to efficiently manage and maintain infrastructures such as water, transportation, energy, and communication technologies. These implications have been sighted as vital in promoting economic growth, poverty alleviation, and improving living conditions in countries that are still developing (United States Economic Development Administration, 2005). The availability of infrastructure facilities and services and their efficiency are considered success factors for business and social development. The NAMSG (2006) argued that major infrastructure failures also require much attention to understand these failures and effective consequence management. To clearly understand the impact of the problem at hand, we sometimes have to look at the possible benefits of the said infrastructure. NAMSG (2006) has already done significant work on the reasons for applying the best practices on infrastructure planning, management, and maintenance to achieve a good quality infrastructure that brings benefits to communities indicated in Figure 1.

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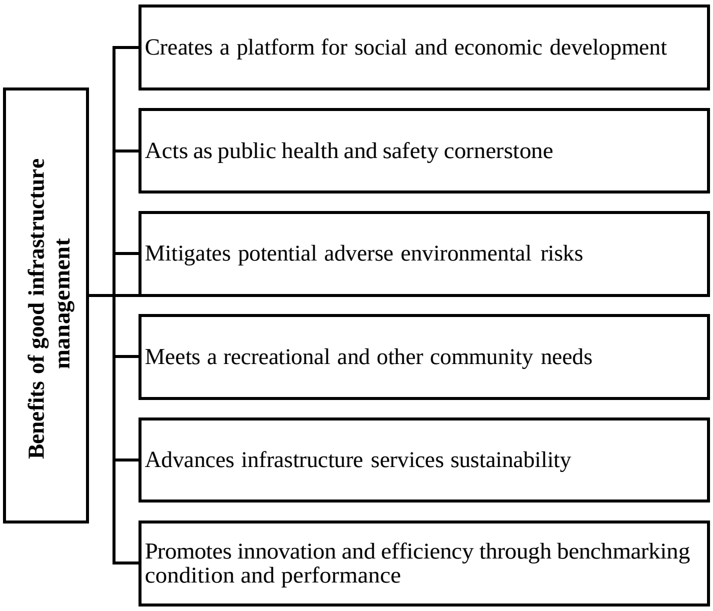

Figure 1: Benefits of good infrastructure management
Source: NAMSG (2006)

2.3 The Nature of Public Infrastructure in Ngqushwa Local Municipality

The municipal infrastructure of Ngqushwa under research is the immovable infrastructure, which according to the New Zealand National Asset Management Support Group (NAMS Group) ((2006), are defined as stationary systems that serve the socio-economic needs of the community. Most of this infrastructure is poorly managed and maintained and hence vulnerable to decay, dilapidation, and invasion. The latter was also highlighted by Boshof (2009), that most of the infrastructure developed since 1994 prematurely failed whilst some are currently on the brink of collapse. This infrastructure takes into account all developed infrastructure and potential vacant land under the municipality. When looking at the municipal infrastructure nature in Ngqushwa Municipality, it is essential to align this exercise with spatial arrangement/orientation and vulnerability. The Ngqushwa municipality is a small rural municipality with one primary node (town), Peddie, and one secondary (town) in Hamburg. The rest are peri-urban and rural settlements, which serve as settlement nodes mainly dominated by farms and rural villages. Peddie town is more of an inland town along the major national N2 road linking Durban and Cape Town. The road traverses within Peddie town. This is the municipality's main hub/centre where the municipal settlements utilize and rely upon services and goods from nearby cities. On the other hand, Hamburg is a small and

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promising secondary node (town) situated along the Indian Ocean of the Eastern Cape and serves mainly as a tourist attraction destination.

According to Boshof *et al.* (2015), municipal infrastructure's condition differs from one location due to numerous factors. They argue that infrastructure in coastal areas is prone to higher corrosion levels than inland areas. Furthermore, they contend that other areas may be at high risk due to natural and man-made causes such as flooding. For example, as Valdez *et al.* (2016) argued, the Hamburg coastal area is more vulnerable to the factors mentioned above, including corrosion, flooding, etc., due to the corrosive nature of seawater areas. On the other hand, Peddie, a semi-inland town, is more vulnerable to man-made factors due to a higher or lower population than Hamburg. The type of infrastructure found in Ngqushwa Municipality is similar to that discussed by the NAMS Group (2006), which include the following:

- Land needed for infrastructure and development.
- Roads and Bridges: This includes all internal public tarred and gravel roads as well as formal and informal bridges
- Storm-water: This includes all storm-water drains, pipelines, and channels;
- Buildings: This consists of all municipal buildings, including community halls and security guardhouses which are owned by the municipality
- Recreational facilities: these include parks, sports fields, and public open spaces; and
- Cemeteries

3. Methodology

3.1 Research approach

According to Creswell (2014), three research methods are qualitative research, quantitative research, and mixed methods. This research employed a qualitative research approach**,** which, according to Creswell (2014), allows the researcher to collect observations and ascribe clarification based on general themes or trends. The qualitative research approach was considered to enable direct interaction between the researcher, participants, and the subject being researched, which is municipal infrastructure regarding the impact of poor management. According to Williman (2011), qualitative research records quality than quantity. The researcher chose the qualitative approach because the study deals with human experience and municipal infrastructure observations. A study by Amoah and Tyekela (2021) sought to find the socio-economic impact of land redistribution on the beneficiaries in the Greater Kokstad municipality of South Africa also adopted qualitative and thematic methods.

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3.2 Target population and sampling method

According to Amoah (2019), the research population represents all members belonging to the defined group. For this research, twenty participants, including municipal employees, focus groups/local organizations, and local business owners were interviewed to ensure an unbiased sample population. Leedy and Ormrod (2014) define sampling as the process whereby the researcher selects a smaller group of participants from a large population to tell us what the larger population might tell us when asked the same questions. According to Leedy and Ormrod (2014), when there is a large sample size, there is a great probability that the general population will be reflected in the sample. Williman (2011) also argues that random sampling helps to ensure no bias and that no part of the population is strongly represented. The researcher interviewed a total of 15 participants. However, the researcher used 15 participants' responses for analysis since saturation point. No new information manifest is usually reached between 12th and 20th participants in qualitative studies using the interview as a data collection instrument (Creswell, 2014).

3.3 Data collection method

Interviews were conducted to obtain the views of the selected participants on the impact of poor management and maintenance of infrastructure. The interviews were done face-to-face at the participant's offices, thus allowing the researcher to ask further probing questions and clarify issues with the interviewer during the interview process. According to Williman (2011), when the researcher wishes to obtain adequate information, interviews are more suitable as the researcher can develop questions that allow for further probing.

3.4. Data analysis method

Creswell (2014) also defines data analysis as taking data and putting it back together with the primary intent to make sense of collected data. Data were analyzed using the contents analysis technique known as the coding technique. According to Leedy and Omrod (2014), data coding helps researchers from initial observations explore arising issues and look for themes that emerge and recurring events for categorization. Upon completing the data collection, the data were then grouped and sorted for analysis following Creswell and Clark (2007) proposal for qualitative content analysis:

1. ***Data management or organization*** – collected data will be carefully read by the researcher after organizing and transforming it into a transcript form to make it easy to understand, retrieve, and manage.

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2. ***Data analysis, description, and classification*** – data was conceptualized, classified, sorted, and organized into different categories in a structured form of themes and sub-themes with features essential to the subject phenomenon. The researcher checked and verified the accuracy and quality of the transcriptions.
3. ***Data representation and visualization*** – the researcher labelled and represented data into themes and sub-themes and interpreted it to give meaning. The researcher further presented and placed data in the form of themes and statements.

4. Findings

4.1. Participant's profile

Female constitutes the majority of the participants (67%), 53% have their current post for over 5 years, meaning they understand the research phenomena and thus could give accurate information. Also, 60% of them have Bachelor degrees or higher. Table I below illustrates the participants' biographical profiles. The participants are involved in the municipal management and activities; thus, they are knowledgeable about the challenges resulting from the poor management of these municipal infrastructures.

Table I: The Participants' Biographical Profile

Participant Codes	Gender	Post	Number of years in the post	Level of education	Role in Municipality
P1	Female	Project Technician	7	Post Graduate Diploma	Coordination, supervision & monitoring
P2	Male	Supply Chain Manager	10	B-Tech Degree	Coordinate procurement of Infrastructure
P3	Male	Property Valuer	3	National Diploma	Valuing of land for accounting purposes
P4	Male	Manager	10	Bachelor Degree	Municipal building maintenance
P5	Female	Asset Practitioner	10	Bachelor Degree	Bookkeeping
P6	Female	Manager	12	B-Tech Degree	Planning & execution of projects
P7	Female	Manager	5	Bachelor Degree	Coordination & Planning
P8	Female	Manager	8	Diploma	Manage and coordinate unit
P9	Male	Manager	8	Diploma	Managing, Coordinating,

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					supervising & monitoring
P1 0	Male	Manager	3	Honours Degree	Coordinating & facilitation
P1 1	Male	Secretary	1	Bachelor Degree	Planning & Execution
P1 2	Female	Rate Payer's Association	Not applicable	Grade 12/Matric	None
P1 3	Female	Treasurer	3	Grade 12/Matric	Bookkeeping
P1 4	Female	Manager	8	Diploma in Tourism	Planning & record keeping
P1 5	Female	Forum Member	3	Honours Degree	Farming & Infrastructural Planning & Execution

4.2 Participants opinions on whether the municipality is properly managing infrastructure

The participants were asked this question to understand the respondents' personal and professional opinions on how the management of municipality infrastructure is effectively done to form the basis for the next question regarding the socio-economic effect on poor infrastructure management. The respondents' responses are shown in Table II. About 87% of them indicated that the municipality does not properly manage the infrastructure. However, the remaining 13% believed the municipality manages its infrastructure correctly. Limited funding, poor service delivery, and lack of skilled personnel were common reasons for poor municipal infrastructure management.

Table II: Proper Management of Municipal Infrastructure

Question	Responses	Frequency	Percentages	Reasons given
Do you think the municipality is properly managing infrastructure? *If not, why?*	Yes	2	13.33%	
	No	13	86.67%	Lack of Synergy
				Lack of plans and sufficient budgets for the function
				One-sided Focus
				Human and Financial capacity challenge
				Poor service delivery
				Poor planning and inadequate funding for maintenance
	Do not know	0	0	
	Total	**15**	**100%**	

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4.3 Participants opinions on the impacts of poor infrastructure management for socio-economic development

This question sought to understand the respondents' opinions on the implications of poor municipal infrastructure management on social and economic development. The responses of participants are shown in Table III below.

Table III: Impacts of poor infrastructure management socio-economic development

Question	Themes	Frequency	Percentages	Rank
In your opinion, what are the impacts of poor infrastructure management on socio-economic development?	Lack of investment attraction and job creation	7	46.66%	1
	Political/community instability	3	20%	2
	Insufficient revenue	2	13.34%	3
	Tourism decline	2	13.34%	3
	Increase in Poverty levels	1	6.66%	4
	Total	**15**	**100%**	

The majority (47%) saw a lack of investment and job creation as the main areas that were negatively impacted by poor infrastructure management. About 20% emphasized political and community instability as one of the negatively affected areas. Thirteen (13%) referred to insufficient revenue generation as another negatively affected area. Another 13.34% sighted tourism decline. The remaining 6.66% mentioned an increase in poverty levels.

5. Discussions

5.1. The effects of poor infrastructure management

Based on the findings, the causes of poor municipal infrastructure management are the lack of investment and job creation, political/community instability, insufficient revenue, tourism decline, Increase in Poverty levels, mobility problems, and corruption, respectively. These causes are discussed as follows;

Theme 1: Lack of investment attraction, job creation, and increased poverty

This section covers the three issues related to lack of investment, job creation, and poverty raised by the participants, ranked as number one impacted by poor management. The lack of investment and job creation was presented as the significant impact of poor management and infrastructure maintenance. This was related to the economic function of infrastructure, wherein creating jobs and attracting investment are central to infrastructure development and management. The UN-Habitat (2011) also backed this importance, stating that infrastructure development directly impacts the Southern African region's socio-economic development.

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As discussed earlier, much investment and economic growth of any area heavily rely on its quality infrastructure to support the socio-economic needs. Also, Boshof (2009) summarized the impacts of poor/failures of municipal infrastructure and argued that they adversely affect individuals and organized formations. They are social, economic, financial, political, and environmental. It is a well-known fact that investors and developers will not consider areas with dilapidated or lack of proper infrastructure due to investment risk. They are always looking for viable areas. According to Boshof *et al.* (2015) and Foster (2008), poor municipal infrastructure management and maintenance fail socio-economic development because of fewer employment opportunities, recreation activities, social cohesion, and no inward investment to grow the local economy.

The Republic of South Africa (2003) mandates municipalities to use their local resources, including infrastructure, to promote local economic growth and improve communities' lives. UN-Habitat (2011) also emphasizes that both in the policy and academic realms, there is a long-standing view that adequate infrastructure services supply is essential to ensure that poverty is reduced and sustainable economic development. This perceived link/relationship has eminent implications of the failure to efficiently manage and maintain infrastructures such as water, transportation, energy, and communication technologies. These implications have been sighted as vital in promoting economic growth, poverty alleviation, and improving living conditions in countries that are still developing (United States Economic Development Administration, 2005). Below are some of the views expressed by the participants;

> **Participants 03 & 13:** *"Tourism is negatively affected and declines causing loss of jobs and poverty."*
>
> **Participant 7**: *"Poverty levels rise with the continued poor management of infrastructure."*

Theme 2: Political/community instability

Bello and Osinubi (2017) also highlighted poor institutional support and political instability resulting from improper infrastructure management. The most evident results of poor management and infrastructure maintenance are the public service delivery protests that often face many municipalities in the country. The political and community instability can be attested to the communities' reactions when the government fails to deliver on infrastructure promises, mainly through public protests resulting in public property destruction and vandalism. This has become the only way for communities to express their anger and disappointment at the government. In most cases, the sad part is that the government often gives in and immediately addresses the issues raised through these protests. It is a known fact

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that this is the main reason why these protests may continue because it gives an idea that for services to come, people must fight for them, and sadly it is a very violent fight that leaves infrastructure badly damaged and vandalized.

Participants related the poor management of infrastructure to the status of the existing infrastructure, which was either vandalized, ageing, or invaded in the case of land and vacant buildings. This is also backed by Palmer *et al.* (2016), who argue that there is evidence of structural deterioration, invasion of potential development land due to poor management and neglect. This directly affects service delivery as the municipality cannot meet the service delivery needs of the communities due to failing infrastructure. Likewise, according to the African Union (2014), many African countries have been affected by infrastructure degradation, inefficient services, railways and roads of poor quality, inadequate information, and communication technology, which is supposed to be the backbone of a country's economic growth and competitiveness. In recent years, the chosen study area has faced ongoing service delivery protests like many municipalities across the country, with many of them resulting from poor service delivery. Infrastructure management and maintenance is not just an ordinary function that anyone can do, rather a specialized area for facility managers and real estate professionals. Thus, if the municipalities do not recognize this anytime soon, they will continue facing the resulting problems of deterioration, aging/decay, vandalism, and public service delivery protests. Below are some of the views expressed by the participants.

> **Participants 01 & 10**: *"Poor collection of revenue, disgruntled communities which will lead to political instability, lack of investment and poor job creation, are some of the impacts of the problem".*

> **Participants 06 & 11**: *"Political and community instability becomes the results of the subject problem."*

Theme 3: decline in revenue

Some participants associated the inadequate revenue generation with poor infrastructure management and maintenance and were ranked number three with tourism decline. This aspect relates to the economic function of municipal infrastructure wherein, through quality services, investors in the business and residential sectors will want to invest in the area, thus increasing the municipality's revenue base. The other important aspect of this is the state's property prices, services, and available infrastructure in the area. By implication, if an area has well-developed and maintained infrastructure, property prices are likely to appreciate and thus increase property rates that the municipality can generate from such properties. The

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other aspect relates to the sale and disposal of municipal properties. This is considered a direct, once-off, and short-term investment that results from property disposal. There is also the long-term investment that results from leased properties that are occupied for business purposes. Here the municipality benefits twice from rentals and rates charges. Finally, suppose the municipality does not invest in infrastructure management and maintenance. In that case, it loses the opportunity to generate various types of revenue as no investor will be interested in investing in such an area.

Based on these responses, economic development seems more critical for the participants than the social aspect. This is because many people believe that economic wellbeing enables one to support and sustain their social wellbeing. After all, the social function of infrastructure only supports leisure and psychological aspects of life. This is true because the lack of income results in poverty, resulting in other social problems, including increased crime levels. The literature also revealed that municipal infrastructure plays social and economic roles (African Union, 2014). Failure to deliver quality and sustainable infrastructure results in society's social and economic problems. Below are some of the views expressed by the participants.

> **Participants 01 & 10**: *"Poor collection of revenue, disgruntled communities which will lead to political instability, lack of investment and poor job creation, are some of the impacts of the problem".*

> **Participant 12**: *"Corruption becomes a big problem."*

6. Conclusions and Recommendations

Municipal infrastructure plays a significant role in the development plan of any country, including South Africa. These infrastructures service the community, the general public, and tourists; thus, it is significant to the municipalities and the country. However, it has been revealed that municipal infrastructure is poorly managed due to limited funding, lack of synergy, insufficient budgets, one-sided focus, and skilled personnel. Consequently, these negatively impact various aspects of municipal social and economic development, including revenue generation, investment attraction, job creation, political/community instability, poverty levels, and tourism. Based on the findings, the study recommends that the government consider developing more practical infrastructure management policies and plans, including the Asset Management Plan (AMP), Asset Register and Asset System (AR), and the Asset Performance Management System to all municipalities. This infrastructure management has been used in countries such as the United States and has proven an effective public infrastructure management strategy. Funding should be

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prioritized for the function as a matter of urgency to catch up with the management and maintenance needs. Funding should also be extended to the dedicated department/unit's capacity-building initiative with skilled and experienced personnel in the facilities management field. These funds should be monitored to ensure they are used for their purposes. Municipalities with an excellent record of effective infrastructure should be given more funding as a reward to encourage others to do the same. The Local Municipal Infrastructure Finance Management Act (Act 32 of 2003) should be broadened to make room for the municipalities to consider the involvement of private organizations in managing the country's municipal infrastructure on behalf of the government. This is to minimize poor service delivery in the municipalities due to ineffective infrastructure management and corrupt practices. More studies should also be done in municipal infrastructure management to identify other possible innovative sources of funding that the municipalities could adopt.

Research limitation

The study was conducted in only one municipality; thus, the findings cannot be generalized. Albeit the findings may apply to municipalities with similar settings in South Africa.

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Proceedings of the DII-2021 International Conference: "Building Smart, Resilient and Sustainable Infrastructure in Developing Countries"

DII-2021-011

Effective Management for Perceived Success of Infrastructure Development for SOE's

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Abstract

The purpose of this paper is to present the leadership archetypes required for the effective management of South Africa's infrastructure-related state-owned enterprises (SOEs). A questionnaire was distributed to establish the leadership archetypes necessary for those employed at SOEs to ensure the success of SOEs' infrastructure development through leadership development/ authentic leadership. Purposeful sampling was used. The population who participated in the study had knowledge of the research topic. The study found a positive relationship between innovation, emotional intelligence (EI), the fourth industrial revolution (4IR), infrastructure management, and leadership training for the perceived success for infrastructure development of SOEs through leadership development/authentic leadership. The study has produced a new theoretical model to be used in the academic field. It will also assist organisations who seek to increase their firm's performance. The study provides necessary leadership archetypes for successfully recruiting influential leaders/managers in SOEs involved in infrastructure development. The positive relationship between effective management and perceives success enhance organizational performance. This study further indicates where the focus should be for employees' leadership development, namely innovation and infrastructure management, fourth Industrial revolution agility, and emotional intelligence.

Keywords – State-owned enterprises (SOEs), Leadership training and Effective management

1. Introduction

State-owned enterprises (SOEs) worldwide have a unique purpose, mission, and objective that relate to some aspect of public service and social outcomes. By design, an SOE is owned by Government but may have external shareholders such as private businesses (Sturesson *et al.,* 2015). Some SOEs that have faced leadership problems globally include, but are not limited to, the Republic of Tajikistan, Eskom, Transnet, South African Airways (SAA), and Denel (Auditor General, 2017; Kim and Ali 2017).

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The challenges faced by these entities can collectively be characterised by a lack of political commitment to SOE reform, including the interference of the government in the SOE management, which affects performance (Kim and Ali, 2017). This lack of commitment poses excellent challenges to improving SOE performance, as seen in many Asian countries, where SOEs tend to deploy board members from the ruling political party or Government who are then difficult to remove or replace when the need arises (Kim and Ali, 2017). While SOE mandates vary across countries, their common objective is, ultimately, to provide essential services to the public (Sturesson *et al.,* 2015).

According to (Mutize and Gossel, 2017), South Africa's SOEs, furthermore, play a critical role in improving the social and economic wellbeing of the country. However, as Cohen (2017) noted, South Africa's SOEs (e.g., SAA) are often reported as running at a financial loss. Such losses lead to these enterprises requiring governmental bailouts every financial year (Mutize and Gossel, 2017). In addition, Cohen (2017) notes that the problems within these institutions primarily emanate from issues of and in leadership.

Cohen (2017) states that the nature of SOEs, thus, requires an integrated approach that combines both political and business approaches, as SOEs, in most cases, tend to operate as hybrids (i.e., political institutions that are led by politicians while simultaneously operating as businesses). These entities require individuals working in them to have the skills and capacity of trained business managers. However, Cohen (2017) further notes that this proximity and link between politics and business lack accountability when management fails. Based on this understanding, the current study aims to develop a leadership model for South Africa's infrastructure-related SOEs, mainly focusing on Eskom and Transnet.

2. Objectives of the Research

The main objective of this study is to propose an effective management model for infrastructure-related SOEs. This objective has been further broken down into three research objectives, as presented in the following subsection.

This study adopts the logical hypothesis that limited evidence links leadership styles and effective management and/or desired organisational performance. However, the researcher sought to turn this logical hypothesis into an empirical hypothesis by putting it to the test. Therefore, the kind of leadership style (i.e., model) has been used in this study to determine the overall performance of an organisation (i.e., Eskom and Transnet).

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2.1 Research Objectives

- To present various leadership approaches at the disposal of SOEs to promote effective management of infrastructure at these enterprises.
- To investigate leadership challenges experienced by, specifically, Transnet and Eskom over the past few years.
- To interrogate the leadership accountability structures currently present at both investigated State-owned enterprises (i.e., Transnet and Eskom).

3. Literature Review

To better understand what effective, efficient, and accountable leadership at both the political and business levels entails, it is essential first to discuss some of the most common definitions of leadership, as provided by scholars of the subject. To that end, this section details some of the key findings on this topic as gained from the extant literature.

Sağnak and Kuruöz (2017) define authentic leadership as leadership that embodies honesty, integrity, transparency, and respect. These authors also cite Walumbwa (2008), who indicates that authentic leadership designs a specific leader archetype that encourages positive psychological capacities and ethical climate (Sağnak and Kuruöz, 2017). This climate, in turn, should drive greater self-consciousness in employees, and instil, within the principled perspective, the steady analysis of information and correlative transparency on the part of leaders, working with their followers, to drive personal growth (Walumbwa, 2008, in Sağnak and Kuruöz, 2017). Alsolami *et al.* (2016) further note that leaders should possess new leadership archetypes to meet the increasing demands most effectively for innovation in and across any number of aspects within organisations.

2. Research Methodology

2.1. Method of Data Collection

The researcher employed a positivistic research paradigm in this study. The main objective is to fulfil the study's objective, to develop a theoretical model for effective management for perceived success of infrastructure development for State-Owned Enterprises and test if it influences organisational performance. Data collection was conducted through a survey-based approach after the researcher had developed a questionnaire.

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Based on the aim of this study, primary data were collected. Farquhar (2013) notes that in gathering primary data, a researcher should aim to determine new (participant) experiences and should, thus, include these through research question(s) designed to gather new data. Researchers also add additional knowledge through the employment of rigorous research methods. In so doing, a researcher can gain the long-lasting ability to question data sources and thoroughly assess research Farquhar (, 2013).

A questionnaire (i.e., survey-based approach) is adopted as the data collection tool for this study. According to Nishishiba *et al.* (2017), a questionnaire collects data accurately. It can provide researchers with a method to collect large sets of data fairly quickly, even when there are budget constraints on their research. If necessary, a questionnaire can even be administered to the whole population of interest (Nishishiba *et al.*, 2017).

A pilot questionnaire was first distributed to twenty-five people who work in the respective SOEs chosen for this study. The objective of releasing a pilot questionnaire was to test if the questions were clear and related to the developed model. Participants in the pilot survey made a few suggestions, and corrections were undertaken accordingly. The final questionnaire was distributed through QuestionPro. Most of the targeted participants were gleaned from those working at the study's chosen SOEs (i.e., Eskom and Transnet). In contrast, a small number of participants were taken from those who have a deep understanding and knowledge of how the chosen SOEs operate, even though they are not based in South Africa.

2.2. Population and Sampling

Rahi (2017) defines sampling as choosing a population segment for interrogation in a research project. The sampling method determines a representative population, uses the data collected for analysis from this sample, and reaches a conclusion. A sample can further be defined as a subgroup of a population (Frey, 2000). Sampling, thus, means that some part of a study population is selected for observation so that a researcher may better understand the whole population (Thompson, 2012).

Deliberate sampling is referred to as non-probability, or purposive sampling was used as the sampling method for the study. In this study, most participants were drawn from various provinces across South Africa, while a smaller number were drawn from outside the country. This smaller group of participants were included due to their understanding of the operations of SOEs in South Africa.

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2.3. Data Analysis

Bryne (2017) states that quantitative analysis employs mathematical methods and, more specifically, statistical methods to determine results. This analysis is then displayed by using computer packages that produce images. Researchers can then use these images to furnish the quantitative information collected as graphs or similar outputs to enhance reader understanding Bryne (, 2017). Furthermore, according to Rowley (2014), data analysis generally refers to the processes related to gleaning meaning and gaining consideration from various datasets gathered during research to promote future action, research, and theory constructs.

Rowley (2014:2) states that to ensure accurate data analysis, when conducting data gathering, researchers should ensure that questions posed to participants are based on extant literature, and researcher experience can also ensure the inclusion of good and necessary questions. In terms of this current study, the researcher has over 20 years' experience in the field under investigation, which was useful for formulating relevant questions that were easy and understandable for respondents to answer. In this way, it was possible to obtain reliable data for analysis. Due to the high level of reliability provided in the data collection phase, it was easier to analyse the gathered statistics through the adoption of sequential equation modelling (SEM).

3. Proposed Theoretical Model Presentation

The researcher presented a proposed theoretical model of effective management for the perceived success of the infrastructure development of SOEs through leadership development. The researcher identified the independent variables, namely, innovation, emotional intelligence (EI), the fourth industrial revolution (4IR) and infrastructure management when constructed together for effective management. The intervening variable is leadership training for the perceived success of the infrastructure-related SOEs. The dependent variable is the perceived success of the infrastructure development of SOEs through leadership development.

Eskom and Transnet, over the past number of years, have recruited leadership to oversee infrastructure projects, with these projects deliberately or inadvertently having overrun on time and costs and displaying overall poor quality. This study, therefore, outlines how these two specific organisations have managed their infrastructure projects by examining the organisations' choices (both conscious and unconscious) surrounding how they model intended and unintended organisational performance. The value of testing the stated hypothesis concerning the two chosen SOEs is that the findings could help leaders, both

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within these entities and similar ones, trace their leadership strides and identify where they could have gone wrong. Through such identification, it may become possible for leaders to make much more informed leadership decisions that could lead to intended (positive) outcomes.

The aim of this analysis is, thus, to investigate the relationship between the effective management of employees and the perceived success of the SOEs in question. To this end, effective management was measured as a function of four constructs, namely 1) 4IR agility, 2) emotional intelligence (EI), and 3) infrastructure management and 4) innovation. These constructs are management constructs, which made them suitable for this study, as presented in Figure 1.

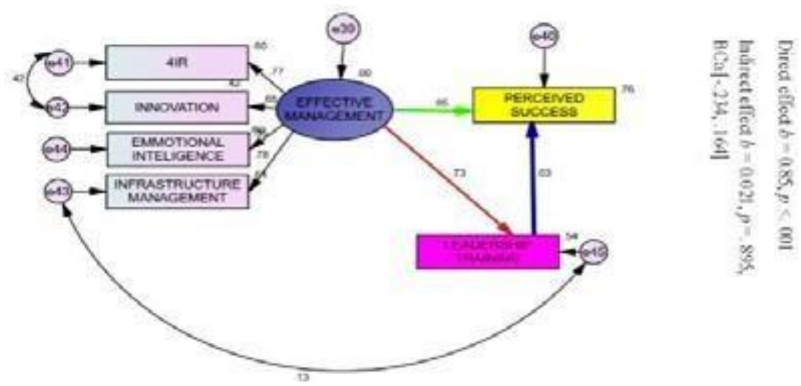

Figure 1: Proposed Theoretical Model

Source: Author's Construction

3.1. Operationalisation of the Dependent and Intervening Variables

3.1.1. Dependent Variable: Perceived Success of the Infrastructure Development of SOEs through Leadership Development

For this study, the variable 'perceived success of the infrastructure development of SOEs through leadership development' refers to the development of authentic leaders who are

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trained in and understand what effective infrastructure management of SOEs entails. Previously, based on the researcher's observations, SOEs have been generally appointed chief executive officers (CEOs) who have little to no knowledge of what occurs in the built environment undertaken by the SOEs. This lack of leader knowledge has exacerbated the current situation of poor SOE management. Els *et al.* (2017) further presents the concept of leadership derailment, which refers to "a growing phenomenon that threatens leadership sustainability, where leaders with impressive track records reach a leadership plateau and derail because of a mismatch between job requirement and leadership skills''. It should be noted that Poisat (2019:2) has stated, "a key theme that emerges is the leader's 'ability to get things done by influencing others' and change".

3.1.2 Intervening Variable: Leadership Training

To meet the purpose of this study, leadership training was deemed to refer to the training needed to develop successful SOEs leadership. This 'good leadership', in turn, should be aimed at advancing the perceived success of infrastructure development within SOEs. In most cases of SOE leaders, the Government (the primary shareholder) deploys appointed leadership to positions within SOEs without first ensuring that those appointed have the proper and necessary skills that align best with the activities conducted by the SOE deployed. Therefore, leadership training could close this gap based on the variables that align with the perceived success of infrastructure management.

Els *et al.* (2017:30) argue that large organisations treat training and development as a secondary endeavour. However, particularly in cases where there are limited budgets, neglecting the rewards that come with positive leadership development can prove even more costly (Else *et al.*, 2017:30).

3.2 Operationalisation of Independent Variables

3.2.1 Innovation

For this study, 'innovation' refers to creating a better way of doing something and is used about both or either services and/or products. In terms of this definition, SOEs' leadership should, thus, be able to understand and champion innovation to promote the perceived success of their SOEs' infrastructure development. Zawawi *et al.* (2016:87) further define 'innovativeness' as a critical culture in any management team and/or organisation to produce new ideas to gain a competitive advantage and ensure the longevity of the organisation.

Similarly, according to Baregheh, Rowley, and Sambrook (2009:1334), innovation is the composite process whereby firms develop thinking into new and/or better products, service,

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or processes, to gain a competitive advantage and, thereby, uniquely identifying themselves as ''successful' within their specific marketplace. Taylor (2017:131) also states that innovation is the design and application of new design processes, products, services, and delivery methods that produce a competitive edge in the marketplace due to improved efficiency, effectiveness, and quality.

3.2.2 Emotional Intelligence

Els *et al.* (2017:58) explain that the concept of EI dates back to the term 'social intelligence' originated by Thorndike in the 1920s. Carlsson and Lyrbäck (2019:1), citing Palmer, Walls, Burgess, and Stough (2001), further indicate that the specific 'EI' term originated in the 1990s when Peter Salovey and John D. Mayer used it to name one of the main justifications for managing modern-day employees within firms. Marín, Pan, and Guirao (2019:68) similarly explain that the term was reportedly initially introduced by Wayne Payne in 1986, in Payne's doctoral thesis titled A Study of Emotion: Developing Emotional Intelligence; Self-integration, Relating to Fear, Pain and Desire. Emotions, according to Tripathy (2018:2), exist across many aspects of human action and decision-making. Emotionally intelligent people understand emotions and use this thoughtfulness to manage their own emotions rather than others.

3.2.3 Fourth Industrial Revolution Agility

Schwab (2016:1) states that the 4IR is characterised by a combination of technologies "blurring the lines between the physical, digital, and biological spheres". Shivdasani (2019) believes that South Africa must 'get the basics right' if the country wishes to take full advantage of the 4IR. This author further quotes President Cyril Ramaphosa, detailing how South Africa should embrace the 4IR to better address the country's persistent challenges of poverty, lack of employment, and inequality (Shivdasani, 2019).

The 4IR has long been anticipated by many to significantly impact jobs worldwide, as robotics, automation, and artificial intelligence (AI) become ever-more prolific (Adendorff and Putzier, 2018:55). Adendorff *et al.* (2018:12), for example, have cited Falcioni (2016) in noting that the first industrial revolution mechanised production, the second one used electric power for mass manufacturing and the third used information technology to automate production. Moreover, 4IR can potentially twist the lines between the digital, the physical and the biological realms.

3.2.4 Infrastructure Management

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As it relates to this current study, the concept of' infrastructure management' refers to the monitoring and project management of construction projects that SOEs undertake. Memon *et al.* (2006) explain that the repetitive problems in construction are recording the deviations that occur on-site in line with the as-built schedule. The current practice is that changes from the planned schedule are only recorded after significant time has passed. Traditional construction monitoring of tasks is costly and prone to errors; hence, digitalisation is recommended.

Li *et al.* (2019:14) further state that "project team's knowledge and skills can promote environmental practices implementation, and that environmental practices implementation positively influences environmental and organisational performance".

3.3 Effective Management

Namiq (2018) emphasises the importance of multiple skills for effective management. The need for leaders to have many different skills is especially necessary when managing the new generation workforce, as these employees tend to come from diverse cultures, regions, and backgrounds, which all impact their ability to function well within an organisation (Namiq, 2018). The younger generation is also quickly reaching high positions. The older and younger generations have unique archetypes, with the older generation having work experience but lack technological experience, and the younger vice-versa. Supple (2009) provides tips for effectively managing this multi-generational dynamic by using communication, motivation, education, celebration, and making progress. In this study, the four constructs identified at the theoretical model presentation (5) equals effective management.

4. Reliability and Validity of Constructs

4.1. Validity of the Data

Heale and Twycross (2015) define validity as the scale by which a notion is correctly assessed in a quantitative study. For example, a survey initiated to investigate depression but which normally asses' anxiety would not be seen as 'valid'. The second quality assessment in a quantitative study is reliability (i.e., the accuracy of a data collection instrument Heale and Twycross (2015). Validity concerns what a tool measures, while reliability has to do with how correctly the tool does so(Haradhan, 2017; Tavakol and Dennick, 2011).

In this study, a pilot study was conducted to ensure that even minor errors were found and corrected before formal data collection. The demographic information gathered was used to identify respondents who have relevant knowledge of the research topic to provide

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confidence in the data provided. Twenty-five participants were identified, and all response. Few errors and suggestions were put forward, and the question was updated before a final questionnaire was sent out. The collection tool used was QuestionPro, which is explicitly designed to identify even incomplete questions. SEM was then used to analyse the data. An online free statistics calculator version 4.0 (2021) for structural equation models was used to determine if the results obtained are valid based on the sample size. The anticipated effect size was 0.1; the desired statistical power level was 0.8, the number of latent variables was 1, number of observed variables was 6, the probability level was 0.05, the minimum sample size to defect effect was 87. The minimum sample size for the model structure was 200; the recommended minimum sample size was 200.

4.2. Reliability of the Data

According to Heale and Twycross (2015:), reliability relates to the consistency of a measure. A participant completing an instrument meant to measure motivation should have approximately the same responses each time the test is completed." Similarly, both Haradhan (2017) and Tavakol and Dennick (2011) state that reliability relates to the faith that can be placed in the data collected from the used tool (i.e., the degree to which any measuring instrument controls for random error).

For this current study, the researcher ensured that the questions used in the questionnaire were based on the extant literature and the researcher's own personal 20 years' worth of experience in the field. It was possible to formulate easy questions for participants to understand, thereby ensuring reliable data collection. The reliability provided through the instrument also enabled easy analysis of the gathered statistics through SEM.

4.3 Cronbach's Alpha Measurement

Both Tavakol and Dennick (2011) and Bonet and Wright (2014) state that Lee Cronbach introduced alpha in 1951 to determine a measurement of the internal validity of a test or scale. The Alpha measure is presented as a number between 0 and 1 (Bonet and Wright, 2014:2; Tavakol and Dennick, 2011:53). Internal consistency, in turn, is used to define the scale upon which all the elements in a test measure the identical concept. Thus, internal validity is interlinked with the inter-relatedness of the elements within a test. It should be noted that internal consistency should be established before a test can be used for research or examination purposes to guarantee validity.

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According to (Bonet and Wright, 2014:2; Tavakol and Dennick, 2011:53) state that "in comparison, reliability estimates show the amount of measurement error in a test. To streamline this process, the interpretation of reliability is depicted as the correlation of the test as it stands. Thus, squaring this correlation and then subtracting from 1.00 provides the index of measurement error. For example, if a test has a reliability of 0.80, then there is a 0.36 error variance (random error) in the scores (0.80×0.80 = 0.64; 1.00 – 0.64 = 0.36). To calculate the effect of measurement error on the observed score of an individual respondent, the SEM must be calculated" (Bonet and Wright, 2014:2; Tavakol and Dennick, 2011:53).

4. Findings and Discussion

This broader sample ensured that accurate and representative data were collected for this study. The following tables (Table I-III) reflect the participants' demographic information. In particular, these tables cover participants' education, gender, and age.

Table I: Education

Education			
	Frequency	**Percent**	**Valid Percent**
Matric	3	0.9	0.9
Certificate	7	2.1	2.1
Diploma	30	9.0	9.0
Degree	77	23.0	23.1
Honours	74	22.1	22.2
Masters	130	38.8	39.0
Doctorate	12	3.6	3.6
Total	333	99.4	100.0
Missing	2	0.6	
Total	335	100.0	

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Table II: Gender

Gender			
	Frequency	**Percent**	**Valid Percent**
Male	207	61.8	62.9
Female	122	36.4	37.1
Total	329	98.2	100.0
Missing	6	1.8	
Total	335	100.0	

Table III: Age

Heading	**Heading**
N	314
Missing	21
Mean	42.80
Median	42.00
Std. Deviation	8.730
Range	53
Minimum	21
Maximum	74

SEM was then used to analyse the data to determine any positive relationships from the conceptual model framework.

Figure 1 also presents a diagram of the Mediation Model with Regression Coefficients, Indirect Effect, and Bootstrapped CIs. Statistical mediation analysis was conducted to

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determine if Leadership Training mediates the relationship between Effective Management and Perceived success.[Assumptions of linearity, normally distributed errors, and uncorrelated errors were checked and met.] The means, standard deviations, and intercorrelations can be found in Table III. Figure 5.1 shows the β’s and p values for the effects. Leadership training did not statistically significantly mediate the relationship between effective management and Perceived success, β = .021, BCa CI [-.234, .164].

Table IV: Regression weights.

			Estimate	**S.E.**	**C.R.**	**P**	**Label**
H_	<---	Effective Management	1.159	.121	9.547	***	B
K	<---	Effective Management	1.251	.155	8.071	***	A
L_	<---	Effective Management	1.388	.130	10.678	***	
F	<---	Effective Management	1.109	.117	9.450	***	
J_	<---	Effective Management	.989	.093	10.638	***	
M_	<---	Effective Management	1.000				
K	<---	Leadership Training	.026	.073	.351	.726	C

The above table IV indicate a relationship between effective management to H, K, L, F, J, M, while leadership training indicate no relationship to perceived success

Table V: Standard Regression weights

			Estimate
H_	<---	EM	.733
K	<---	EM	.850
L_	<---	EM	.774
J_	<---	EM	.780
M_	<---	EM	.595
F	<---	EM	.650
K	<---	H_	.027

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The above table V the variables that make effective management from the most important to the least as follows; J, L, F, and M. Table VI presents the reliability statistics of this current study.

Table VI: Reliability Statistics

Variable	Cronbach's Alpha	Number of Items
F. Innovation	.729	4 (F1 DELETED)
H. Leadership Training	.838	5
J. Infrastructure Management	.730	5
K. Perceived Success through Leadership Development	.782	5
L. Fourth Industrial Revolution Agility	.888	5
M. Emotional Intelligence	.874	5

To evaluate whether the five items that were added up to create the four constructs used in this study formed a reliable scale, Cronbach’s Alpha was calculated. The Alpha for each construct is shown in Table VI. Values over 0.7 indicate that the items form a scale with fair internal consistency and reliability (Leech *et al.*, 2005). In terms of this current study’s scale, the Alpha for Leadership Training was greater than 0.8, indicating good internal consistency.

Exploratory factor analysis was also done on the collected data, along with principal axis factor analysis with varimax rotation. This latter analysis was done to measure the underlying structure for the 30 items of the questionnaire. Seven factors were requested since the items were specifically designed to index four constructs: innovation, the 4IR, EI, leadership training, infrastructure management, and perceived success through leadership development.

Cronbach’s Alpha was calculated. The Alpha for each construct is shown in Table VI. This finding implies a positive relationship between these respective factors and leadership training for the perceived success of infrastructure-related SOEs. In terms of innovation (F1), it was found that this factor does have a link to perceived success. As such, this factor

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impacted the Cronbach's Alpha score and was, thus, deleted. F1 was an outlier because the participants are all managers, who could have been biased in their responses to this particular question. Therefore, the model was revised only to present the variables that had a positive relationship to leadership training for the perceived success of infrastructure-related SOEs. Despite the exclusion of F1, the theoretical model is not changed from the one proposed (see Figure 2).

Figure 2: Theoretical Model

5. Conclusion and Recommendation

There is a significant relationship between effective management and perceived success ($p<.001$). Similarly, there is a significant relationship between effective management and leadership training ($p<.001$), and there is no significance in terms of leadership training moderation ($p=0.726$) to the perceived success. Therefore, the study adopts the logical hypothesis that there is enough evidence linking leadership styles and effective management and/or desired organisational performance (perceived success). Therefore, it is recommended that the SEOs recruit or develop their leaders by conducting leadership training by the four established constructs (i.e. 4IR, EI, Innovation and infrastructure management), as these can aid in providing generally effective management. The recommended constructs will provide specific effective management for the perceived success of infrastructure development for SOEs in South Africa.

6. Further Research

The article points out the importance of effective management in the SOEs that embark on infrastructure development. Based on this outcome, further research should investigate the

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prospect of social responsibility in effective management for the perceived success of infrastructure development for SOE's.

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Proceedings of the DII-2021 International Conference: “Building Smart, Resilient and Sustainable Infrastructure in Developing Countries”

DII-2021-012

Assessment of African Countries Strategic Position to Leverage on China's Belt and Road Global Strategy

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Abstract

African countries, particularly the Sub-Saharan region, have a huge infrastructure deficit and inadequate technical competence to effectively tackle regional infrastructure development, economics, trade, and cooperation issues. The yearning to realise sustainable development and alleviate abject poverty in the 21st century in Africa through infrastructure development is a genuine concern. The study explores challenges hindering the African continent from strategically and collectively leveraging China’s Belt and Road (B&R) project to develop its long, yielding infrastructure investment and regional integration. The study adopted a systematic review method to explore existing knowledge on the potential influence of the Chinese economic reform and opening has on the African continent. The China reform birthed the emerging new world order- China’s B&R project. The B&RI is China’s international strategy with great force in infrastructure development and investment, which advocates for economic prosperity for developing and developed countries based on a win-win scenario, as China’s increasingly strategic political and asset position in the global community. The study findings argue that the African continent’s international position has a strategic and competitive edge of leveraging on the emerging new world order- China’s Belt and Road initiative to intensify its technical competence and capacity building and develop integrated infrastructure projects within Africa. The study recommends that the African Union Commission (AUC) and its Regional Economic Communities should jointly plan and strategically utilise the China B&RI platform to encourage effective governance on infrastructure development and the creation of local industrialisation.

Keywords: African regional integration, China’s belt and road strategy, Infrastructure development

1. Introduction

Africa Infrastructure Country Diagnostic (AICD) (2011), Ncube *et al.* (2017), and Bridges Africa (2017) acknowledged that infrastructure development is a key driver for the African development agenda towards reducing poverty, increasing economic growth and attainment of sustainable development goals. Ncube *et al.* (2017) state that infrastructure comprises the

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stock of basic facilities and capital equipment that propel productivity of society such as roads, bridges, rails, airports, telecommunications, roads and electricity, and other public work.

In the 1960s, the African countries’ leaders embarked on an ambitious infrastructure development plan, such as the trans-African highways- which proposed Cairo to Dakar, Tripoli to Windhoek and Lagos to Mombasa road's network system (Mutume 2002). Unfortunately, no significant success has been made in this regard, as the African region is still in dire need of infrastructure development that would foster its economic development process, regional infrastructure cooperation, and integration (Mutume 2002). Forward to the year 2015, the African Union (AU) Commission (2015) evoked the spirit of Pan- Africa in pronouncing its continental aspiration, which geared towards building the world-class infrastructure that would criss-cross and integrate the entire African countries through communication and infrastructure network systems. In addition, 2015 AU’s vision aimed to develop a critical mass of highly educated citizens in science, technology, and innovation (STI) skills and capacities to drive local industrialization, manufacturing and global competitiveness (African Union Commission, 2015). Mutume (2002) highlighted that in the 1960s, African liberation masterminds and leaders planned and agreed to build an integrated infrastructure within the continent to foster intra-African trade and regional development; however, about five (5) decades, no significant achievement yet in this course. One could ask if this AU's vision of 2015 would be regarded as a déjà vu of the 1960s, which merely reflects an aspiration and political rhetoric?

A few years ago, the African Union Commission (2015) pronounced its Agenda for 2063, that is, to implement regional integration. It is a flagship program at a pace of 10-Year strategic intervals on its implementation plan. The proposed programme is: to build an integrated and high-speed train network, establish a continental free trade area, and related issues. Ncube and Lufumpa (2017) claimed that Africa needs about US$93 billion annually to finance its infrastructure gap. Thus, prioritising African’s infrastructure projects across regions is a necessity. However, some African countries earn financial and technical support to invest in new infrastructure development, build smart cities, and build a new industrial and economic zone (Ncube and Lufumpa 2017). Mutume (2002) states that planning and constructing new infrastructure involves huge capital outlays and, in combination with expenditure for maintenance and management on the existing facilities. Thus, most African governments cannot provide on any significant financial scale for infrastructure development, as the Bridges Africa (2017) states that financing infrastructure in Africa is a huge challenge with the size of the gap, its high cost of materials and technology needed.

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Bridges Africa (2017) further highlights that mobilising only the internal resources in Africa is not enough to meet its infrastructure challenges. These challenges are cascaded through its lack of financial capacity, inadequate skills resource pool, and technical capability to develop itself substantially. Thus, these developmental challenges within Africa require external partnership, such as China's B&R global project.

According to Naisbitt *et al.* (2017), China is well aware that most of the Belt and Roads Initiative (BRI) networks lack the capacity required to invest in their infrastructure. They do not even have the strategic resources needed to embark on huge infrastructure development in many cases. Thus, the African infrastructure development agenda requires an adequate and predictable funding mechanism. The China Global Television Network (CGTN) (2019) dialogue and discussion on China's role in the BRI's incentive and risk assessment in the global market with Mr Bill Jones, the chief intelligence on the review of infrastructure investment. Mr Jones claims that China has a unique funding mechanism through its foreign direct investment strategy within its BRI project. China's BRI financial orientation is becoming a global template for funding infrastructure projects in developing countries (CGTN, 2019).

1.1. Acute Infrastructure Development Challenges in African countries

Mutume (2002) Africa lags when compared with other developing regions worldwide in terms of infrastructure development. This measure particularly focuses on the quantity, quality, health and safety cost and access (Mutume, 2002). The AICD (2012) states that the weakness of infrastructure in Africa is a huge obstacle to the continent's capacity to face international competition. Lufumpa *et al.* (2017) argue that Africa's productivity remains lowest compared to other regions worldwide, despite its vast natural resources and growing human population. Lufumpa *et al.* (2017) further said that the inadequate capacity to increase productivity is strongly linked to serious infrastructural shortcomings across sub-sectors such as energy, water, sanitation, transportation, and information and communication technology (ICT) Africa. Bridges Africa (2017) argues that the large scale and long-term financial implication and nature of infrastructure projects require in Africa, which is usually beyond the capacity of African countries, is a significant challenge.

In addition, Lufumpa and Yepes (2017) affirmed that Africa needs to improve its capacity and efficiency on its various institutions and agencies that would effectively be responsible for its development and management infrastructure. Thus, institutional reform and a strong support system are necessary for effective infrastructure development in Africa. Unfortunately, Ncube and Lufumpa (2017) state a tendency among development agencies

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and experts who considered that planning, financing, and construction techniques are the most challenging issues in delivering infrastructure in Africa. Bridges Africa (2017) also argues that the long-term infrastructure gap is one of the most significant structural constraints hindering Africa’s development agenda. This is not an easy challenge to address with quick fixes.

1.2. Purpose of the Research Study

The purpose of the research was to critically review the existing literature knowledge and gain in-depth insights on the influence of China’s Belt and Road Initiative (B&RI) towards implementing the African continent’s aspiration on regional integration through infrastructure development. However, what approach should the African Union (AU) be utilised to leverage its strategic market position; and collectively advance its infrastructural development needs to foster regional integration.

2. Research Methodology: Systematic Review

This study is a development of a preliminary study of a large research endeavour towards investigating how the African countries and African Union (AU) could utilise their strategic position to leverage on the emerging new world order. China’s B&RI global strategy toward realising its infrastructure development gaps, skills capacity building, and economic and regional integration. Thus, the main research will be adopting an empirical research method to investigate and obtain opinions strategically, perceptions, and experiences among the African Union Commission state-members on its pursuit on the agenda of economic and regional integration and infrastructure development and connectivity in Africa.

However, this research paper is based on a content analysis based on a critical review of related literature on China’s B&RI influence in Africa and Africa’s infrastructure challenges and prospects to leverage the emerging new world order. Hart (2001) states that the literature review is a selection process of available information, both published and unpublished documents. Hart (2001) the documentation of this is information on the topic ought to contain ideas, data and written evidence from a particular standpoint to fulfil certain aims or express certain views on the nature of the research the topic under investigation. Jesson and Lacey (2006) state that performing a critical literature review is regarded as a desk research study in methodology terms. This involves a process of critical reviewing and synthesizing the study using existing secondary sources. Therefore, the study is a theoretical investigation, which utilised secondary data from articles from google scholar, academic articles,

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government gazette, Acts and policies, development agencies, research and development institutions, and textbooks on themes such as Infrastructure development in Africa, China’s Belt and Road Initiative, China-Africa Cooperation, African Union agenda on regional integration of infrastructure and economic development. Thus, this study was carried out using scoping research review that was carried out in which 19 articles were systematically identified, extracted, reviewed, analysed and synthesized accordingly.

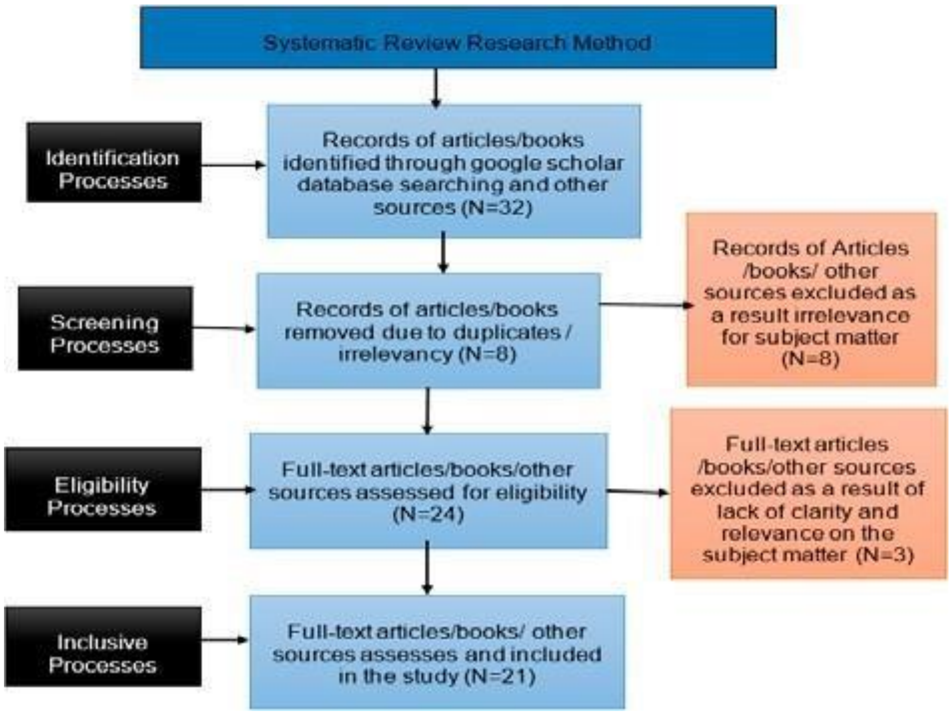

Figure 1: Systematic review process and protocol

3. Theoretical Survey and Analysis

3.1 African Infrastructure Development Needs and Challenges for Regional Integration

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According to Xiao and Yabin (2017), Africa is endowed with natural resources and an increasing population as a potential for working-age that should drive the economy. However, despite its isolated progress in developing its urban areas, the issue of inadequate infrastructure development is one of the critical challenges to grow its sustainable development and economic growth. According to the United Nations and NEPAD Agency (2016), the quest for industrialisation is at the core of Africa's plan for structural transformation and infrastructure development. Ncube *et al.* (2017) claimed that new infrastructure investments in Africa in telecommunications, roads, and electricity would further and significantly influence its acceleration towards sustainable development and stable economic growth. The United Nations and NEPAD Agency (2016) state that in the year 2012, there were over 800 active infrastructure projects worth over $700 billion across Africa: 41% in transport and 37% in power. These two sectors are crucial for Africa's industrialization and economic sustainability.

Lufumpa *et al. (2017)* claim that the Africa Infrastructure Development Index (AIDI) monitors infrastructure development status and progress across the continent. The AIDI focuses mainly on four major components of infrastructure: transport, electricity, ICT, and water and sanitation infrastructure, which have a significant impact on productivity, economic growth and industrialisation of any given society. The AICD (2011) and Ncube *et al.* (2017) added that infrastructure is the key ingredient of Africa's post-Millennium Development Goals agenda. It can foster its socio-economic growth and realisation of sustainable development goals. Lufumpa *et al.* (2017) further acknowledged that infrastructure development should be considered the key driver and critical enabler to the African continent's future progress in enhancing its productivity, human capital development, poverty reduction, and sustainable economic growth. Bridges Africa (2017) asserts that if Africa is prosperous in its development ambitions, adequate hard and soft infrastructure should be a mandatory condition and priority for the African policymakers.

3.2 African Continent needs to collaborate with the Emerging New World Order

According to Mubila and Yepes (2017b), capital investment requirement in Africa is huge, as its annual infrastructure investment needs are approximately US$93 billion, which one-third would only cover the operations and maintenance. Mubila and Yepes (2017) further state that with Africa's current spending at about US$45 billion annually, this financing is sizable and requires appropriate management to maximize the value of the local and foreign investment. Xiao and Yabin (2017) state that the Sino-African collaboration in infrastructural development strives for mutual benefit; as such, all engineering projects are undertaken by

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the China organisations which involve infrastructure development are relevant to the needs and issues of Africa development.

Naisbitt *et al.* (2017) further claim that The Forum guides china's overall policies towards African countries on China-Africa Cooperation (FOCAC), which facilitates the coordination of infrastructure between different African countries and improves connectivity. Wen (2016) argues that the benefits of a partnership with China institutions and firms would stem from the capacity and capability of individual countries, and the region's worldview, development, and negotiating strategies, and industrial and economic policies. Wen (2016) further advocates that African countries or perhaps the African Union must leverage its strategic position in determining and negotiating a better deal with China's infrastructure investment for the continent. The African Union should strategically examine China's BRI and utilise it to achieve its aspiration of regional infrastructure and economic integration. Xiao and Yabin (2017) urge African countries through its African Union Commission (AUC) and its Regional Economic Communities (RECs) to capitalise on China's B&R infrastructure strategy to team up in planning and promoting infrastructural development and industrial and economic collaboration. This approach can foster and accelerate industrialisation and agricultural modernisation in Africa, especially in the Sub-Saharan region. In addition, Xiao and Yabin (2017) indicated that Sino-African collaboration is an asset and a source of hope and optimism in African infrastructure development.

3.3 Understanding the Philosophy of China's Belt and Road Initiative and its Importance for African Continent Infrastructure Integration

According to Wen (2016), China's industrial revolution, which started about four decades ago, is one of the most important game-changer for economic and geopolitical phenomena of the 21st century, as it is igniting new growth across the globe. Naisbitt *et al.* (2017) claim that the Chinese ancient economic philosophy- called Silk Road has birthed the Belt and Road Initiative, which aimed to revitalise and rejuvenate China and the global economy. Naisbitt *et al.* (2017) argue that the structure of the international economic map led by the developed nations focuses on financial markets as its financial wealth mostly comes from arbitrage, trading of securities, debt rather than actual trade, investment, and service. However, the idea behind the B&RI differs significantly from such structure, as its focus on investment into infrastructure, manufacturing, processing, trade, and services; and to develop the interior first (Naisbitt *et al.,* 2017). The overall view of Africa is that the B&R policies

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will benefit the continent, where infrastructure and connectivity are significant considerations for development. Xiao and Yebin (2018) claimed that the western nations are becoming conscious in recognising that China's foreign direct investment and infrastructure development projects in Africa are part of its global strategy to build infrastructure within Africa. It also provides access to its growing middle-class market as a first-mover; and fosters cooperation and win future continental strategic support.

The African Union Commission (2015) asserts that its Pan African vision is to integrate and position the African region for prosperity, peace, increase its productive citizens, and project the continent as a dynamic force in the international arena. Thus, in addition to the African Union strategic position, Lufumpa and Yepes (2017) noted that there are regional economic communities and pan-African institutions such as the New Partnership for Africa's Development (NEPAD) and the African Development Bank (AfDB). This would provide a framework capable of supporting the African agenda for infrastructure development at national, regional, and international levels. These institutional frameworks would facilitate engagement and negotiation with Africa's development partners and support continental infrastructure procurement (Lufumpa and Yepes, 2017). The Pan African vision seems to resonate with China's B&RI project. According to Naisbitt *et al.* (2017), the Belt and Road (B&R) Initiative is an attempt by China to strategically connect several continents of different history and cultures towards economic prosperity. Never, in modern history, that one country has to orchestrate an initiative to form Belts and Roads of cooperation, bonding people to people, promoting investment and consumption, encouraging dialogue and understanding (Naisbitt *et al.*,2017).

3.4 China's Capability and Influence on the African Countries Mega Infrastructure Development

Bluhm *et al.* (2018) highlighted that one of the earliest and major disappoint African countries had with the Western power, or developed nations were in the 1960s. It was the proposed TAZARA railway project, which was rejected to be financed by the G7 nation; as a result, the World Bank and the United Nations doubted the technical feasibility and economic viability of the project. However, despite the extraordinary engineering challenge that involved moving 89 million cubic meters of earth and constructing 320 bridges, 2,225 culverts, and 22 tunnels, China financed and completed the construction project worth US$415 million within three years (Bluhm *et al.*,2018). Naisbitt *et al.* (2017) reiterated Africa's historic disappointment with the Western development agencies, which witnessed many stalled projects. Africa highly welcomes China's approach for its infrastructure needs

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in terms of roads, rails, and ports facilities. In this regard, China's own experience in building infrastructure as a catalyst for economic development is of great relevance to Africa infrastructure development and regional integration. Supporting this view, Ncube and Lufumpa (2017) acknowledged that the past few years have shown that financing infrastructure projects in African regional may not be the most challenging obstacle to overcome by African countries in the quest for infrastructure development and regional integration. Ncube and Lufumpa (2017a) further claimed that the number of institutional investors allocating assets to infrastructure development in Africa had risen considerably, especially in China increased risk appetite.

Ncube, Lufumpa, and Kararach (2017) admonished that African Union and regional government should identify innovative sources of attracting finance for its infrastructure needs and take advantage of the renewed interest shown by donors and investors in the infrastructure sectors. The AICD (2011) claimed that about 30% of Africa's infrastructure is dilapidated and urgently needs refurbishment. Moreover, the cost implications of Sub-Saharan Africa's infrastructure services are up to at least twice as high as other developing countries due to diseconomies of scale and lack of effective competition. The AICD (2011) further argues that solving the infrastructure problem in Africa will require sustained spending of about $93 billion per year. This sum represents around 15 percent of the gross domestic product (GDP) of Sub-Saharan Africa. It would represent a level of infrastructure development comparable to that seen in China during the 2000s. Xiao and Yabin (2017) also admonished that the financing of infrastructure projects within African countries should undertake scientific assessment upon ascertaining each party's risk tolerance could it embark on any given project. This would encourage the minimisation of any potential risk of insolvency and scepticism of China's loan conditions. Thus, the success of the infrastructure project would depend on how African governments execute and maintain them. In addition, for long-term sustainability, it is required that China's capacity be incorporated into a medium-term contract for operation and maintenance. This would encourage skill transfer, capacity building, and infrastructure sustainability (Xiao and Yabin, 2017).

The International Energy Agency (IEA) (2016) claims that across the globe, from the year 2010 to 2020, Chinese construction and energy infrastructure companies are the main contractors- mostly Engineering, Procurement and Construction (EPC) contracts for about 150 projects in power plants, and Transmission and Distribution (T&D) (see Table I). The IEA (2016) further states that the Chinese power projects in Sub-Saharan Africa focus on capacitating and sharing risk and knowledge of the projects contracted by local contractors in the electricity mix.

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Table I: Chinese power projects in Sub-Saharan Africa 2010 and on-going

	Generation Capacity			T&D capacity		
	Completed projects	**Under construction**	**Planned and finance**	**Completed projects**	**Under construction**	**Planned and financed**
East Africa	14	9	5	10	10	1
West Africa	17	4	2	6	2	2
Central Africa	8	5	2	5	1	2
Southern Africa	15	7	8	4	5	1
Total	**54**	**25**	**17**	**25**	**18**	**6**
	96			**49**		

Source: International Energy Agency (IEA) 2016.

Table I indicated the Chinese dominating and leading role in constructing power generation, transmission and distribution infrastructure assets in the Sub-Saharan African region. According to the IEA (2016), Chinese construction and energy infrastructure firms are the main contractors. They undertake the critical responsibilities of engineering design, procurement and construction [EPC] contracts process with about 150 projects in Sub-Saharan Africa concerning power plants and transmission and distribution (T&D) lines projects. Thus, the Chinese construction firms contribute significantly to capacitating the sub-Saharan Africa power infrastructure development (IEA, 2016). Table I indicated about 54 power projects in generation capacity had been completed. In contrast, about 25 power generation infrastructure projects are under construction, and 17 power generation projects were solely planned and financed under the Chinese' belt and road global initiative. In addition, across Sub-Saharan Africa, Chinese international firms are undertaking about 49 power infrastructures in transmission and distribution (T&D) projects, of which 25 projects have been completed, 18 are in progress, whilst about 6 projects are fully planned and funded by China, through the B&R projects (IEA, 2016).

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Table II: China’s B&R Initiative Outcomes from 2013-2016

B&R Tangible Outcomes From 2013-2016			
Sector/Area of Activities	**Number of countries Benefited**	**Number of Project / Capital Invested**	**Salient features of the projects/investment**
Transportation	26 Countries	38 Major transportation infrastructure	Many are trans-boundary roads and rails linking B&B countries
Power	19 Countries	Invested in 40 Power stations	Electricity transmission, gas, and oil transmission stations.
Economic and Trade Zones	18 Countries	52 economic and trade zones	Introduction of a new model of special economic and trade zones to support and foster development in B&R countries
Trade & Investment	All B&R and G7 Countries	Total investment in B&R is about US$51.1 billion The Volume of commodity trade between China and B&R countries reached US$3.1 trillion	Increased transport and investment expand trade between China and B&R countries.

Source: Adopted from Naisbitt *et al.*,(2017).

Table II indicates China's global presence and leading role in developing transportation and power supply infrastructure projects, trade and investments, development of special economic and trade zones, policy coordination, and financial integration across the network of B&R countries (Naisbitt *et al.*,2017). Table II has shown that through China’s B&R global project, about 38 major transportation projects, such as transboundary roads and railways connecting the about 26 B&R countries, has been completed, whereas about 40 power station projects such as electricity transmission and oil and gas power transmission stations across 19 B&R countries (Naisbitt *et al.*,2017). In addition, China, through the B&R project, had a total volume trade of commodities worth about US$3.1 trillion with the B&R affiliated countries, and about US$51.1 billion has invested across B&R countries (Naisbitt *et al.*,2017). Table II also reveals that through its B&R global, China has established 52 special economic and trade zones within 18 B&R countries (Naisbitt *et al.*, 2017). According to Naisbitt *et al.* (2017), the Chinese government are reinventing the landscape of globalisation through its unique development framework that fosters significant infrastructure development, investment, and reconfiguration of the world economic order and a rebalancing

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of power, and cooperation and win-win strategic choices among the nations participating in the B&R project initiative.

In addition, the Forum on China-Africa Cooperation in 2015 China pledged to offer US$60 billion and support for the "Ten Major Collaborative Plans"- areas such as industrialisation, agricultural modernisation, infrastructure, finance, green development, trade and investment, poverty reduction and public welfare, public health, and peace and security. Naisbitt *et al.*, (2017) China's commitment to building roads, infrastructure and communication in other countries of the B&R networks go beyond development. Based on experience, China understood how critical its road and infrastructure network was to foreign investors over the past three decades of opening. Without the government investment in transport networks, investors simply would never have come to invest. Xiao and Yabin (2017) agreed that China's investment in Africa infrastructure development has a clear competitive advantage. It offers lower investment costs due to its maturing technological and efficient engineering capacity towards fostering the quality and speedy delivery of the construction project. Lufumpa *et al.* (2017) acknowledged and claimed that Africa's weak physical infrastructure base impeded the region's progress towards an improved living standard, poverty reduction, domestic and international trade and investment, and socially inclusive gross domestic product (GDP) growth. Dreher et al. (2017) claimed that between 2000 and 2014, about 4,304 projects worth approximately U.S.$351 billion has been financed, implemented or completed by the Chinese development project agency. Naisbitt *et al.*,(2017) The Belt and Road (B&B) Initiative is China's 21st-century project for new world order and global governance. It gears towards creating new economic infrastructure, new trade routes, and a new balance in global relationships. Naisbitt *et al.*,(2017) The B&B project will become an engine of growth for China, and it will feed the demand of developing neighbours and provide infrastructure for the regions along its routes.

4. Discussion and Conclusions

Thus, the researchers acknowledged that since the 1960s and now, the African continent infrastructure deficit and lack of strong economic and regional integration. There is a huge obstacle in its transformational agenda for regional integration in their areas such as transportation network, water and power supply, information and communication technology, trade and industry. The inadequate infrastructure and economic integration within the regional and related issues have stalled its potential for global competitiveness, local industrialisation, eradication of poverty, and the realisation of its development agenda towards reducing poverty, increasing economic growth, and attaining sustainable

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development goals. The research survey and analysis indicated various factors such as weak institutional and administrative capacity; inadequate financial framework and capacity; and inadequate technical competencies; lack of robust regional governance; and the inability of the African Union Commission (AUC) and the Regional Economic Communities (RECs) to the coordination of efforts among its member of the states towards infrastructure integration and economic development are the major obstacles hindering its African continent, the prospect of stable economic development, regional economic integration and infrastructure development. The research analysis has highlighted the potential opportunity for Africa towards realising its development agenda as the 21st century has ushered in the new world order from the East- China's Belt and Road (B&R) initiative. China's B&R seems to be a beacon of hope as it beams its light for the African countries and the African Union to strategically and collectively tackle its issues of underdevelopment, poverty, inadequate human capital development and skills, economic turmoil, unnecessary segregation among the nation-states, war and infrastructure deficits. China's B &R is highly profited oriented. However, it strives for win-win development strategies; as it understands and acknowledges that empowering developing a region such as Africa through infrastructure development-transportation and seaports, economic and industrial zones, sharing and the transfer of technology and managerial and technical competencies would deepen their global market and cooperation, and positive influence.

Thus, the research concluded and recommended that the numerous regional and bloc structure and a framework within the African continent, such as the African Union Commission (AUC) and its Regional Economic Communities (RECs) is a strong strategic tool to holistically plan and negotiate African infrastructure development and integrated regional and economic development. The AUC and RECs should present a common front towards developing and negotiating its strategic infrastructure development needs with China's B& R project. This approach can transform the landscape of the African continent in areas of advanced and integrated transportation, power, energy, electricity, water, skills, ICT capacity, governance, industrialisation, and poverty reduction. Also, for the continent to create readiness for the 4th industrial revolution's challenges whilst increasing the purchasing power and social mobility among its citizenry.

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Proceedings of the DII-2021 International Conference: "Building Smart, Resilient and Sustainable Infrastructure in Developing Countries"

DII-2021-025

On-Time Delivery of Residential Property Development Projects in Gqeberha, Eastern Cape

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Abstract

This study was to identify core issues that need to be addressed to minimise and mitigate the effects of delays/on-time delivery in property development projects. The main aim was to investigate the factors influencing the successful completion of property development projects for property developers. The empirical study was conducted using a quantitative statistical approach by distributing 100 research questionnaires. Only 62 valid responses were received, representing a 62% response rate to members falling within the sample population: clients, contractors, real estate companies and consultants within the property development sector, respectively. The sample population was limited to the Built Environment Professionals registered with the South African Council for Project and Construction Management Professions (SACPCMP) and the Association of South African Quantity Surveyors (ASAQS) as well as Stakeholders in the property development industry in Gqeberha, Republic of South Africa (RSA). Variables such as political factors were found to affect businesses, including government policies and tax laws. Economic factors such as inflation rate, market demand, interest rates, and the disposable income available to end consumers were found to impact business profitability directly; one social factor that affects the market performance of a housing project was the brand name of the developer. Legal factors: the laws that govern the use and development of land give landowners great relief in deciding how to use the ground, but this relief goes with restrictions. Therefore, the named variables are shown to influence the perceived on-time delivery of property development projects. This study will assist project stakeholders with measures to identify and mitigate the effects of factors affecting the successful completion of property development projects.

Keywords: Construction; residential property development; Project management; on-time delivery

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1. Introduction

Property development is understood as an integrated process that revolves around numerous components that link distinct phases in the development cycle and involve a combination of significant production factors: land, labour, capital, and enterprise (Abrey, 2014). With the widely publicized project failure rates and related cost overruns, more property entrepreneurs are turning to approaches that may help them improve their project management practices (Jugdev and Thomas, 2002; LaSalle, 2013). Many property organisations make projections on their operations and processes to plan, manage and complete their projects successfully (Ibbs and Kwak, 2000). As such, project managers in the property industry play a crucial role; not only in the operational activities of architectural, engineering construction and property development companies (Edmun-Futwe *et al.*, 2000), but also in facilitating the entire process to meet the needs and the expectations of the people involved in, or affected by, project activities (Schwable, 2015) and the development of infrastructure in every country (Edmun-Futwe *et al.*, 2000).

Inuwa *et al.* (2014) state that features of project management failure characterise property developers' performance. These emanate from abandonment, cost and time overruns, poor workmanship, poor management capability, financial difficulties, poor planning and budgeting, poor mechanisation and a high frequency of litigation. Moreover, in their study, Olatunji (2010) found that property development projects fail due to developers' poor performance, incompetence, inexperience, poor planning and budgeting, and the adoption of traditional management approaches, which have proved to be ineffective in the management of property development projects. However, Olatunji (2010:) posits that factors causing property development delays differ from country to country due to different prevailing conditions. Nonetheless, the South African construction industry lacks literature focusing on property development project failures or success. Hence, the study aimed to examine if political, economic, social, and legal factors influence the completion of property development projects within the timeframe in Gqeberha (formerly known as Port Elizabeth), South Africa (RSA). We Present these factors in an empirical framework (Figure 1), in which we assume that all variables may have a potential significance on the on-time delivery of residential property development.

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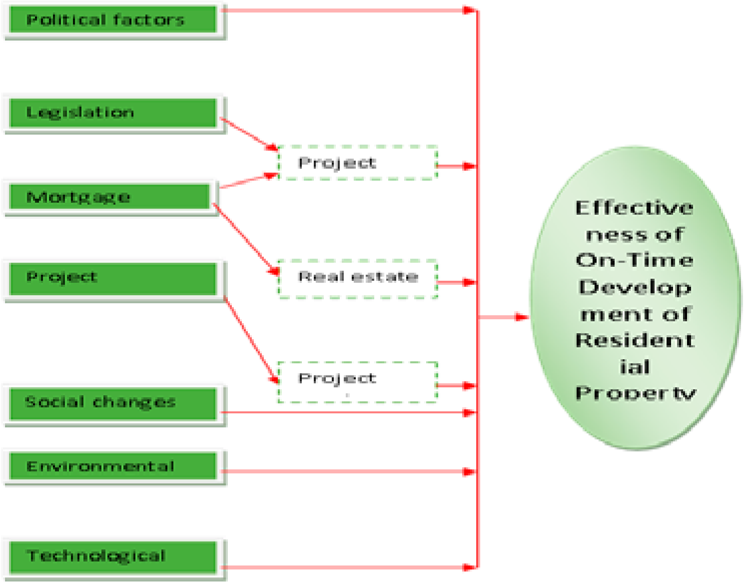

Figure 1.: Empirical Framework depicts that all variables play a significant role in the on-time completion of residential property projects in Gqeberha.

Following on this introduction, the paper will present the review of the literature; theoretical framework upon which the research question hinges; the research material and methods that were used to undertake the study/collect data; a presentation of the results as well as the discussion of the results and how they link to the literature. Finally, we present a conclusion and suggests areas for further research.

2. Literature Review

2.1. Problems facing property developers

According to Giezen (2012), sometimes things are not as simple as they seem, and sometimes, they are not as complex as they seem, either. Projects make up a significant portion of work in most business organizations or enterprises, and successfully managing these projects is crucial to an enterprise's success (Schwalbe, 2015). However, according to Mahmood *et al.* (2006), from the beginning of the 1990s, the business climate in the property development industry has witnessed unprecedented dynamic changes as organizations

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respond to increasing competition within a stagnant or declining market. Hence, the industry's procurement methods also changed, with clients allocating more significant risks to property developers (Mahmood *et al.*, 2006).

Property developers increasingly find themselves accountable within such a changing industry climate, not just for the project's technical content. Moreover, property developers are also confronted by issues that have traditionally not been part of their responsibility (Mahmood et al., 2006; Edmun-Futwe and McCaffer, 2000). Sometimes, they pay penalties that increase overall project costs. Thus, firms turn to project management as part of their competitive advantage strategy (Jugdev and Thomas, 2002). Every construction project has the following constraints: time, cost, and quality in property development (Owour, 2016). The mismanagement of time could harm the project's outcome concerning cost and quality (Olatunji, 2010). However, Liu *et al.* (2004) suggested that the development of property entrepreneurs is dependent on the sustainable improvement of the performance of property development companies in the industry rather than on the increasing number of practitioners. Thus, research should be undertaken to explore the relationship between performance against standards and the effectiveness of property entrepreneurs' performances in the workplace as perceived for property development to improve.

2.2. Task categories in the property development process

In each stage of the development process, numerous tasks must be completed to achieve the desired increase in value and move on to the next stage in the process (Venter, 2006). For the Development matrix, these tasks have been separated into eight broad categories that have various required specific tasks (Botha, 2013); acquisition, financing, market studies and marketing strategies, environmental, public approvals, improvements, transportation and accessibility, and disposition.

2.3. Problems facing the provision of residential property

Problems faced in the provision of property by the government are problems of plan implementation, a lack of adequate data relating to the magnitude of the problem due partly to the absence of a national data bank on the property, inconsistency in government policies and programmes, lack of efficient and sustainable credit delivery to the property sector, relatively low income in comparison with property market prices, the high cost of building

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materials, the rapid annual growth rate of the population, a lack of effective coordination among property agencies, and the politicisation of property issues (Ajibola *et al.*,2012; Kouski *et al.*,2005). Botha (2013) further states that the impediments to affordable residential property are also due to the rise in property construction cost, land tenure, land acquisition process, cost of registering land title, town planning regulations and building bye-laws guiding urban land development. Other factors include the high cost of land survey and building approval processing, the ever-increasing cost of building materials, lack of infrastructure, securing loans, and higher cost and the pace of building a residential property. Additionally, Ajibola *et al.* (2012) specifies that the challenges in providing affordable residential property for South Africans include legislation, registering of property, risk sharing, absence of a national credit database, a stable macro-economic environment, the knowledge gap, dealing with licenses, taxes, enforcing contracts, the high cost of building materials, and infrastructure. However, residential projects make up a significant portion of work in most business organizations or enterprises. Thus, successfully managing these projects is crucial to an enterprise's success (Schwalbe, 2015) and could benefit residents of RSA.

2.4. Feasibility and viability study for development to avoid unforeseen delays

A feasibility study in property development is very crucial. It assists in showing the same characteristics as those of problem-solving in general, constituting an attempt to match the determining elements of the context in which the problem arises and the suggested solution. Moreover, Bryson and Lombardi, (2009) mention that suggested development is sometimes restricted by a lack of resources such as finance and time available to the investor. The ultimate objective of a feasibility study is to evaluate the available applicable information and compare this with the development objectives (Cadman and Topping, 2004). Therefore, it is not a plan of action guaranteeing success but only a systematic evaluation of development opportunities and restrictions (Buitelaar, 2004).

2.5. Operationalisation of variables

The Literature on this paper focuses on issues affecting the on-time delivery of projects. Variables such as Political factors, Economic factors, Social factors, and legal factors have been operationalised:

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Political factors

There are several negative effects regarding the influence that politics has on the real estate market. However, there are continually great improvements in the market from local buyers and internationally (Engel and Volkers, 2012). But even so, property development projects still face several statutory fees and levies (Engel and Volkers, 2012).

Economic factors

Levels of economic growth and poor mortgage availability harm property development as residential mortgages represent 56% of all leading South African households' budgets' (Mukami and Nganga, 2015). Kauskale and Geipele (2017) discussed that it is of great importance for real estate investments and entrepreneurship planning in the construction industry is the business cycle economic fluctuations and real estate market cycles as they influence sustainable development in the country in general. Fluctuation is a term that describes changes in material, labour, plants or equipment market prices in construction. Real estate prices are one of the key indicators of economic activity. Enterprises operating in the real estate industry should consider the business cycle and the real estate cycle and the cycles in the financial markets and the liquidity cycle, as they affect property sales intensity and the number of transactions in the industry.

Social factors

Engel and Volkers (2012) state that a social factor that may affect the market performance of a housing project would be the brand name of the developer, as it takes years of servicing a society by maintaining high standards of work in the process of construction and sale. The supply of property is fixed, so increased demand for property exerts pressure for land to be used more intensively (Real estate article, 2017). Factors such as increasing crime, an ageing population and population growth rates are part of the social dimension. An increase in the ageing population may impact the types of building projects required

Legal factors

The laws that govern the use and development of land in South Africa give landowners great opportunities in deciding how to use land, but this goes with restrictions (Natsvaladze and Beraia, 2018). According to Johnson *et al.* (2014), legal factors embrace legislative and

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regulatory constraints or changes. For example, legal changes might include restrictions on company mergers and acquisitions or new tax treatments of profits earned overseas (Johnson *et al.*,2014). Furthermore, Legal matters of particular concern may include the following (Natsvaladze and Beraia, 2018):

- easements
- access regulations
- water and mineral rights
- zoning and other use restrictions

3. Methodology

For this quantitative study, structured questionnaires were presented to houndred (100) residential property development practitioners, i.e. property project managers, real estate companies and consultants within the property development sector, staff as well as clients and contractors working for property developers, who were randomly selectected due to their availability and willingness. The questionnaires were presented neatly, politely, and concisely, to ensure that the data was not sensitive. The respondents can also relate to the intentions of the research, thereby enhancing the value of the collected data. The research instruments were not unnecessarily lengthy and assured privacy towards respondents. Hence, this was a quantitative study and, thus, the sampling survey engage a simple random sampling technique. This sampling method was used to generate convenient and appropriate sample size for the surveys. The respondents were required to indicate the extent to which they agreed with a statement on a 5-point Likert scale. Out of the 100 questionnaires circulated, only 62 valid responses were received, representing a 62% response rate.

4. DATA ANALYSIS AND INTERPRETATION

4.1. The influence of political factors on the effectiveness of on-time delivery of residential property projects in Gqeberha.

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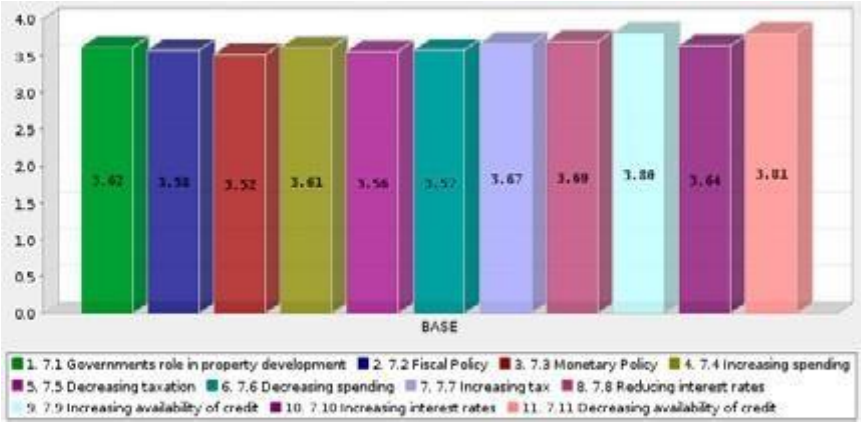

Figure 2: Political factors on residential property

Figure 2. illustrates the results from the respondents based on the effect of political factors on residential property development projects. They believed that political factors have a strong influence on the on-time development of the residential property. The lowest factor was a monetary policy with a mean score of 3.52 and a standard deviation of 0.83, at a confidence interval of ninety-five (95%). However, the highest factor that strongly influenced the on-time completion of residential property development projects was a decreasing availability of credit, with a mean score of 3.81 and a standard deviation of 1.03, sharing the same confidence interval of 95%.

Table I. below had made it possible to distinguish the Mean Score (MS) performance, in the sense that when MS for the above variables was 3.64, meaning that it is > 3.40 but is ≤ 4.20. This means that ranking the influence of political factors on the effectiveness of on-time development of residential property in Gqeberha has a significant difference. Therefore, political factors were found (effective to near highly effective) to negatively impact or influence the on-time delivery of residential property development projects.

Table I: Ranking of influence of political factors on the effectiveness of on-time development of residential property in Gqeberha.

	Variables	**Score**	**Ranking**
1.	Decreasing availability of credit	3.814	1
2.	The increasing availability of credit	3.797	2
3.	Reducing interest rates	3.695	3
4.	Increasing tax	3.667	4
5.	Increasing interest rates	3.639	5

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6.	Governments role in property development	3.623	6
7.	Increasing spending	3.607	7
8.	Fiscal Policy	3.583	8
9.	Decreasing spending	3.567	9
10.	Decreasing taxation	3.559	10
11.	Monetary Policy	3.525	11
	Average	**3.643**	

4.2. The influence of economic factors on the effectiveness of on-time development of residential property in Gqeberha.

Figure 3. below illustrates that the respondents on the effect of economic factors on residential property development projects believed that there is a strong influence on on-time development of the residential property, with the least factor being seasonal fluctuations with a mean of 3.61 and a standard deviation of 1.07 at a confidence interval of 95%. The highest factor was macroeconomics in property development that strongly influenced the on-time development of residential property with a mean of 3.97 and a standard deviation of 1.03 at a confidence interval of 95%.

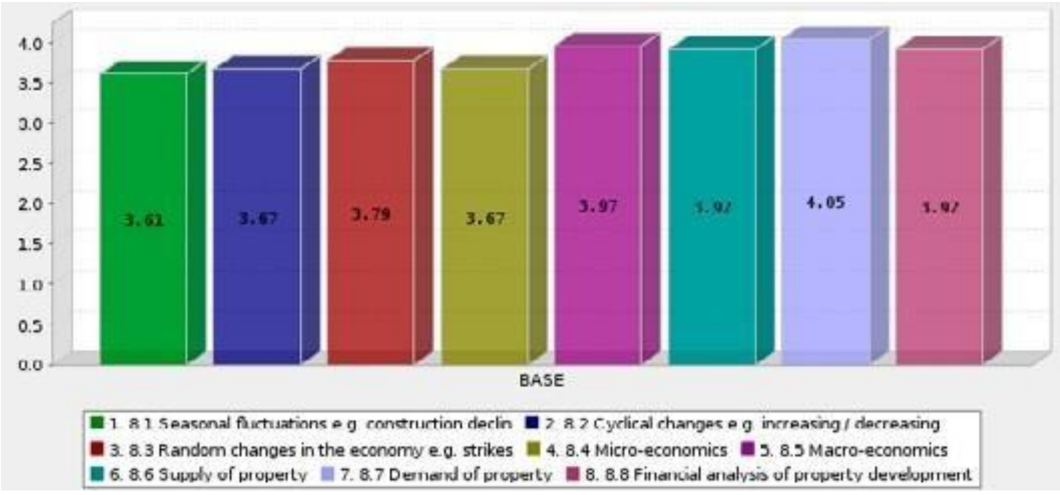

Figure 3.: Influence of the economic factors on the effectiveness of on-time development of residential properties in Gqeberha.

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Table II. below illustrates the performance of the MS in the sense that the average MS for the above variables was 3.82, meaning that it is > 3.40 but is ≤ 4.20. This means that the respondents believed that the economic variables have a significant difference. As a resault, these variables have an influence on the on-time delivery of property development projects. Therefore, from these results, we can depict that economic factors on the effectiveness of on-time development of residential property in Gqeberha play a major role, with the highest-ranking variable being the demand for property.

Table II: Ranking of the influence of the economic factors on the effectiveness of on-time development of residential property in Gqeberha.

S.No	Variables	Score	Ranking
1	Demand of property	4.050	1
2	Macro-economics	3.966	2
3	Supply of property	3.918	3
4	Financial analysis of property development	3.918	4
5	Random changes in the economy, e.g. strikes	3.787	5
6	Cyclical changes e.g. increasing / decreasing	3.667	6
7	Micro-economics	3.667	7
8	Seasonal fluctuations, e.g. construction declines in winter months	3.607	8
	Average	**3.822**	

4.3. The Influence of the following social changes on the effectiveness of on-time development of residential property in South Africa.

Figure 4. below illustrates that social changes in property development strongly influence the on-time development of the residential property, with the lowest factor being social media with a mean of 3.71 and a standard deviation of 1.09 at a confidence interval of ninety-five percent (95%). The highest factors that influenced the on-time development of residential property were urban growth and income patterns in the economy, with the highest mean of 3.97 (rounding up) and a standard deviation of 0.88 at a confidence interval of ninety-five percent (95%).

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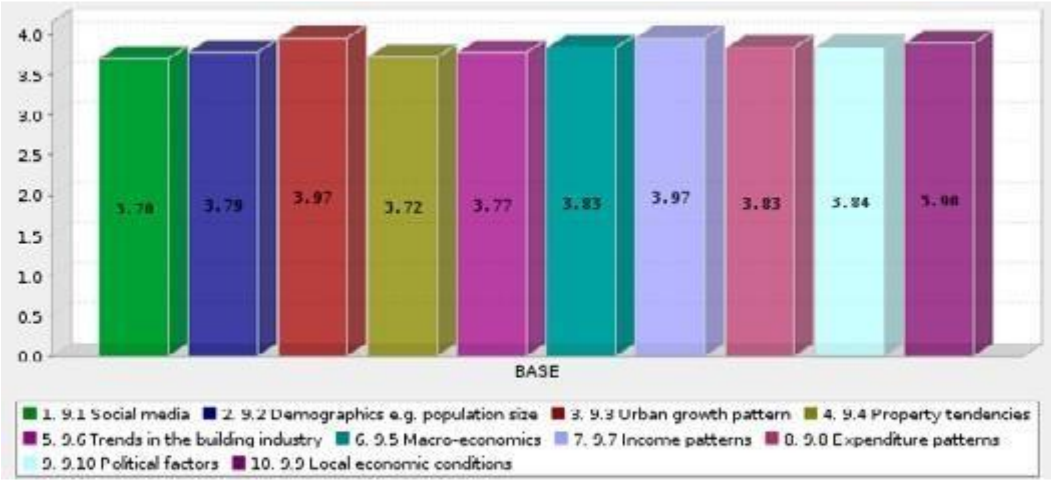

Figure 4: Influence of the following social changes on the effectiveness of on-time development of residential property in Gqeberha.

Table III. below demonstrates the performance of the MS in the sense that when the average MS for the above variables is 3.83, it is >3.40 but is ≤4.20. This shows that the respondents suggest that the above variables are effective to near highly effective influence to on-time delivery of property development projects. By ranking the influence of social factors on the effectiveness of on-time development of residential property in Gqeberha, respondents were able to prove that there is significance difference of social changes on on-time delivary of residential housing with urban growth patterns of credit being the most infuencial followed by income patterns, with a difference of 0.001.

Table III: Ranking of influence of the following social changes on the effectiveness of on-time development of residential property in Gqeberha.

S. No	Variables	Score	Ranking
1	Urban growth pattern	3.967	1
2	Income patterns	3.966	2
3	Local economic conditions	3.898	3
4	Political factors	3.839	4
5	Macro-economics	3.833	5
6	Expenditure patterns	3.833	6
7	Demographics, e.g. population size	3.787	7
8	Trends in the building industry	3.770	8
9	Property tendencies	3.721	9

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10	Social media	3.705	10
	Average	**3.832**	

4.4. Influence of the following legislation issues on the effectiveness of on-time development of residential property in South Africa.

The effect of legislation issues on the on-time delivery of residential property development projects is illustrated in Figure 5. The lowest factor is the transfer of ownership in property development, with a mean of 3.75 and a standard deviation of 1.07 at a confidence interval of ninety-five (95) percent. The highest as perceived by respondents in this regard was conveyancing delays, with a mean of 3.87 and a standard deviation of 1.05 at a confidence interval of ninety-five (95) percent.

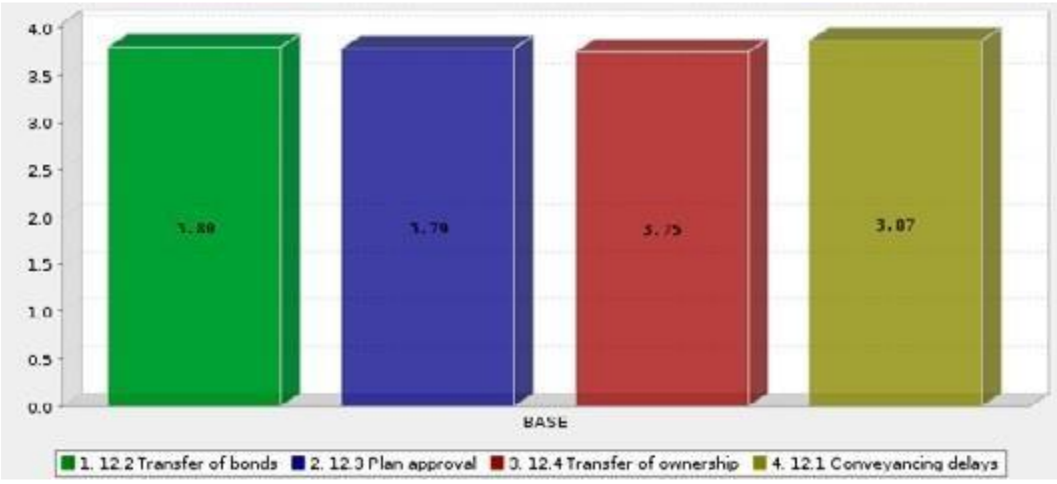

Figure 5.: Influence of the legislation on the effectiveness of on-time development of residential properties in Gqeberha.

Table IV. below has made it possible to distinguish the performance of the MS in the sense that the average MS for the above variables was found to be 3.80, which means that it is > 3.40 but is ≤ 4.20, thus suggesting that further, legislation variables show results of effective to near highly effective on the on-time delivery of property development projects. Therefore, ranking of the influence of legislation issues on the effectiveness of on-time development of

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residential property in Gqeberha appears to have a significant difference as depicted on the table below, the highest-ranking variable in this regard being conveyancing delays at one (1) and the lowest being transfer of ownership at four (4).

Table IV: Ranking of the influence of the following legislation issues on the effectiveness of on-time development of residential property in Gqeberha.

S. NO	Variable	Score	Ranking
1	Conveyancing delays	3.869	1
2	Transfer of bonds	3.803	2
3	Plan approval	3.787	3
4	Transfer of ownership	3.754	4
Average		**3.803**	

5. Discussion

The empirical framework in this study was graphically illustrated in figure 1. From the results, we can depict that all variables have a significant difference on on-time delivery of property projects, with social changes (MS = 3.83) and economic factors (MS = 3.82) being the most influential, followed by legislation and then political factors (MS = 3.643). Out of the 32 factors investigated, the demand of property (an economic factor with MS of 4.050) was the most influential variable, followed by urban growth patterns and income patterns (Social changes factors with 3.97 MS, respectively). These findings could mean that if there is a high/low demand of property, the income is high/low, too, leading to positive/negative urban growth. Alternatively, it could mean that many projects are available with the increased demand for housing, urban growth, and income patterns. Therefore, property development agencies, project managers, contactors, developers, and/or clients turn to have more projects to run than they can handle. Thus, this can lead to delays or failure of completing residential property projects on time.

Although political factors were the least factors to influence the on-time delivery of residential projects, one might consider them to possess as much influence as the economic

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and social changes. This is because monetary policies directly affect income patterns, which in return affects the availability of credit.

Furthermore, it is clear from these findings that all the variables are interrelated, as a change in one variable can make a change in all variables, resulting in either delays or completions of projects within the speculated time frame. These findings are, therefore, in coherence with the findings of the studies mentioned in the literature. Consequently, we conclude that the assumption that political, legislative, social changes and economic factors directly impact the on-time delivery of residential property projects in Gqeberha, as their mean scores fall with a mean range of 3.40 to 4.20. Thus, we adopt the empirical framework.

6. Conclusion and Recommendations

Below are the conclusions and recommendations for political, economic, social and legislation factors:

Political influences

It is apparent from the empirical framework proposes that the political factors have an effective influence on the on-time delivery of property development of residential property in Gqeberha. The research suggested that residential property developers in South Africa should respect political influences, such as the government's role in property development. These include Fiscal Policy, Monetary Policy, Increasing spending; Decreasing taxation, Decreasing spending, Increasing tax, Reducing interest rates, Increasing availability of credit, Increasing interest rates and Decreasing availability of credit to avoid delays that may hinder the completion of property projects on-time.

Economic factors

Clearly, from the results, most of the sample population highly rated the influence of property economics on the effectiveness of on-time development of residential property in Gqeberha. It is recommended that residential property developers in South Africa should consider exploiting property economic factors to include: Seasonal fluctuations; Cyclical changes; Random changes in the economy; Microeconomics; Macro-economics; Supply of property; Demand of property; and Financial analysis of property development before embarking of a property project.

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Social changes

As denoted from the empirical framework, most of the sample population also highly rated the influence of social changes on on-time development of residential property in Gqeberha to have a significant influence that may be positive or negative towards completing a project. Therefore, it would be ideal for residential property developers in South Africa to consider social changes to include: Social media; Demographics; Urban growth pattern; Property tendencies; Macro-economics; Trends in the building industry; Income patterns; Expenditure patterns; Local economic conditions, as well as Political factors in their decision making.

Legislation issues

The information abstracted from the empirical framework and the majority of the sample population highly rated the influence of legislation issues on the effectiveness of on-time development of residential property in Gqeberha. Subsequently, residential property developers in South Africa should consider technological factors: Conveyancing delays; Transfer of bonds; Plan approval and Transfer of ownership when planning.

Although this study aimed to find out if these variables affected the on-time delivary of residential propertys, we also found that these factors may have been related, i.e. a change in one variable changes may bring a change to another. Therefore, we recommend that a study to prove such a theory be conducted. This paper supports the notion that most PESTEL factors harm the on-time delivery of property development projects in Gqeberha, so it should be the same for the country. However, this study was composed of a small sampling population, thus being considered a pioneer study.

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DII-2021-038

The Impact of Indoor Environmental Quality on Building Occupants Productivity and Human Health: A Literature Review

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Abstract

The COVID 19 pandemic has caused a dramatic change in the human lifestyle. This change has had devastating effects on human health and productivity. Currently, people spend a substantial amount of time indoor due to the lockdown of the pandemic. Consequently, the impact of indoor environmental quality (IEQ) on building occupants' health and productivity becomes a crucial area of study which needs urgent attention. Therefore, this paper discusses the critical factors affecting IEQ in buildings and their impacts on occupants. The methodology involves a thorough review and analysis of selected published journals. The search included journal articles, books, and conference proceedings on the impact of IEQ on building occupants from different databases, including ScienceDirect, Taylor, and Francis, among others. Five (5) critical factors influencing IEQ were identified from the 70 reviewed literature. These factors are 'building plan layout, indoor air quality, indoor thermal condition, indoor lighting quality, and acoustic environment comfort'. The impacts of the identified factors on residential occupants' productivity and health were discussed. The current change in the lifestyle in which most activities are done indoors calls for a re-examination of the factors that impact building occupants' health and productivity. This paper provides an understanding of the critical factors affecting building occupants' productivity and general lifestyle. The knowledge of these vital factors will not only assist the construction professionals in their decision-making. Still, it will promote new construction innovations that can improve building occupants' health and productivity.

Keywords: Indoor environmental quality, productivity, well-being, indoor comfort, and occupants health.

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1. Introduction

Human beings continue to strive to create indoor environments wherein they can feel comfortable. This is because most human lives are spent inside a building at home, school, or office. Empirically, previous studies have indicated that more than 80% of human lives are spent indoors (Mujan *et al.*,2019; Al Horr *et al.*, 2016). For instance, students spend a fair bulk of their time in lecture rooms. Employees likewise spend a very large portion of their time in offices.

Moreover, at the end of each day, everyone returns to stay indoors after daily activities. Asmar *et al.*,(2014); Seppänen *et al.* (2006); Schneider (2002), and several other authors have specified a direct link between the physical environment in which students have lectures, learning effectiveness, and student learning outcomes. However, the current universal change from production to a knowledge-driven economy has finely tuned researcher interest in occupant comfort in workplace environments Haynes et al., (2017); Kim and De Dear (2013) for business sustenance and flexibility, innovation, and target goal-driven.

Several studies have been conducted on occupant comfort in office workplaces, which focused on the impact of indoor environmental quality (IEQ) on workers' job satisfaction and productivity. Leaman (1995) noted a significant negative correlation between office workers' higher view of discomfort in IEQ and individual productivity results. In addition, Lipczynska *et al.* (2018) found that individual office staff reported an increase in daily productivity with an increase in thermal comfort based on observation. Other researchers have investigated the possible impact of IEQ on staff productivity and comfort. In a multi-user office setting, Mulville *et al.* (2016) discovered a negative impact between staff frequent occurrences of headache and staff discomfort with noise and IAQ and pick out the impact of IEQ on productivity. Furthermore, De Been and Beijer (2014) found out that staff in multi-user offices noticed a lesser progressive, positive impact of their work environment, Sadick (2020), privacy, and productivity compared to workers in private offices. Hence, it takes as little as a window too high for sunshine, air conditioning too weak for the size of the room, or even a door placed at an indifferent place to distort one's focus in an office or lecture hall.

In recognition of Indoor Environmental Quality's (IEQ) impact on educational facilities' office staff and consumers, universities and schools are increasingly interested in measuring and understanding their buildings' performance. Similarly, considerable attention is being given to IEQ of various building types ranging from residential to institutional, educational, and industrial buildings in western countries and other parts of the world in other to prevent the building occupants from being susceptible to the effects of indoor air contaminants (Liao *et al.*, 1991). Globally, IEQ is generally recognized to have simultaneous effects on people's

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health. It can promote or stagnate people's comfort, productivity, and contentment with their physical environments.

The US Centers for Disease Control and Prevention defined IEQ as the air quality in an office or other building environment (Kubba, 2017; Kibert, 2016). IEQ is a complex issue. It involves a building layout plan, indoor air quality (IAQ), acoustics, thermal comfort, electric lighting, daylighting, and access to outdoors views. Consequently, IEQ is found to affect a full range of human sensory conditions (Yousef *et al.*, 2016; Apte *et al.*,2000). Empirical studies indicated a correlation between headaches, dizziness, tiredness, difficulties concentrating, unpleasant odour, and high Carbon Dioxide concentrations. Mendell *et al.* (2013) (cited in Yousef *et al.*, 2016) further noted a correlation between ventilation and illness-related absence in Californian schools.

This study discusses the critical factors affecting indoor environmental qualities in residential buildings, offices, and tertiary institution-building and their impacts on the general wellbeing of building occupants. This is a literature-based paper and reports the findings of the preliminary literature review, which form the first part of the proposed research. The paper recommends specific green measures that could enhance students' well-being and academic performance that the universities planning departments need to consider during the design and construction of building projects.

2. Literature Review

The term "indoor environmental quality" is an aspect of sustainability that deals with specific issues affecting human life inside a structure during occupancy (Mujeebu, 2019). This aspect of sustainability deals with conditions that typically include indoor air quality (IAQ), views, thermal comfort, lighting, acoustics, etc. Each of these aspects plays a different role to help improve the consumers' comfort and the overall performance of the structure while in occupancy of the building. Research over the past decades has increased industry comprehension of the indoor environment. Consequently, there is a better understanding that improved environmental quality can enhance the quality of life of the building occupants and increase the property value, should resale be an option (Mujeebu, 2019).

Undoubtedly, the impact of IEQ on building occupants has become an important research issue, with guidelines of sustainable design being endorsed by entities from different countries across the world. A notable example is the Leadership in Energy and Environmental Design (LEED™) certified by the United States Green Building Council, wherein architects, engineers, and interior designers are called to satisfy certain IEQ standards in the insides of the structures they design. According to Choi *et al.* (2013), conducting a post-occupancy evaluation (POE) is one recognised way to determine if designs

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to implement IEQ standards are met successfully about one year after the occupation of the sustainable building. Tertiary-wise, conducting such an evaluation survey would reveal students' views on the level of their satisfaction with IEQ of their lecture halls and the influence of IEQ on their learning and, perhaps, its effects on their academic performance.

Previous studies have revealed specific IEQ components which mostly have significant effects on building occupants. The measurement of these parameters will determine workers' and students' satisfaction or otherwise. For this literature review to thoroughly reflect the green building needs to satisfy IEQ, key factors that makeup IEQ must be identified and analysed. The key factors that make up IEQ include; building layout plan, Indoor air condition, indoor thermal condition, indoor lighting quality, and acoustic environment comfort. With the recent increase in the necessity for designing green buildings and the use of green building guidelines globally over normal building strategies, the discussion presented helps establish a link between workers, students' comfort, and health parameters and parameters within green building guidelines.

3. Research Methodology

This study critically reviews and analyses the impact of indoor environmental quality on workers' productivity/health and students' health and academic performance. To achieve the aim and focus of this study, the methodology adopted in this research is purely literature review, which involves the following steps:

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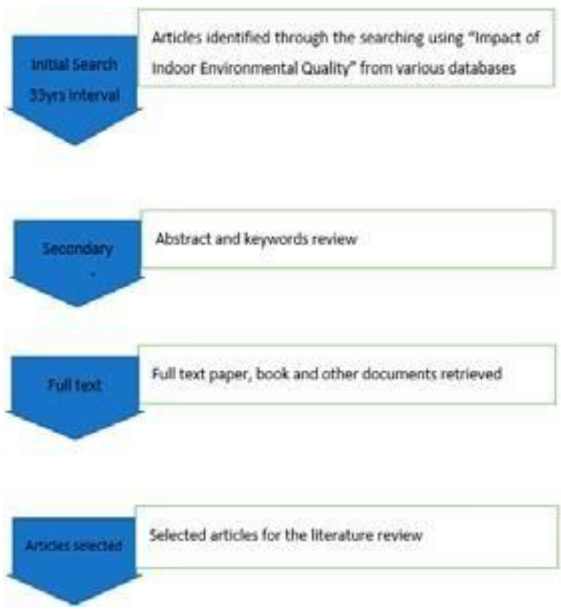

Figure 1. Flow diagram of the searching process and paper retrieval.

After retrieval of the selected articles, which were critically reviewed and analyzed, the result and factors affecting IEQ were itemized, and the impacts were addressed. The review process follows the flow chart shown in figure 1. The final stage involved discussions, conclusions, and recommendations based on the findings from the literature.

4. Research Discussion

4.1. Indoor Environmental Quality (IEQ)

According to The National Institute for Occupational Safety and Health (NIOSH), IEQ is the quality of a building environment, focusing on the interior comfort related to the health and well-being of the occupant within the building (NIOSH 2013). Therefore, enhancing building occupants' health, productivity, and well-being should be crucial in building interior design (Guerin and Martin 2010) as cited in (Bae *et al.*, 2017).

However, several researchers were able to identify the following as major factors influencing the quality of IEQ; building layout plan, Indoor air condition, indoor thermal condition, indoor lighting quality, and acoustic environment comfort in any building (Mujan *et al.*,

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2019; Kang *et al.*,2017; Al horr Y *et al.*, 2016; Haapakangas *et al.*, 2012; Jungsoo and Richard, 2012; Park and Yoon, 2011; Kaarlela-Tuomaala *et al.*, 2009). The quality of those identified IEQ factors was unanimously agreed by researchers as the major factors which influence the quality of IEQ at any building regardless of the building use.

4.1.1 Classification of building

A Building is a complete structure with a wall and roof, built for permanent, dwelling, and business (Daily Civil, 2021). There are different types of buildings such as residential buildings, educational buildings, Institutional buildings, Assembly buildings, commercial buildings, mercantile buildings, industrial buildings, commercial buildings Storage buildings. All these types of buildings are used for different purposes and require levels of IEQ. This research, however, focuses on residential, educational, and commercial buildings

4.2. Factors Influencing IEQ

4.2.1 Building Layout Plan

The availability of interior circulatory space design layout quality is one of the basic influencing factors of IEQ. It impacts the occupants' behaviour, result delivery, and overall performance (Al horr Y *et al.*, 2016). Circulatory space is important in classrooms, offices, and other building types. Two standard office design layouts are; Open-plan (Multi-User) and private offices. The multi-user office houses more persons than a private office, the sharing of the office (Multi-User) eases communication among its co-workers (Kupritz, 2003) as cited in (Kang *et al.*, 2017). The Multi-User office layout lacks visual privacy, which reduces the occupant's working area and increases disruptions and social contacts among its occupants. Furthermore, the multi-user office design layout is an inadequate acoustic environment (Kim and De Dear 2013). Nevertheless, humans' well-being and effective work performance in an office and students in schools cannot be neglected. Researchers were able to itemize the important factors influencing the indoor environmental quality of residential buildings and office layouts. The availability of workspace, interior furniture comfort, ease of occupant movement and equipment, those factors are always put into consideration during the design of residential building and offices, with significant consideration on satisfaction, efficiency, well-being and work productivity of the occupants' (Kim and De Dear 2013; Kim and De Dear 2012).

Furthermore, numerous surveys by scholars were able to disclose that the comfortability of a multi-user office layout is influenced by the work procedures (Kosonen and Tan, 2004), work forms (Haynes, 2008), and the difficulty of the work responsibilities (Maher, 2005). Several researchers developed a design phrase introduced in the last decade to tackle

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presenteeism among workers and students. These include the challenges facing workers or students who carry out their daily tasks while suffering from health problems that reduce productivity or other occurrences that disturb them from total productivity (Centre for Mental Health, 2011; Johns, 2010; Turpin *et al.,* 2004).

The report from research conducted by Shan *et al.* (2018) on IEQ quality amid students revealed that inefficiently set parameters could have an extreme impact on students' cognitive skills. This report could be generally agreed upon for inhabitants' population of the same climatical area. On this note, it could be seen that the quality of the indoor environment extremely impacts peoples' health in their studies, living and working environment. Institution, industry, and home residents must prioritise providing hale and hearty indoor facilities in which inhabitants and staff feel comfortable and enabling environments for prosperity.

4.2.2 Indoor Air Quality (IAQ)

The worth of IAQ is an additional important considerable factor influencing human comfortability, productivity, health, academic performance, among others (Olesen, 2005). Bad IAQ greatly impacts humans' lives, reducing productivity, health imbalance symptoms such as tiredness, headaches, sluggishness, and mental fatigue (Al horr Y *et al.,* 2016; Kosonen and Tan, 2004).

The intensity of air quality inside of a building tends to have an impact on IAQ. Varjo (2015) noted intensity as an important factor influenced by the ventilation frequency within the building and means of gaseous emissions from the building and live load (occupants, furniture, and equipment). Nevertheless, Kang *et al. (2017)* thought that increasing ventilation within the building effectively improves the IAQ level. Sundell *et al.* (2011) carried out a thorough literature review on the consequence of ventilation rates on human health. Their study revealed that an increase in ventilation rate would reduce the human symptoms in an office if the rate can make up to around 25L/s per individual.

In addition, the experiment studies carryout by Park and Yoon (2011) and Kang *et al.* (2017) showed, if the rate of ventilation in a building is higher, it tends to reduce the percentage of inhabitants displeased with the air quality in the building, which in-return boost the dwellers' efficiency. Nevertheless, occupants in any building perceive air freshness circulation in a building has a substantial positive contentment relationship with the IAQ.

The investigation performed by Knasko (1993) concluded that irritation from odours has a negative consequence on occupant mood, task performance, and health condition. Furthermore, studies performed by Micheal *et al.* (2005) and Danuser *et al.* (2003) further

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agreed with their conclusion. They revealed that ambient unfriendly odours could affect the amount and time required for visual attentional capture performance reasoning tasks and the rapidity of the data process. In addition, Gaygen and Hedge (2009) believed that introducing deodorant to improve IEQ for office and hostel occupants' productivity may not significantly impact all areas of work performance as expected. The measurement of the following parameters of IAQ is the basis for checking indoor air quality: available oxygen, carbon monoxide, air temperature, relative humidity, levels of particulate pollution, carbon dioxide, ozone, nitrogen dioxide, sulfur dioxide, volatile organic compounds, ammonia, and air velocity within the building (Mujan *et al.*, 2019). These parameters influencing IAQ with their allowable tolerances in some regions are listed in Table I. In addition, the following conditions surrounding the building location also affect these parameters (sulphur dioxide, nitrogen dioxide), the design/construction of the structure, the heating, ventilation and air conditioning system, the building layout, work, and life progressions.

The two common approaches in building design that are engaged to control the indoor air quality in a building are; utilizing ventilation frequency, which decreases air impurity (Al horr et al., 2016); reducing or completely getting rid of pollution sources inside outdoor of the building. This will help in reducing the incoming pollutants in the indoor air.

Empirical studies have proven that an increase in outdoor air supply paces in residential, office environments will enhance air quality and decrease the intensity of air pollutants (Park and Yoon, 2011; Wargocki *et al.*, 1999; Liao *et al.*, 1991). The biological, chemical and physical investigation must be conducted to acquire a complete IAQ for any building (Bluyssen, 2004).

Table I: Parameters influencing indoor air quality and their utmost permissible tolerances for humans accepted in different World regions

Parameter		**Region** **USA**	**EUROPE**	**CHINA**	**JAPAN**
Air temperature	LIMIT REFERENCE	22.5-26°C in summer 20.0-23.5°C in winter ANSI/ASHRAE	22-27°C in summer 20-23°C in winter WHO	22-28°C in summer 16-24°C in winter AQSIQ	17-28°C MHLW
Relative humidity	LIMIT REFERENCE	40-60% in summer 30-60% in winter ANSI/ASHRAE	25-45% WHO	40-80% in summer 30-60% in winter AQSIQ	40-70% as 8-h MHLW

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air velocity within the building	LIMIT REFERENCE	0.25 m/s WHO	0.25 m/s WHO	0.3 m/s in summer).2 m/s in winter AQSIQ	0.5 m/s MHLW
Ventilation (external air)	Recommended according to the space or number of occupants depending on the type and purpose of the facility.				
Carbon dioxide	LIMIT REFERENCE	8h outdoor ambient 50 000 ppm <700 ppm ASHRAE/ACGIH	1h 8h 24h 10 00 ppm 5000 ppm 1000ppm WHO/MAK	24h 1000 ppm AQSIQ	24h 1000ppm MHLW
Carbon monoxide	LIMIT REFERENCE	1h 8h max 35 ppm 9 ppm 200 ppm ASHRAE/OSHA/EPA	30 min 8h 50 ppm 30 ppm WHO/MAK/HSC	1h 10 $\mu g/m^3$ AQSIQ	1h 20 ppm MHLW
Formaldehyde	LIMIT REFERENCE	30min 1h 8h 0.081 ppm 76 ppb 27 ppb SHRAE/OSHA/EPA	5 min 30 min 8h 1 ppm 0.081 ppm 0.03 ppm WHO/MAK/HSC	1 h 0.08 ppm AQSIQ	5h 0.08 ppm MHLW
Nitrogen dioxide	LIMIT REFERENCE	15min 1h 1yr 5 ppm 3 ppm 0.05 ppm GGIH/NAAQS/EPA	1h 1yr 0.1 ppm 0.02 ppm WHO/MAX	1h 1yr 240 $\mu g/m^3$ 80 $\mu g/m^3$ AQSIQ, SEPA	No current consensus
Ozone	LIMIT REFERENCE	1h 8h 0.1 ppm 0.05ppm SHRAE/OSHA/EPA	8h max 0.064 ppm 0.05ppm WHO	1h 0.1 $\mu g/m^3$ AQSIQ	No current consensus
Sulphur dioxide	LIMIT REFERENCE	8h 1yr 2 ppm 80 $\mu g/m^3$ ASHRAE/OSHA/EPA	1h 24h 1yr 0.133 ppm 0.048 ppm 0.012 ppm WHO/MAK	1h 0.5 $\mu g/m^3$ SEPA	No current consensus
Total volatile organic compounds	LIMIT REFERENCE	No current consensus	8h 300 $\mu g/m^3$ UK	8h 0.6 AQSIQ	No current consensus
Particulate matter less than 2.5 um in size	LIMIT REFERENCE	8h 24h 1yr 3 $\mu g/m^3$ 35 $\mu g/m^3$ 15 $\mu g/m^3$	24h 1yr 25 $\mu g/m^3$ 10 $\mu g/m^3$ WHO/MAK	No current consensus	No current consensus

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		SHRAE/OSHA/EPA			
Particulate matter less than 10 um	LIMIT REFERENCE	8h 24h 1yr 10µg/m^3 150 µg/m^3 50 µg/m^3 ASHRAE/ACGIH/EPA	8h 24h 1yr 4 µg/m^3 50 µg/m^3 20 µg/m^3 WHO/MAK	24h 0.15 µg/m^3 AQSIQ	No current consensus
Total suspended particles	LIMIT REFERENCE	8h 15 µg/m^3 OSHA	No current consensus	No current consensus	No current consensus
Extremely fine particles <1.0 microns	LIMIT REFERENCE	No current consensus	No current consensus	No current consensus	No current consensus

Source: Mujan *et al.,(*2019)

4.2.3 Indoor Thermal Conditions

Indoor thermal condition (ITC) is associated with the degree of air in circulation within the building. This plays an important role in the comfort level that the inhabitant drives, thus directly impacting occupant work productivity (Al horr *et al.*, 2016; Li *et al.*, 2011) and occupants' satisfaction within the building environment (Humphreys, 2005).

A survey report by Humphreys (2005) conducted in 26 multi-user offices in Europe reveals the level of inhabitant contentment with indoor temperature, which was identified as a critical factor to their satisfaction with the IEQ. Furthermore, Mark and Lul (2012) surveyed Hong Kong; the result of their survey affirms that the degree of indoor temperature comfort has a notably positive relationship with work productivity and inhabitant satisfaction. Researchers then gathered that workers' performance tends to drop down if the room temperature rises from the acceptable room temperatures (i.e., 21 to 25℃) to higher ones (over 26℃) (Lan *et al.*, 2011; Hygge and Knez, 2001).

In addition, research conducted by Maula *et al.* (2016) indicates that unsuitable high temperatures negatively impact occupant concentration, mood, and motivation for work. Nevertheless, thermal comfort is determined by six factors grouped under four environmental factors (mean radiant temperature, relative humidity, air velocity, and air temperature) and two human personal parameters (human rate of metabolic and means of insulation via clothing). These are used to determine the index of PMV, known as the thermal comfort forecast model (Katafygiotou and Serghides, 2014; ISO 7730, 2005).

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The six factors should be considered during the design stage of the building (Steemers *et al.,* 1992) as cited in (Al horr *et al.,* 2016). Based on the standard, the PMV model offers a benchmark and well-organized method for the assessment of the building internal thermal comfort, which designers use as a standard for building and generally accepted by the international standard (ISO 7730, 2005), BS EN ISO 7730, (2005) and ASHRAE 55, (2013). Furthermore, it should be noted that climatic conditions, age, gender all significantly impact the ITC perceived by the inhabitant. In addition, to accurately analyse thermal comfort, psychological and physical aspects ought to be considered (Al horr *et al.,* 2016; Lin and Deng, 2008).

4.2.4 Indoor Lighting Quality

lighting is an essential requirement in a building. Thus, its quality influences inhabitants' visual comfort, health and productivity output. Those impacts cannot be neglected. Natural lighting (daylight), the primary source of indoor lighting, is the ideal source of light that proffers the best lighting for human visual and aid comfort without affecting human sight. Researchers (Bommel and Beld, 2004; Nagy *et al.,* 1995) reported that natural lighting from doors, windows and any other opening in the building poses more importance to the occupants' comfort more than its primary requirement for view and light, it also has an impact on occupants' psychological needs. Non-natural lighting is an alternative vital lighting mode in a building.

The system of artificial lighting is designed to enhance clear visual activities in the absence of natural light. For instance, in the case of a multi-user office; where the non-natural (artificial) indoor lighting is well designed with high-quality lighting. Researchers were able to affirm that it has a beneficial impact on the occupants, which relieves inhabitants' tiredness, eye glare symptoms, and improves productivity (Haapakangas *et al.,* 2012; Kowalska *et al.,* 2011 and Baron *et al.,* 1992). Although, the type of artificial lighting design used in the building affects the total electrical energy consumption and occupants' comfort (Kang et al., 2017). Nevertheless, artificial lighting has an impact on occupants if the lighting is over-design or under-design. Occupants is liable to be uncomfortable when their indoor lighting is not properly designed (Galasiu and Veitch, 2006).

The occupants' indoor lighting satisfaction in an office environment is affected by the nature of activities done in the offices (Jennings *et al.,* 2000; Yamakawa *et al.,* 2000). For instance, staff whose major task is on the computer will like reduced light levels than those not working (Escuyer and Fontoynont, 2001). Similarly, Jennings et al. (2000) disclose that graphic designers prefer lesser light levels than lawyers in their research. This is because the designer would need to do most of their work on the computer.

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4.2.5 Acoustic environmental comfort

The acoustic environment comfort of a building is the ability to safeguard its inhabitant from noise pollution, thereby offering an acoustical environment that suits the primary purpose of the building design (Giannakourou and Balla, 2006). Landstorm *et al.* (1995) reported that acoustic comfort and occupant productivity directly connect in commercial buildings. Although Sundstrom *et al.* (1994) reported that the growth in multi-user offices staff has led to problems related to acoustic discomfort and lack of privacy in the building, it was acknowledged as important issues affecting staff productivity and drive to work effectively.

Notwithstanding, Andersen *et al.* (2009) and Anderson (2008) reported that the recognition of acoustic comfort as an important parameter in indoor comfort needs urgent attention. Their report indicated that the built professionals do not give high priority to acoustic comfort during building design. This negligence towards IEQ is what leads to various negative impacts encountered by the building occupants. Those negative impacts affect productivity and health-related problems of the inhabitant. Moreover, acoustic issues are originated from outdoor noise. The sources could be furniture and equipment, airborne sounds, noise from indoor facilities (Al horr *et al.,* 2016).

Nevertheless, quite a lot of research; (Lee et al., 2015; Mark and Wang, 2015; Kim and Dear, 2012; Mak and Lui, 2012; Smith-Jackson and Klein, 2009) concluded that poor indoor acoustic state cause detriment to building inhabitants. This leads to a decrease in work productivity, job dissatisfaction and also health-related problems. However, some researchers were able to identify two main factors causing problems related to indoor acoustic quality: disturbance from noise (Lee *et al.*,2015; Kim and Dear, 2012) and absence of communication privacy (Hygge and Knez, 2001; Landstorm *et al.,* 1995).

Nevertheless, the intensity, range, and time difference in which noise has been generated may influence the degree of disturbance. Furthermore, human action noise, irregular sounds, uncontrolled conversation, and different telephone ringing may increase the inhabitant's level of disturbance and annoyance (Veitch *et al.,* 2002). Low noise intensity is a major requirement for occupant satisfaction in a building (Kim & Dear, 2012). Therefore, those undesirable negative impacts generated by noise are caused by several factors, such as the forms of noise and demographic factors of the inhabitant (Kaarlela-Tuomaala *et al.*,2009; Venetjoki *et al.,* 2010, Mak and Lui, 2012; Ou, 2015).

It was reported by several field research and laboratory experiments that high speech privacy definitely would decrease the negative impact of inappropriate speech noise and efficiently improve inhabitant productivity (Haka *et al.*,2009; Venetjoki *et al.*,2006; Hongisto, 2005).

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Notwithstanding, to effectively control the problems of acoustic discomfort at the design stage, built professionals should check the indoor purpose which the building will serve and outdoor activities around the building environment (Bluyssen *et al.,* 2011). Therefore, indoor acoustic problems need urgent attention, which should be tackled at the building design stage.

5. Conclusion and Recommendation

This study examined the indispensable contribution of the current published retrieved literature on “indoor environmental quality”. The article brings to light the 5 important crucial factors influencing inhabitant well-being, environmental satisfaction, comfort, work productivity in offices, and occupant health:

(1) building layout plan; the orientation of the build is of high importance as occupants' opinions rest on the facilities available such as personal circulatory space, equipment, proximity to natural air and furniture comfort.

(2) Indoor air quality; dwellers' satisfaction is directly related to the quality of air freshness, positioning of the window to access natural air, and artificial ventilation means.

(3) thermal comfort; the physical parameters associated with thermal comfort are relative humidity, indoor air velocity, and temperature.

(4) light quality; the major key determinate factor associated with indoor light quality are artificial lighting and natural lighting, those two controls the level of comfort in a building.

(5) acoustic comfort; noise is the major disturbance that hinders occupant comfort in academic, office, and residential environments.

However, all the articles consulted were in agreement with those factors. In place of this, there is no mistrust about these five factors being the primary influencer of indoor environmental quality that typically influence occupants' well-being, comfort, and productivity in any building. The majority of those factors can be addressed from the building design phase through well planned M&E operating system. The elaborate interconnectedness amid those five IEQ influencer factors has been examined.

It has been justified that those factors significantly impact occupant well-being, productivity, health and influence student academic performance. The article explained the negative impact of IEQ on human feelings and reactions to work in an indispensable working environment, illustrating how they respond to a dissatisfied state of poor air quality and thermal comfort for the occupants. More reasons for those five factors must be examined

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logically to secure an adequate understanding of the indoor environmental quality within the built environment. In conclusion, Table I. shows the parameters influencing indoor air quality and their maximum permissible tolerances for humans, accepted in different world regions.

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DII-2021-033

Evaluation of Current Maintenance Management Systems Adopted in South Africa: A Case Study of Public Facilities

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Abstract

Public facilities in most South African provinces are poorly managed due to several known and unknown factors. This paper seeks to evaluate the maintenance management system adopted by municipalities to identify the underlying factors that militate against implementing a developed maintenance system. An exploratory design and a case study research approach were embraced. Qualitative data were collected utilising a semi-structured interview from facilities and maintenance managers within the municipalities. A total of 30 participants were targeted and scheduled for an interview. However, only 25 (i.e. 83.3%) availed themselves of the interview. Thematic analysis was used to analyse the collected data. The findings revealed that poor implementation of maintenance management systems n public facilities leads to faster deterioration of facilities. Moreover, it became evident that deteriorated facilities increased cost burden, maintenance backlog, and safety risk. The findings also show that the maintenance systems of the municipalities were poorly implemented. Lack of implementation results from lack of resources (manpower and equipment), the inadequacy of funds, lack of expertise, lack of leadership, lack of staff training, lack of maintenance departments or poor maintenance structures and lack of security system. No earlier research has thoroughly investigated the underlining factors hindering the implementation of the maintenance system of municipalities n the South African context.

Keywords: Building maintenance, facility management, maintenance management system, municipalities, South Africa

1. Introduction

Facility maintenance is identified as an area that has been given little attention n most public facilities n South Africa, thus resulting n quicker deterioration (Noorliza, Muhammad, Hassan and Hayati, 2014). Most public structures are often inadequately maintained where building elements (walls, windows, roofs, doors, floors.) and facilities frequently lack maintenance and repair. Some residential and office buildings of public institutions have not

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seen any significant maintenance or shown minor signs of maintenance since they were constructed, some dating back to the colonial era. This has resulted in facilities being n a dilapidated state, with some being abandoned. The neglect of the facility maintenance s attributed to several factors. Poor planning, improper maintenance systems and lack of expertise affect government facilities maintenance negatively (National department of public works, 2006).

Additionally, Kovacevic *et al. (*2016) believe maintenance errors occur due to inadequate implementation of maintenance management systems caused by a lack of expertise of maintenance personnel. The consequences of neglecting facility maintenance are less visible n the short term, and as a result, managers tend to short-sightedly cut down maintenance budgets (Adamu and Shakantu, 2016). inadequacy or shortfall of budgets for maintenance, f not significantly increased, will constantly result in lower service level standards or the government having to incur high costs to replace/upgrade facilities or equipment shortly (SALGA, 2013). Cloete (2002) also noted that the maintenance of buildings and incorporated facilities n many government organisations are perceived as less critical than construction or procuring new facilities. This is indicative that the government put more effort into procuring new facilities whilst the maintenance of existing facilities s neglected. However, it is critical to implement an effective maintenance management system to ensure that facilities continue to perform their purpose, keep the aspects that make them functional, retain their worth, and make them more enjoyable and safe to use (Basari *et al.*, 2013). Maintenance works must be proactive, effective, and efficiently managed (Choka, 2012). Availability of resources and allocation of equipment, budget, personnel, facilities condition report and maintenance strategy plays a huge role n achieving the efficiency of public facility maintenance management system and improving ts conditions (Mojela, 2013). There is ample literature about maintenance management systems of public facilities; however, many focused on the particular department of government facilities, e.g. schools, universities and hospitals. Moreover, studies that have investigated the underlining factors hindering the implementation of the maintenance system of municipalities n the South African context s minimal. Thus, this study evaluates factors hindering the performance of the maintenance system of municipalities n South Africa.

2. Overview of Maintenance

Maintenance, n general, has different meanings to different people. According to Kovacevic *et al.* (2016), maintenance means neutralising lost performance to the extent that the lost performance s acceptable. Whether this loss s “acceptable” or not depends on the standards set by the owner and the user (Kovacevic *et al.*, (2016). On the other hand, Olanrewa *et al. (*2010) perceive maintenance as a process carried out to preserve, repair, protect and care for building or plant/equipment components so that they can perform their intended functions. n this paper, maintenance s described as the processes and services required to conserve,

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protect, and maintain facilities to continue to fulfil their intended functions and offer a safe environment for users throughout their life span. The value and importance of facility maintenance cannot be underestimated. Maintenance begins the day the builder leaves the site or the day the facility s handed over. The design and selection of materials, workmanship, function, use and their interrelationships determine the amount of maintenance required during the facility's life (Olagunju, 2012). The neglect can lead to the rapid increase of deterioration of the elements and finishes of the facilities (Jortberg and Lemer, 2010). Therefore, proper maintenance helps to minimise deterioration, defects, degradation and failure, ensuring optimum performance during their life cycle and providing value for the user's commitment and enhancing the community's perception (Abdul *et al.*, 2010). The table below shows the potential consequences of the neglect of facility maintenance.

Table: Potential consequences of the neglect of facility maintenance

Potential implications of poor facility maintenance	**Example of the consequences**
Threats to health and safety	• Deterioration of health • Safety failure • Structural failure
Services failure	• Loss of service power • Failure of heating, ventilation, and air-conditioning
Excessive cost	• Cost of energy • Domino effect– Minor failures leading to major failures • Cost of replacement vs cost of repairs • Production losses • Assets losses (facility content)
Cost to society	• inability to recruit and retain workers • Lack of morale • Neglected mage • Lack of preparedness

Source: Jortberg and Lemer (2010:9)

3. Maintenance management systems

A good maintenance management system requires a lot of technical labour and competent individuals (Blessing *et al.*, 2015). t entails planning, implementing, regulating, and evaluating the facility's maintenance performance (Blessing *et al.*, 2015). t s, therefore, crucial to have an effective maintenance management system n place to ensure that

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maintenance costs are kept low. That maintenance personnel can do maintenance effectively. According to Bothma and Cloete (2000), the following are some of the immediate advantages of a properly established maintenance management system:

- Strategic maintenance planning
- System of distributing limited resources against priorities
- Maintenance plans and schedules that are formalized
- Accurate zero-based budgets Actual maintenance expenditures
- Facilities records
- A record of facilities current state/condition

An adequately integrated maintenance management system will also bring the following long-term benefits, according to Bothma and Cloete (2000):

- A shift from unscheduled maintenance to planned maintenance
- Long-term maintenance cost savings
- Lower life cycle cost
- increased facility availability and safety
- Shorter downtime and backlog.

Therefore, government/municipalities need to develop and implement an effective maintenance system to improve public facility maintenance. According to Abdullah *et al.* (2015), the following are factors that make up a good maintenance management system:

Maintenance policy

The first and most important aspect to consider when developing a maintenance management system s maintenance policies. A policy s a set of guidelines for allocating resources and taking actions between different maintenance tasks (Peng, 2013). The organisation must agree on the formulation of maintenance policy to guarantee that t s valuable to the firm and practicable by the management team (Lee and Scott, 2009). Therefore, t s critical to developing maintenance policies early n the planning process to properly plan maintenance methods (Peng, 2013).

Maintenance prioritisation

Setting maintenance priorities helps one to effectively utilise the maintenance budget (Simpeh *et al.*, 2014). According to Wing *et al.* (2016), t s common for facility or maintenance managers to have difficulty determining maintenance priorities. Facility or maintenance managers are usually under growing pressure to prioritise the limited resources to complete maintenance work required and capital renewal needs (Wing *et al.*, 2016). Unscheduled/unplanned facility maintenance, system unavailability, and higher expense to repair or replace damaged components due to short/emergency notice procurement are repercussions of poor maintenance resources and capital prioritising (Lavy, 2014).

Performance or condition standards

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According to Oluwayin (2014), maintenance work s usually associated with cost; therefore, defining an acceptable maintenance standard can be difficult. However, maintenance standards may be acceptable to the person who pays for the labour or the person who receives the benefit or to some outside authority n charge of enforcing minimal standards (Cobbinah, 2010). However, the acceptance may be influenced by building or facility laws, health and safety, and the availability of maintenance resources such as plans and policies (Lee and Scott, 2008).

Maintenance condition assessment

After determining the condition standards, condition assessment can then take place. According to Oluwayin (2014), the most significant aspect of the maintenance management system s condition assessment, the foundation for planning and managing facility maintenance. A condition assessment aims to determine how much preventative maintenance s required for facility upkeep (Wahida *et al.*, 2012). As physical and operational surroundings impact facilities, the condition or state of the facilities evolves throughout time (Wahida *et al.*, 2012). Thus, accurate and consistent condition assessments s required for caring out maintenance works before they negatively impact the facility's performance (Choka, 2012).

Budgeting

According to Blessing *et al.* (2015), a maintenance budget s a cost estimate based on the expenses of labour, equipment, materials, and other items needed to complete maintenance tasks. The estimates should be examined by the applicable public sectors responsible for oversight (e.g. Department of Public Works, Education, Health, among others) to ensure that they are n the right order of magnitude (Blessing *et al.*, 2015). n other words, the maintenance personnel will be responsible for monitoring and continuously updating the actual expenditures of labour rates and material and service costs against the budget for the year. Other costs associated with maintenance are indirect costs, which are the consequential cost resulting from the failure of execution, such as delays n material deliveries, loss n production, wastage of materials, environmental issues and many others (Wienker *et al.*, 2016). These costs can be five times higher than the direct cost, which many organisations often underestimate or do not cater to. Figure 1 shows an "iceberg" of maintenance costs.

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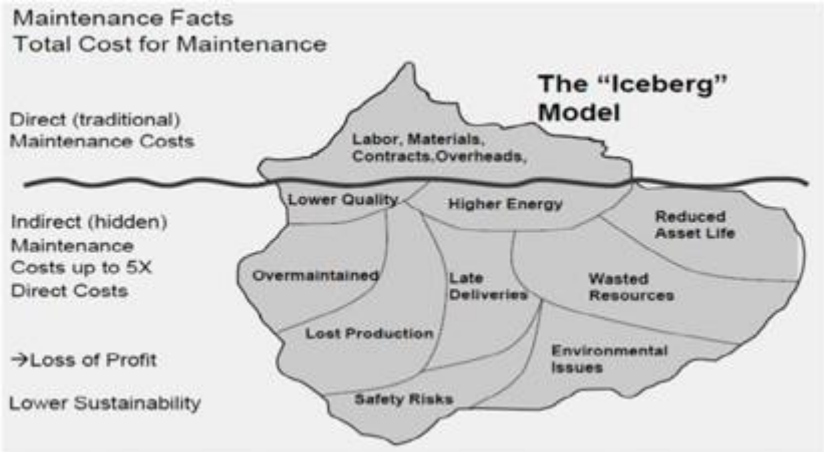

Figure 1: Maintenance facts on the total cost for maintenance

Source: Wienker, *et al.*, (2016:414)

Asset inventory/register

The asset inventory contains information such as the names of facilities, serial numbers of assets or facilities, the location of the asset or facility, its functioning condition, depreciation value, maintenance status, and inventory number, among other things (Oluwafemi and Ibrahim, 2014). Therefore, all assets or facilities possessed by an organisation must be registered and recorded n ts assets inventory or registered to manage its facilities efficiently (Oluwafemi and brahim, 2014).

Maintenance strategies

According to Mydin (2015:60), maintenance strategies are divided into two groups: planned and unplanned maintenance. There are two types of planned maintenance consisting of two types of maintenance: corrective and preventative maintenance. The facility's maintenance goals determine the application of these categories and the facility's nature or equipment to be maintained n the work environment (Rastegari and Salonen, 2015). Straub (2012:188) define corrective maintenance as "any maintenance activity which s required to correct a failure that has occurred or is in the process of occurring". Preventive maintenance was created to overcome the drawbacks of corrective maintenance by lowering the likelihood of failure, avoiding unexpected loss, and achieving cost efficiency (Mydin, 2015:61). Figure 2 shows the relationship between corrective and preventive maintenance.

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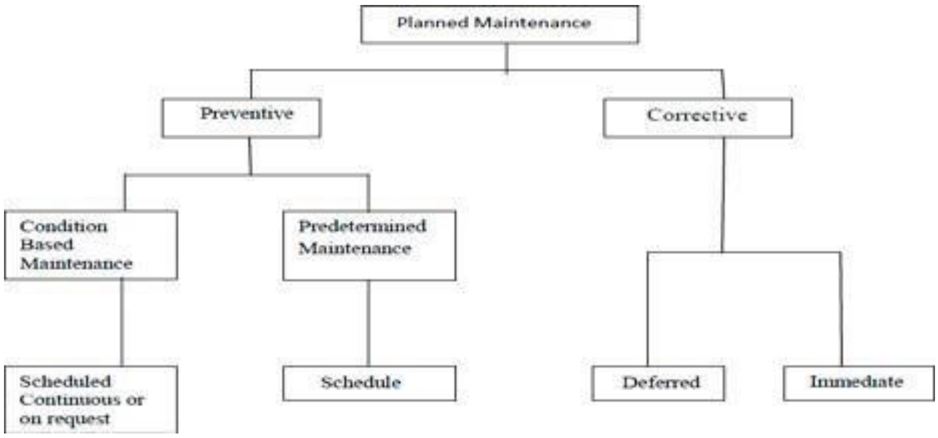

Figure 2: Classification of preventive and corrective as planned maintenance

Source: Yates and Ge (2010:399)

Scheduling and planning
Maintenance priorities, inspection, life cycle costing, facility requirements, health hazards, fire and life safety are all variables that go into maintenance planning and scheduling (Babor and Plian, 2008). The process of establishing future decisions and actions required to achieve specified goals and targets most efficiently and effectively s known as maintenance planning (Al-Turki, 2010). At the same time, the process of arranging the tasks outlined n the maintenance plan into a time frame s known as scheduling (Al-Turki, 2010). Maintenance planning and scheduling aim to cut costs, eliminate risks, and improve competitiveness (Al-Turki, 2010).

Maintenance execution
According to Ogbeifun (2011), maintenance execution s determined by the volume of work and the convenience and benefits of various sourcing techniques. There are two common techniques of maintenance execution, namely, in-house and outsourcing. Kurdi *et al.* (2011:451) define outsourcing as *"the procurement of services from sources that are external to the organisation".* At the same time, *i*n-house maintenance involves using traditional experts to offer and manage facility services (Amos and Gadzekpo, 2016). The in-house experts are expected to plan and monitor, oversee, care, quality measures and retain control of any activities not developed by the organisation. This is to keep the facility functions of the organisation running smoothly and maintain an appropriate level of expertise n the management team (Amos and Gadzekpo, 2016). The choice of maintenance execution depends on the organisation. Some organisations prefer the in-house method, while others prefer outsourcing. However, others use the combination of both since in-house and

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outsourcing have unique qualities and abilities to achieve the best value for money and the purpose of maintenance work (Ahamed *et al.,* 2013).

4. Research Methodology

4.1 Research approach and design

An exploratory design was deemed appropriate for this study. The "case study" approach s the research strategy that matches better with the characteristics of the study. The preference of a case study strategy is that the main research question in this work s "what". Moreover, s case study research has a great potential to achieve high conceptual validity, and t can provide concrete and context-dependent experience (Starman, 2013). Three cases consisting of two municipalities and public works within the departments of facility maintenances were selected. This allowed the researcher to n-depth and closely examine the data within a specific context.

4.2 Research area, sample and targeted respondents

This study was conducted in a Province in South Africa. The research was limited to the target population who have been involved n the maintenance of public facilities. Purposive and quota sampling approaches were adopted to select respondents from all the management levels within the organisation (junior, intermediate and seniors). The respondents included maintenance officers, engineers, and project manager's experts.

4.3 Data Collection

To fulfil the intended objective of the study, both primary and secondary data were collected. A review of the literature was first conducted to explore and evaluate the current adopted maintenance management system n public facilities. This was done by reviewing relevant literature in books, articles in accredited journals, published and unpublished works such as dissertations, records from the maintenance departments and web-based publications. A pilot interview was conducted to test, refine, and restructure the interview guide for conducive data collection. A semi-structured interview was used as the data collection instrument.

Furthermore, a total number of 30 participants were targeted. However, *25 participants availed themselves of the interview.* Conducting semi-structured interviews has the advantage of allowing participants to provide reliable and comparable qualitative data (Akinyoden and Khan, 2018). The collected data were transcribed and analysed n Braun and Clarke's Six Simple Steps thematic analysis process. The purpose of adopting these six steps was to provide a clear and usable framework for thematic analyses. Braun and Clark's six simple steps are:

- Step 1: Familiarise yourself with data

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- Step 2: Generate initial codes
- Step 3: Search for themes
- Step 4: Review themes
- Step 5: Define and name themes
- Step 6: Prepare reports

Validity, creditability, dependability, transferability and confirmability were employed to ensure that the findings were trustworthy and rigorous. This then eliminates any biases. To achieve this, the transcribed data was sent to the participants to verify and resolve any discrepancies that may have arisen.

5. Results and Empirical Analysis

The researcher selected three management levels in all three identified and selected cases (Senior, Middle & Junior). The reason was for the researcher to investigate, compare and draw parallels on the results obtained across or among all participants. A total of 25 participants were interviewed from three cases. Case A consisted of 9 participants, whilst cases B and C each consisted of 8 participants. The researchers firstly presented each case separately. The combined summary of all the cases s also presented and discussed.

The findings suggest that 66.7% of participants n case A occupied the top management level. In the case of B, only 25% of participants occupied top management level whilst most participants (i.e. 50%) were juniors. Similarly, 62.5% of participants n case C occupied junior management level, whereas 25% occupied top management level. The total indicates that both the top and lower-level management were equally represented. Table I shows the total number of participants' response rates of each case, while Table II shows a full participant profile.

Table I: Management level of part

Management level	**Case A**		**Case B**		**Case C**		**Total**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Top	6	66.7	2	25	2	25	10	40
Middle	2	22.2	2	25	1	12.5	5	20

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Junior	1	11.1	4	50	5	62.5	10	40
Total	**9**	**100**	**8**	**100**	**8**	**100**	**25**	**100**

Table: Profile of participants

No.	**Management level**	**Position/ title**	**Experience (years)**	**Qualification level**	**Registration status**
1	Junior	Control work inspector	2	ND (National Diploma)	N/A
2	Top	Construction project manager	12	BTech Degree	Professional Engineer (ECSA)
3	Top	Engineer	10	BSc Degree	Candidate Engineer (ECSA)
4	Middle	Maintenance/building inspector	4	ND (National Diploma)	inactive Candidate Construction Project Manager (SACPCMP)
5	Middle	Control work inspector	5	ND (National Diploma)	N/A
6	Top	Construction project manager	11	BSc Degree	Candidate Construction Project Manager (SACPCMP)
7	Top	Maintenance Manager	20	BSc Degree	Professional Construction Project Manager (SACPCMP)
8	Top	Control Work inspector	10	Building certificate (N4)	N/A
9	Top	Construction project manager	12	BTech Degree	Candidate Engineer (ECSA)
10	Junior	Engineer	3	MSc Degree	Professional Engineer (ECSA)
11	Junior	Maintenance/building inspector	1	Diploma (N6)	N/A
12	Top	Construction project manager	15	BTech Degree	N/A
13	Top	Engineer	7	BTech Degree	Candidate Engineer (ECSA)
14	Middle	Maintenance/building inspector	4	ND (National Diploma)	N/A
15	Middle	Construction project manager	4	BTech Degree	N/A
16	Junior	Control Work inspector	3	ND (National Diploma)	N/A
17	Junior	Control Work inspector	1	BTech Degree	N/A
18	Top	Construction project manager	12	BTech Degree	Candidate Construction Project Manager (SACPCMP)
19	Junior	Control Work inspector	2	Diploma (N6)	N/A
20	Junior	Supervisor	4	Diploma (N6)	N/A

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21	Junior	Maintenance/building inspector	1	ND (National Diploma)	N/A
22	Junior	Maintenance/building inspector	1	BTech Degree	Candidate Engineer (ECSA)
23	Junior	Supervisor	5	Diploma (N6)	N/A
24	Middle	Maintenance/building inspector	6	Diploma (N6)	N/A
25	Top	Construction project manager	8	BTech Degree	N/A

5.1 Maintenance Management System Factors Rating

To better understand the current maintenance management systems adopted n public facilities n South African Provinces, participants were asked to rate each of the maintenance management system's factors of their institutions on a scale of 1 to 10. The ratings are presented as: 1 & 2 = Very poor; 3 & 4= Poor; 5 & 6= Fair 7 & 8 = good, and 9 &10 = Excellent. The findings of each case are presented separately.

Case A

It can be deduced from Table V that participants from case A-rated all the factors of the maintenance management system n the range of 'absent' to 'fair'. Asset register was rated by the majority of participants (77.8%) as absent. Moreover, most of the respondents rated all the other maintenance management factors 'very poor or poor.

Table V: Rating of factors of the maintenance management system

Factors	**Ratings**											
		1	2	3	4	5	6	7	8	9	10	**Total**
	Absent	Very poor		Poor		Fair		Good		Excellent		
Maintenance policy			11.1	33.3	44.4	11.1						100
Maintenance prioritization	11.1			44.4	11.1	11.1	22.2					100
Maintenance condition standards			33.3	11.1	22.2	22.2	11.1					100
Condition assessment			11.1	33.3	22.2	33.3						100
Asset register	77.8				11.1	11.1						100
Maintenance budget				33.3	44.4	22.2						100
Maintenance strategy	33.3			11.1	55.6							100
Maintenance plan				44.4	33.3	11.1	11.1					100
Maintenance schedule	11.1		22.2	22.2	11.1	22.2	11.1					100
Maintenance execution				22.2	55.6	22.2						100

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Case B

it can be deduced from Table V that participants from the case rated all the factors of the maintenance management system factors in the range of ‘absent’ to ‘fair’. Fifty percent (50%/) or more respondents rated four factors absent, whilst the other maintenance management system factors were rated as either very poor or poor.

Table V: Rating of factors of the maintenance management system

Factors	Ratings											
		1	2	3	4	5	6	7	8	9	10	Total
	Absent	Very poor		Poor		Fair		Good		Excellent		
Maintenance policy			12,5	12,5	62,5	12,5						**100**
Maintenance prioritization	37,5			37,5	25,0							**100**
Maintenance condition	50,0		37,5	12,5	12,5							**100**
Condition assessment			37,5	25,0	25,0	12,5						**100**
Asset register	87,5			12,5								**100**
Maintenance budget				37,5	62,5							**100**
Maintenance strategy	75,0	12,5			12,5							**100**
Maintenance plan				75,0	12,5	12,5						**100**
Maintenance schedule	87,5				12,5							**100**
Maintenance execution				37,5	37,5	25,0						**100**

Case C

It can be deduced from Table VI that participants n case C rated six of maintenance management system factors absent.

Table VI: Rating of factors of the maintenance management system

Factors	Ratings											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
	Absent	**Very poor**		**Poor**		**Fair**		**Good**		**Excellent**		
Maintenance policy	87,5	12,5										**100**
Maintenance prioritization	62,5		37,5									**100**
Maintenance condition standards	87,5		12,5									**100**
Condition assessment	12,5		37,5	12,5	25,0	12,5						**100**
Asset register	100											**100**
Maintenance budget	12,5			37,5	50							**100**
Maintenance strategy	87,5				12,5							**100**
Maintenance plan	25,0			37,5	37,5							**100**
Maintenance schedule	87,5			12,5								**100**
Maintenance execution			50,0	37,5	12,5							**100**

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Table VII presents a justification response summary from participants concerning the above maintenance management system ratings. It is clear from the responses that the conditions of public facilities are n a terrible state due to lack of or poor i mplementation of the maintenancemanagement system.

Table VII: Summary of maintenance management system rating from all cases

	CASE A	CASE B	CASE C
Maintenance management system factors rating	Participants rated most of the factors as either "very poor or 'poor'. The main reasons for the ratings are: • poor implementation of policy, • insufficient budget, • retention of the old staff, • constant changes of priority system due to changes of MECs, • implementation of poor standards, • poor timeline of implementing condition assessment, • poor implementation of strategy, • the poor approach of maintenance plan, • poor implementation of maintenance schedule (irregular updates), • Poor implementation of maintenance execution due to lack of resources (human and equipment) for the in-house team and poor selection of contracts when outsourcing. Seemingly, only one factor, 'asset register,' was perceived as absent.	Three factors were rated absent by participants, which were asset register, condition standards, maintenance schedule and strategy, whilst the others were rated as either "very poor' or 'poor' due to the following reasons: • poor implementation of policy, • insufficient budget, • retention of the old staff, • unclear priority system, • poor timeline of implementing condition assessment including non-technical assessment, • the poor approach of maintenance planning, • Poor implementation of maintenance execution due to lack of resources (human and equipment) for the in-house team and poor selection of contracts when outsourcing.	Participants rated almost all factors 'absent', whilst the others were mainly rated as either "very poor' or 'poor' due to issues such as: • lack of maintenance department, • lack of skilled staff, • lack of equipment and tools, • lack of funds, • corruption, • poor selection of contractors • no policy to guide how maintenance should be carried out.

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6. Discussion

6.1. Profile of Participants

Participant's profile consisted of strata groups: management level, current title/position, experience within the current position, highest qualification level and professional registration. These strata groups enabled the researcher to understand the management level of public institutions and their structure. A total of 60% of participants from all cases are not registered with any professional body. This finding correlates with Gibson's findings. Gibson (2004) revealed that only 13 out of the 47 district municipalities (28%) and 42 out of the 231 local municipalities (18%) have members of the institution of Municipal Engineering of Southern Africa (MESA) among their senior management. This further indicates that many government institutions do not have the necessary skill/continuous development and management experience.

6.2 Rating of their current maintenance management system

To obtain an overall understanding of the maintenance management system, participants were asked to rate the maintenance management system of their organisation. The findings as presented suggest that the maintenance management system of public facilities s poor. Participants revealed several factors that hinder the implementation of the system. The main contributor to public facilities' poor maintenance management system

Choka (2012:67) described the problem of maintaining public facilities n developing countries and indicated that most public facilities had faced challenges maintaining their buildings due to their lack of funds n the last decade. The factors contributing to the ineffectiveness of the maintenance management system have been further discussed below based on the findings n this study.

6.3 Rating of specific factors that make up a maintenance management system

Maintenance policy

The findings indicate that respondents from cases A and B believe that the main problem s implementation. Most of the participants from case C pointed out that the department had no policy. Participants rated the policy as poor due to lack of implementation, lack of funds, retention of ageing staff who are expected to go for pension. Also, most of the participants from cases A and B were aware of GIAMA. The study of Ngobeni *et al.* (2015) also confirms that government do have a national policy framework called GIAMA. Although the national policy framework exists, DPW has argued that all government departments, such as the department of health, education, and many more, have their internal policy that will serve the interest of each facility which s referred to as DIAMA (Ngobeni *et al.*, 2015). Unfortunately,

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developed their policy to guide maintenance. Ngobeni *et al.* (2015) further support the response of participant 9 by stating that most personnel have retired from most government departments without replacement or skills transfer to young people, which contributes to the non-implementation of the policy framework. Lee and Scott (2008) argued that policy plays an essential role n the maintenance management system. It contains all the standards and guidelines to implement all the management tasks and descriptions of the responsibilities of the maintenance personnel. Therefore, for government to effectively manage and implement a maintenance management system, a maintenance policy must be developed and implemented.

Maintenance prioritisation

The findings indicate that the prioritisation system s poor. Issue(s) identified were unstable leadership (the constant change of leadership) and the reactive approach to maintenance due to backlog. The findings correlate with the study conducted by Yusof *et al.* (2012) and Wing *et al.* (2016). Wing *et al.* (2016) identified pressure due to backlog, limited resources to address current and backlog maintenance, poor leadership and lack of capital as challenges with effective prioritisation. These challenges are similar to those identified in this study. The impact of bad prioritisation will often result in unscheduled facility maintenance. System unavailability and additional expense to repair or replace failed components or systems due to short notice (Wing *et al.*, 2016). Therefore, the government maintenance department must develop and implement an effective prioritisation system to reduce a maintenance backlog and manage budget allocations effectively.

Maintenance standard

The participants' responses suggest that the maintenance standard n public facilities s unclear, and implementation s merely based on acceptability, which s driven by. Thus, the standard will remain low because of a consistent low or inadequate budget. In general, maintenance standards can be defined as a minimal level of performance to be achieved (Ganisen *et al.*, 2014:35). Some studies, such as Zavadskas et al. (1998:337), also indicated that maintenance standards depend on the resources available, the degree of maintenance standard, and business objectives. It has, therefore, been established that public facilities are not meeting the minimum level of performance, and budget restriction has been highlighted as the major factor militating against maintaining the good standard. Therefore, municipalities must set acceptable condition standards for each facility. This will enable managers to plan and maintain facilities efficiently based on their required standard and consequently mitigate facilities being more prone to incur defects and underperform.

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Condition assessment

Although condition assessment s part of the maintenance management system, the findings suggest that the approach is ineffective due to a lengthy time frame, inconsistency and non-compliance or ignorance (as n cases A and B). Participants from case C indicated that condition assessment was only done when the community reported an issue or when maintenance was due. A study conducted n South Africa by Mojela (2013) also found that condition assessment was not carried out on most public schools except when the community requested a certain facility to be assessed. Yacob *et al.* (2016) revealed that the inefficiencies and inconsistent implementation of condition assessment could increase maintenance work due to defects and damage to the building facility. Thus, the need to conduct condition assessments crucial for the government department charged with managing facilities.

Asset register

The absence of an asset register could lead to a lack of accurate and inconsistent information on facilities, which, according to Yacob et al. (2016), makes it Additionally, Ngobeni *et al. (2019)* revealed that lack of accurate asset register becomes a problem when having to ascertain assets/facilities that belong to the DPW. The findings from this study suggest that the maintenance department does not have an up to date asset register. This problem can also be transferred from (Ngobeni *et al.,* 2019). The findings also indicate that incompetent personnel and a lack of keeping track of facilities aggravated the problem. These are issues that have previously been identified (Yahaya, 2016). The inability to identify assets/facilities results n the department being unable to identify and properly categorise their facilities (Ngobeni *et al.,* 2019). Therefore, government departments should have an asset register as part of their maintenance system to track records of all assets/facilities.

Maintenance budget

Budget is one of the biggest challenges of maintenance departments. The findings indicate that departments prepare maintenance budgets; however, participants rated maintenance budgeting as poor due to insufficient funds provision, increased backlog, and unrealistic performance expectations. The challenge of insufficient fund provision has been highlighted by many researchers (Xaba, 2012; Simpeh, 2013; Ngobeni *et al.,* 2015; Wing *et al.,* 2016). Xaba (2012) indicated that, although the Department of Education allocates money to schools, it is not enough as the overall financial allocation to schools is 12% for maintenance. This is a “ring-fenced” as it implies that even f maintenance needs to be exceeded 12%, schools could not use funds allocated for other functions. The insufficient provision of funds eventually leads to more backlog, as participants revealed. This assertion is confirmed by

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Ngobeni *et al.* (2015:53), who argued that inadequate or inefficient funds allocations for maintenance work increase maintenance backlog.

Maintenance strategy

Participants also rated the strategy adopted for maintenance. The findings indicate that the implementation of maintenance strategy was poor. The main reasons for the poor rating were lack of implementation, lack of human resources, retention of ageing staff who are expected to go for pension and stuck on outdated strategy. These findings are supported by Velmurugan and Dhingra (2015), who indicated that implementation of maintenance strategy s a great challenge for maintenance managers in the public sector. They further revealed that lack of resources such as manpower, equipment (spares, tools, etc.), deploying the manpower, and managing all the resources have a huge impact in carrying out maintenance. There is a need for government maintenance departments to reevaluate and establish effective maintenance strategies to helpthem perform maintenance work effectively.

Maintenance planning

The findings from participants' responses suggest maintenance was poorly planned, resulting in n a reactive approach. The underlining problem was 'budget constraints. Thus, the study found that a reactive approach to maintenance was adopted due to i nadequate funds provision. This finding correlates with the study (Yahaya, 2016), who found that most maintenance departments adopted a reactive maintenance approach due to poor planning. According to Owusu and Aigbavboa(2016), lack of effective planning may lead to re-occurrence of faults or defects and thus subsequent re-occurrence of maintenance work and eventual loss of initial budget. The re-occurrence of defects or faults may lead to disruption of service delivery through equipment breakdowns or building element/component failures and increase n capital burden. To avoid the re-occurrence of defects, t will be necessary for every government maintenance department to proactively develop a concise facilities maintenance plan to efficiently deal with facility maintenance demands.

Maintenance schedule

The next factor is the scheduling of maintenance work, which correlates to maintenance planning. The findings suggest that most of the participants rated the implementation of maintenance schedule poor. Issues such as inconsistent updates, improper schedules such as scheduling only emergency maintenance works affected were identified. The study of Velmurugan and Dhingra (2014) also mentioned, poor scheduling and updating maintenance work often result n poor maintenance execution. Although maintenance can be scheduled properly, lack of budget allocations of scheduled work remains distressing.

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Therefore, f government does not allocate adequate funding for maintenance works that s planned and scheduled, or the budget is cut mid-year, an increase in deferred maintenance isinevitable (Hamid, Alexander and Baldry, 2010).

Maintenanc eexecution

The findings suggest that both in-house and outsourcing approach was adopted to execute maintenance work. However, participants rated it as poor due to lack of human such as specialised labours, lack of equipment or material for an in-house team, non-transparent outsourcing process, poor selection of maintenance contractors with no expertise. This further results in poor workmanship and performance. Ganisen *et al.*, (2014) found similar settings and mentioned the consequences it brings. They mentioned that these issues delay the maintenance process and increase the criticality of the problems, and even some time t could result in facility services failure (Ganisen et al., 2014). Therefore, the government should hire and train the in-house team, provide the required resources for the in-house team, and select reputable contractors with resources and expertise when outsourcing to ensure that maintenance works carried out effectively.

7. Conclusion

At present, public facilities in some South African provinces are greatly neglected and in unpleasant condition. The findings suggest that this is due to poor implementation of the maintenance management system. The factors that significantly influence the implementation of maintenance systems negatively include inadequate funds, poor policies, lack of maintenance personnel or skill set, lack of maintenance department and structure and environmental factors. The implications of deteriorated facilities are that; facilities cannot perform its function or what it was intended or designed for. The safety of users becomes an issue, and cost implications in replacing components become huge and unaffordable.

7.2 Practical implications

The findings from this study alert maintenance personnel of public facilities on the significant advantages of implementing strategies of the maintenance management system. Findings from this study would also be useful to policymakers in setting benchmarks for selecting

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competent contractors, factors that constitute maintenance management system. These include prioritization of maintenance, condition assessment and standards, planning and scheduling,asset management/register and budgeting) performance monitoring.

7.3 Further studies

The following recommendation is made for further studies:

- This study focused only on public facilities maintenance management systems in South African Provinces. Further studies focusing on the private sector s highly recommended and would be of value. This will provide a broader perspective of improving strategies of the maintenance management system and extends the knowledge not only limited to public institutions but also private institutions.
- Another aspect of further studies may focus on comparing different maintenance management systems applied n public and private facilities within all provinces n South Africa. This may generally give insightful outcomes and explore both practices. This is by identifying the gap between the public and private systems and establishing the best and better system that can work for any sector and facility .e. schools, hospitals, sports grounds, among others in any province n South Africa.

Author Contributions: All authors contributed to all phases of conceptualisation, methodology, investigation, and manuscript writing. All authors have read and agreed to the published version of the manuscript.

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DII-2021-046

Safety and Security in Urban Public Spaces as a Significant Component of Social Sustainability

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Abstract

The social dimension to sustainability is now widely accepted as necessary alongside environmental and economic sustainability. Safety and security as aspects of social sustainability have been undertheorized in the built environment fraternity. Research has proven that theories that dominate the field of urban safety come from social sciences. Still, the motives of this paper are to report and discuss findings from a critical review of the local and international literature of the role of other perspectives, especially those developed by built environment professionals and practitioners. In addition, to assess the design deficiencies of urban public paces (UPS) that lead to them creating an environment for criminality and exposure to threats and vulnerabilities. Based on a five-stage literature review, 39 articles on the safety and security of UPS were critically analysed. A bibliometric analysis using the visualisation of similarities (VOSviewer) software was adopted. The review findings reveal that safety and security in UPS are associated with the environmental design features such as accessibility, visibility, etc. Secondly, surveillance measures in UPS do not address the safety concerns but concentrate mainly on controlling the space rather than people, in that it interferes with spatial planning. This paper argues that spatial structure affects citizens and that innovative urban management is necessary, resulting from a synergy between social and structural elements of a city. To guarantee inclusive and accessible landscape designs, personal safety should be part of the design features of UPS. Spatial planning as a discipline should incorporate measures to combat crime in the city.
Keywords: Crime; Vulnerability; Public space design; Safety; Security.

1. Introduction

No environment reflects the meaning of urban life better than a public space does (Ceccato, 2016). This paper aims to assess the safety and security of UPS in South Africa and bridge the knowledge gap in the planning, design, construction, and maintenance of safer UPS. One of the most important local government tasks is to assure a high level of security (Sinkienė et al., 2012) for the city's inhabitants and visitors. However, governments have realised that safety is about security, community involvement, interaction, and social cohesion. Therefore, the regulation of these UPS is influenced greatly by debates about crime, disorder, and insecurity (Barker, 2016). To advocate for the design of safer and more inclusive cities, geographies of exclusion that have come to define these cities need to be unpacked. Research

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has proven that theories that dominate the field of urban safety come from social sciences (Sinkienė *et al.*,2012), criminology and urban studies (Barker, 2016).

Crime, disorder, antisocial behaviour, and perceptions of insecurity have become organizing objectives of urban governance (Barker, 2016) with distinct implications for how public spaces are planned, designed and regulated when inflected through mentalities of risk and reassurance. Therefore, the motive in this paper is to emphasize the role of other perspectives, especially those developed by landscapers, architects and town and regional planners. This paper reports and discusses findings from a critical review of local and international literature on the safety and security of UPS. It begins by discussing the interdisciplinary insights of UPS safety and security. It explores the right to the city and its public spaces, what determines access, and the results of this paper help identify and suggest corrections in previous UPS planning and avoid them in future projects. This change should help achieve higher safety in cities and their attractiveness and more successful development.

2. Background

2.1 The Concept of safer Urban Public Spaces

Urban planners' perspectives towards the causes and solutions for crime prevention and control in cities (Sinkienė *et al.*, 2012) relate crime to environmental design factors, such as the orientation of entrances and windows, lighting, street accessibility, area visibility, and so on. The issue of safety includes both natural and manufactured disasters. Safety is a fundamental part of the relationship between humans and the environment (Senda, 2015). It can be argued that perhaps the environmental factors mentioned above are no longer serving the cities with that desired effect but need to be revisited and assessed as to whether any improvements or betterments are needed or not. A high rate of crime in cities, especially in urban public spaces, are reported annually. The high crime rate in a city is a serious barrier to the city's spatial and economic development. For example, businesses will migrate to safer places (Sinkienė *et al.*, 2012).

Access to a violence-free and safe public space is the basic right. Phadke (2007) argues that the right to the city and its public spaces should remain a core objective of social justice movements. He suggests that the right to the city means to inhabit urban spaces and participate in a city as an ongoing work of creation, production, and negotiation. He perceives that the struggle for this right is about individuals or even groups and the inhabitant's vision for the future of cities and their ideas of urban democracy. If our urban public spaces are dysfunctional, how do we realise this basic right? It is as if the right to UPS for certain marginal groups has been significantly curtailed. It can be argued that for this right to be maintained even after the design, construction and maintenance of UPS, these spaces should be regulated either by the government or privately.

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Moreover, this securing of the city has led to charges that the ‘right to the city’ for certain marginal groups have become significantly curtailed, fuelling debates about the decline of civil liberties and ‘the end of public space’ (Barker, 2016). Sinkienė *et al.* (2012) believe that innovative urban management would result from a city's social and structural elements. Constructing new urban public spaces is one thing. However, the question remains: do urban planners, landscapers, and architects ever think of what needs to be done on the existing public spaces to combat the feelings of insecurities? Some could argue that introducing technological equipment (i.e., closed-circuit television - CCTV) answers this question. However, Zurawski (2010) used a survey to assess the role of feelings of security and how they might impact attitudes about CCTV. He highlights that the perceived safety of a space / f eelings of safety among people have little to do with the technology and more with socio-relations, of which space is but one part. He suggests that CCTV as a surveillance measure mainly concentrates on controlling the space rather than people in that it interferes with spatial planning.

However, not every UPS needs a camera. Arguably, the use of cameras in some parts of UPS could be viewed as an invasion of privacy. Davies and Velastin (2007) argue that there is, unfortunately, no assurance that surveillance systems will always be used responsibly and only by those with the public interest and safety in mind. The spatial structure of the city has an inevitable role in the city’s safeness and security. Bengtsson (2018) believes that spatial structure in communities affects the citizens to commit the crime. Spatial planning as a discipline should incorporate measures to combat crime in the city. In support of the latter Ratnayake, (2017) suggests that spatial environments may influence individuals’ feelings of fear and criminal behaviour. Re-designing the city streets and buildings could help create comfortable environments, reducing air-conditioning and artificial lighting. In doing so, Sinkienė *et al.* (2012) believe that streets and territories, which are located near the most integrated areas, deserve the greatest part of the attention of planners, decision-makers, residents, among others.

Safety in UPS is not an issue that can easily be dealt with within the boundaries of a single discipline such as criminology (Ceccato, 2016) or sociology. Viswanath & Mehrotra (2008) argues that the solution to UPS safety must emerge from the consultative processes with the community and different disciplines. There is no single discipline that could achieve the safety and security of UPS in isolation. The discourse around urban safety must be located within a broader framework of rights (Viswanath and Mehrotra, 2008). Public participation is key for planning and designing safer UPS. Ratnayake (2017) argues that planning and designing safer UPS requires greater public consultation and participation. Urban development must enable deep economic, social and political engagement for the community, especially the needs of the most vulnerable. Cities need to create spaces for all,

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and the discourse of inclusion must be addressed through policies and structural changes (Viswanath, 2013).

This same author postulates that to create infrastructure accessible to all, urban planners and service providers need to include gender concerns and women's needs in their planning. However, well-designed, well-built, and well-maintained UPS are more likely to be used by a more diverse set of users, including women, children, the elderly, the disabled and others. One factor to the feeling of safety is lighting, which can change how people look at urban trails and public space and allow people to use the area 24 hours per day. Lighting has been used historically but without deeper consideration for human needs in landscape architecture and design (Bengtsson, 2018; Whitzman *et al.*, 2009).

2.2 Urban Public Spaces for all

Cities are a particular form of social life (Viswanath and Mehrotra, 2007) that allow for and encourage different understandings and usages of UPS that are deeply gendered in both access and the right to UPS. As mentioned above, access to a violence-free and safe public space is the basic right, and this right should remain the core objective of the social justice movement. UPS are those areas where all citizens, irrespective of gender, class, age, ability, or any other social identity, have the right to access (Bhattacharyya, 2015). Recently, UPS access to and use is increasingly a privilege rather than a universal right (Barker, 2017). The fear and insecurities that vulnerable population face in accessing UPS prevents them from availing the benefits of being an urban citizen (Viswanath and Mehrotra, 2007). The feeling of lack of safety is highly intensified by physical obstacles such as poor maintenance, poor accessibility, isolated or deserted areas (Kallus and Churchman, 2004)

In an investigation of mediated conviviality and the urban social order, Barker (2016) found three competing mentalities regarding the safety and security of public spaces. He points out that these mentalities were drawn from within the fields of criminology and urban studies, notably:

- Preventive exclusion: assumes that maintaining order requires excluding 'risky' people from public space.
- Reassurance policing: assumes that fostering perceptions of security and order in public spaces is a centrally important function of urban governance.
- The right to the city: assumes that rights are a central organizing concept and public space acts as a barometer of social justice.

However, having mentioned these mentalities above and whether these will eventually yield safer urban public spaces remains fundamental for this study. The right to access and use the

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UPS is dependent on the kinds of boundaries imposed and the nature of the space and its usage (Viswanath and Mehrotra, 2007).

Privatization of urban public spaces is a key aspect of safety and security in these spaces (Bengtsson, 2018). However, public spaces based on the principle of exclusion (Phadke, 2007) might allow some to enjoy gated “high security” spaces and, in a larger sense, do little to expand people’s access to the city. Every area is different, though, depending on the people, the country, the city, nature, and other important factors. Because Bengtsson (2018) views the gated UPS as a key aspect of safety and security. He argues that when a space is moved from public to private, security is increased. His viewpoint is that UPS always need more eyes; thus, privatising them could be an answer.

In some countries, access is restricted according to the time of the day or type of activity rather than absolute and targeted at specific populations what Thorn (2011) calls 'sanitization' of UPS or soft 'enforcement. These UPS are accessible yet closed and inclusive yet controlled. In South African urban areas and many parts of the world, accessing public spaces at night without male companions is risk-taking for women (Sur, 2014). Therefore, for women to access public spaces depends on their ability to manufacture respectability and legitimate access. People enjoy privatized public spaces like nightclubs and lounges without accessing public spaces (Sur, 2014). Furthermore, UPS are not universally accessible for young people and are generally considered adult spaces unless a specific area is designated for them (Dunkley, 2004).

Free and safe access to the city's most important public resources could lead to the economic decay of the city (Kallus and Churchman, 2004). This could be a national disaster, especially in an economic hub city such as Johannesburg in South Africa.

3. Research Methods

This paper is an outcome of a critical review of the literature exploring both local and international perspectives of landscapers, architects, town and regional planners on the subject. This paper aims to assess the safety and security of urban public spaces in South Africa. A critical bibliometric review of the related literature spanning a decade was conducted to achieve this objective. The authors believe that a single discipline cannot address the safety and security of urban public spaces. It needs collaborations across the fields of study, especially by built environment professionals. If South African urban public spaces attract people from all community spheres, even abroad, spatial planning should incorporate safety and security features in the city planning. The environment created by these professionals plays an inevitable role in assuring personal safety.

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Science mapping was adopted as a primary method for this inquiry. This method was selected based on several reasons: (1) it is a generic process of domain visualisation and analysis, (2) it has previously been adopted in construction management research, (3) it characterises intellectual interrelations within the dynamically different systems of scientific knowledge, and (4) it focusses on displaying the structural and dynamic aspects of scientific research (Makabate *et al.*, 2020). Literature was reviewed, analysed, and synthesised through a five-stage process from deferent fields of study, particularly the built environment professionals, to elicit criticisms and gaps in the planning, construction and management of safer urban public space, including revitalising the existing ones. The five-stage process included:

- In-depth and comprehensive review: thematic analysis including ‘the concept of safer urban public spaces’ and ‘urban public spaces for all’ was undertaken.
- Select the data source: Scopus-catalogued journals with the classification of public spaces, urban development, urban planning, urban growth, and sustainable development were selected.
- Perform the preliminary search: only peer-reviewed articles were selected for further analysis. Books and conference proceedings were excluded. This process resulted in 68 documents that qualified for the next stage of screening.
- Focus on the development of UPS: a more comprehensive and visual search of the targeted urban planning journals were included in the analysis. This stage excluded articles that were more focused on political sciences. This process resulted in 39 documents to qualify for the next and final stage of the screening process.
- Identify research documents: bibliographical data was exported from the SCOPUS search engine using a Comma Separated Values (CSV) format. The CSV file was imported into VOSviewer to map the safety and security of UPS scientifically.

4. Results and Findings

In this section, a thorough comparison of deferent scholarly viewpoints from deferent fields of study to compare different points of view or constructs from safety and security studies of urban public spaces was conducted. Based on the related literature conducted above, the study reveals that urban planners’ perspectives towards the causes and solutions for crime prevention and control in cities relate crime to environmental design factors, such as the orientation of entrances and windows, lighting, street accessibility, area visibility. However, the safety issue in UPS cannot be limited only to those environmental design factors but includes both natural and manufactured disasters.

Due to high crime levels in UPS, many cities have resorted to introducing surveillance technology to regulate these spaces. An interesting finding is that safeness of a space/feelings of safety among people has little to do with the technology and more with socio-relations, of which space is but one part. Literature reveals that surveillance measure mainly concentrates

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on controlling the space rather than people, in that it interferes with spatial planning. Spatial structure in communities affects the citizens to commit a crime. Innovative urban management would result from a synergy between social and structural elements of a city. It is interesting to note that solutions to UPS safety must emerge from the consultative processes with the community and different disciplines. Again, and more importantly, there is no single discipline that could achieve the safety and security of UPS in isolation.

One important finding is that the discourse around urban safety must be located within a broader rights framework. These rights are a central organizing concept in public spaces and act as a barometer of social justice. A significant finding is that these spaces should be regulated privately or by the government to maintain this right even after UPS' design, construction, and maintenance. Therefore, one urban management approach of privatization of UPS is revealed as a key aspect in ensuring safety and security in these spaces. Another significant finding is that public participation is key for planning and designing safer UPS.

The literature revealed three competing mentalities regarding the safety and security of public spaces preventative exclusion, reassurance policing, and the right to the city. It is also very interesting to note that to create an infrastructure that is accessible to all, urban planners and service providers need to include gender concerns and women's needs in their planning. Spatial planning as a discipline should incorporate measures to combat crime in the city. More results are evident in the distribution of documents published per country, Table I below depicts:

Table I: Distribution of documents per country

Item	**Country**	**Documents**	**Citation**	**Total link strength**
1	France	1	29	2
2	Spain	1	29	2
3	United States	6	214	2
4	Germany	2	24	0
5	Israel	1	7	0
6	Japan	1	8	0
7	Sri Lanka	1	8	0
8	Sweden	3	32	0
9	Switzerland	1	23	0
10	United Kingdom	6	132	0

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It is very interesting to note from the above table the number of documents published per country in the safety of the UPS subject area. Only the United States (n = 6) and the United Kingdom (n = 6) where at least there are a few documents published. Furthermore, these two countries have had the most citations (n = 214) for the USA and (n = 132) for the UK. What is also critical to note from the table is that the most cited documents come from developed countries. Not even a single African country is featured in the table above. Figure 1 below shows a network of keywords used in the documents shown in the table above.

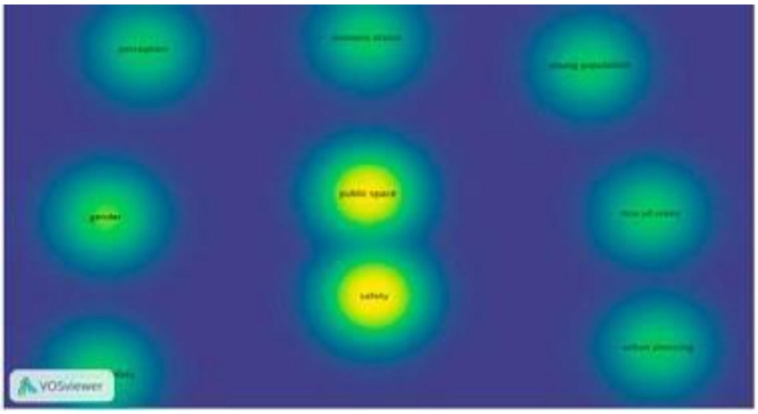

Figure 1: Author keywords occurrences

Table II below the number of documents published per source. The below table indicates a lack of interest from scholars insecurity in urban planning and design. Most sources produced only one document in the period of analysis. However, these single documents per source have had quite a glaring number of citations.

Table II: Number of Documents Published per Source

Item	Sources	Documents	Citation	Total link strength
1	Children's Geographies	2	25	1
2	Cultural Geographies	1	8	0
3	Economic and Political Weekly	2	116	0
4	Environment and Urbanization	1	18	0
5	Gender, Place and Culture	1	29	1

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6	IATSS Research	1	8	0
7	International Criminal Justice Review	1	8	0
8	International Journal of Urban and Regional Research	1	83	0
9	Planning Theory and Practice	1	7	0
10	Professional Geographer	1	103	0
11	Psychology of Violence	1	28	0
12	Rural Society	1	8	0
13	Security Journal	2	18	0
14	Sikh Formations: Religion, Culture, Theory	1	21	0
15	Social Indicators Research	1	23	0
16	Space and Culture	1	19	0

Figure 2 below shows the authors' bibliographic coupling in the safety and security of urban public spaces.

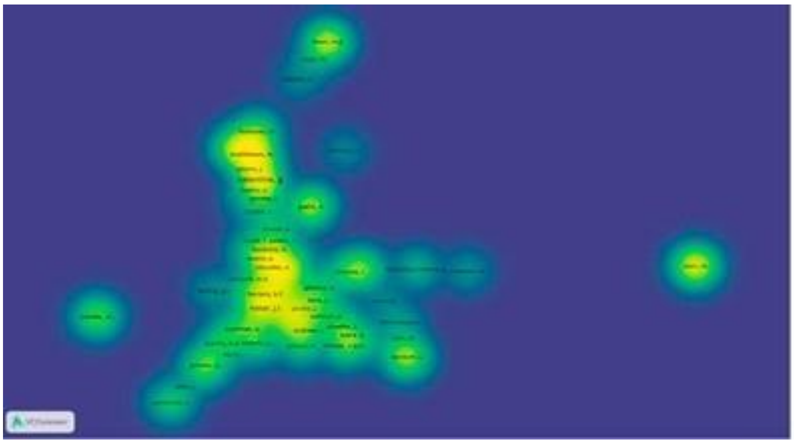

Figure 2: Authors' bibliographic coupling

5. Practical Implications

Looking at UPS as an inherently social concept, we can draw attention to how UPS is always negotiated, defined, and redefined by different scholars. Beyond the physical reality of UPS

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lies an inherently social nature that influences people's actions and relationships they have or might have towards one another. UPS as a social concept allows us to examine these safety and security implications. Infrastructure development must guarantee safety in cities. The demand for infrastructure to reduce risks and enhance access should be part of the generalised claim that all citizens have good infrastructure. High accessibility means more opportunities to walk rather than drive, and if access to parks, playgrounds and recreational facilities is guaranteed, physical activities are increased.

The high levels of crime and free access to the city's most important public resources could lead to social divides and economic decay. Many cities have incorporated safety guidelines into their official plans and zoning by-laws. The same can be done, if at all, in South Africa. This would allow planners to demand that safety features in the city planning are adequate.

6. Conclusions and Recommendations

This paper highlighted the environmental design deficiencies of urban public spaces and the safety and security these designs have in these spaces. The study identified that the urban planner's perspective relates safety and security in UPS to environmental design factors. These factors are no longer serve cities with the desired effect but need to be revisited and assessed on whether any improvements or betterments are needed or not. The results reveal that spatial structure in cities affect individuals to commit a crime. Therefore innovative urban management approaches are needed.

6.1. Recommendations

All the states must take urgent steps to revamp and strengthen highly efficient public lighting facilities, perhaps using smarter lights. Possibly, the urban spaces of each state must initiate to install Light Emitting Diode (LED) lamps, which are deemed as highly efficient, having 50,000 hours of life. It is evident that although the initial installation of these lamps involves higher capital costs, but being highly energy-efficient. It would entail higher savings in terms of its operations and maintenances. This will spur the safety and security of the urban spaces and boost public confidence.

Deteriorating, redundant and demolished buildings with easy access become vulnerable spaces influencing the state of safety in cities. The solution to urban insecurities, particularly for women, must come from the community, the state and the built environment professionals. Consultative processes where the voice of all, especially the vulnerable populations, is fundamental in urban public spaces. Their voice needs to be heard and given value if UPS are to guarantee access for all. An approach towards safer cities involves education on violence issues, grassroots community organisation, and equal access to spaces. Urban development must enable vibrant economic, social, and political engagement for the

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community, especially the needs of the most vulnerable. Cities need to create spaces for all, and the discourse of inclusion must be addressed through policies and structural changes.

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DII-2021-050

Evaluation of the Trend of Residential Mobility in Uyo, Nigeria

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Abstract

The study examined the implication of residential housing mobility on the real estate market in Uyo, Nigeria. Data were obtained from a questionnaire, interviews, and discussions with over 900 respondents from Uyo Capital City, Nigeria households. The research shows the dynamic nature of the residential housing market arising from the mobility of the players on the demand side. This is mainly initiated by the desire for a decent environment, secured neighbourhood, low crime rate, regular power supply, good road network, available water supply, less traffic congestion, proximity to workplace and proximity to other places of interest. The results show that 58.7% of the self-employed, 51% of the civil/public servants and 54.3% of the private sector respondents prefer to live in purpose-designed housing layouts. The implication is that developers of residential properties, for rental or outright sales, would find it more profitable to invest in properties located in designed residential estates rather than open locations. This paper guides the preferred residential property types and their preferred locations in Uyo, Nigeria. It also provides a greater understanding of the pattern of residential mobility in the city, the class of people who move and the major reasons people move from one location to another.

Keywords: Trend, residential real estate, residential property development, housing, location preferences.

1. Introduction

To provide affordable housing in good numbers, investors and the government face the problem of determining the most productive location for property investments. This is a task requiring skill and expertise. The ability to do this is highly dependent on the expertise necessary to determine consumer preferences accurately. This resides in the ability to predict the trend in residential mobility and the readiness of the property market to bring the players together. This research is designed to improve understanding of the dynamics of the residential housing market. The study examined the level of market transactions and the implication of residential housing mobility on the real estate market in Uyo, Nigeria. The outcome of this project is useful in determining the most likely roles that the professionals in

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the property sector can play to facilitate the growth of the property market under specific conditions, thus resulting in high activity in the residential housing market. Despite efforts made by successive governments in Nigeria, there remains a huge gap between the available housing stock and the demand for housing (Ekpo, 2019; Olayiwola *et al.*, 2005; Makinde, 2014; Obi and Ubani, 2014; Oyinke, 2009). Failure in housing provision has adversely affected those in the medium and low-income segment of the populace (Ekpo, 2019; Moore, 2019; Abdullahi and Abd-Aziz, 2010; Akinmoladun and Oluwoye, 2007; Nubi, 2008). This has, to a great extent, contributed to moves by households.

Cities and towns vary in terms of the quality of housing, type of social interactions, economic opportunities and services they offer to their residents. Residents are often faced with choices of where to live. (Akeju, 2007; Henshaw, 2010; Lanrewaju, 2012; Adeoye, 2015; Adetunji and Isah, 2015; Ibem *et al.*, (2011). Neighbourhood preferences drive residential housing mobility, which inadvertently is encouraged by better neighbourhood characteristics and cost factors (Udo *et al.*, 2019). Housing mobility, therefore, has significant effects on the property market. The property's value is directly related to its location and demand and supply functions to the consumer.

Rossi (1955) has characterized residential mobility as a means by which housing consumption patterns adjust over time. In many respects, this characterization remains true today. However, the patterns of residential mobility have undergone transitions over time. Coupe and Morgan (1981) suggest that changes in household and personal characteristics are not the only factors that should be considered in household relocation studies. They note that housing choices may be affected by residential history and market factors or forces that are external to the household.

Before the creation of Uyo, Nigeria, as a State capital, on September 23, 1987, Uyo was a small village with a dispersed settlement pattern typical of the area. It was thinly populated (149,000) by peasant farmers with the absence of an active property market. Since the upgrading of Uyo into the capital city, Uyo has experienced a steady influx of people, which has brought about population and urban growth (1,200,000) and significant activity in the property market. Because housing mobility is a common phenomenon in every society, particularly urban centres, it is expected that the continuous population growth in Uyo city might have altered the previous pattern of housing mobility.

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2. The Study Area

For the location of Uyo on Maps 1, 2 and 3. Uyo started as a small village in the Offot clan, with a dispersed settlement pattern. Peasant farmers thinly populated it. Previously, the area of Uyo was very small, covering not more than 16 square kilometres (Akwa Ibom State, 1989). Uyo served as a Local Government headquarters in what was originally Cross River State, Nigeria. With the creation of Akwa Ibom State out of Cross River State on 23rd September 1987, Uyo assumed the status of State capital. The assumption of Uyo as the State capital led to increased human activities, economic fortunes, population, and rapid urbanization. The limit of Uyo urban area in 1989 covered an estimated area of about 60 km^2. It lies and situates between latitude 4^0 59'N and 5^0 04'N and longitude 7^0 50'E and 7^0 52'E and is located on an elevation of about 60.96 meters (209 ft) above sea level (Uyo Capital City Development Authority, 2007). The population of the city stood at 436,606 in 2006 (National Population Commission, 2006).

Map 1: Akwa Ibom State, Nigeria
Source: Bassey *et al.*, 2019

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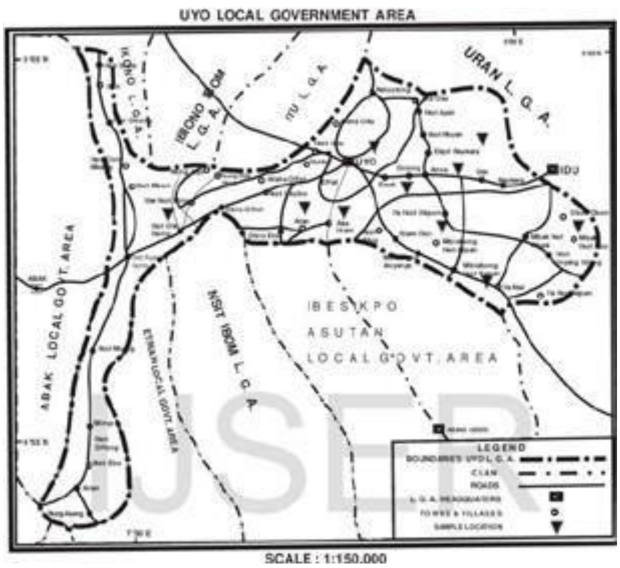
Map 2: Uyo Local Government Area, Akwa Ibom State Nigeria
Source: Science and Education Publishing



Map 3: Uyo Local Government Area Villages.
Credit: Abraham, Federal University Ndufu Alike Ikwo Ebonyi State, Nigeria.

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3. Literature Review

3.1 Concept of Housing Mobility

Clark and Onaka (1983) characterized residential mobility as a combination of an adjustment move (adjusting to the market), an induced move (changes in household composition and life cycle) and a forced move (loss of housing unit or job). This shows that factors contributing to residential housing mobility could be multi-variant and occasionally are unplanned. These are the factors that are important for the understanding of the dynamics in the property market. Animashaun (2012) has suggested that residential housing mobility connotes the movement of residents from one house to another or from one location to another. Understanding the factors that influence mobility is fundamental to the understanding of the property market.

3.2. Types of Residential Housing Mobility

Two types of residential housing mobility (intra-urban and out movement) have been identified to be common in most cities of the world (Moore, 1972).

(i) Intra-urban residential mobility: This is a residential movement within the urban city and has been a major concern to urban planners. It is largely responsible for the changing socio-economic patterns of the neighbourhood, which is generally associated with the deterioration and decline of regions within cities (Cadwallader, 1978). This study is primarily focused on intra-urban residential housing mobility.

(ii) Out movement: this involves movement from urban to sub-urban**.**

In addition to Moore's classification of residential housing mobility, inter-urban residential housing mobility exists. This involves moving from one city or urban centre to another. This type of mobility is claimed to be a major contributor to the urban population explosion.

3.3. Impacts of Residential Housing Mobility

Residential mobility has important implications for both individuals, neighbourhoods and the property market. Clark and Ledwith (2006) have observed that residential mobility poses a problem to the neighbourhood and individuals. They argue that neighbourhoods with high rates of residential turnover do experience more problems than stable neighbourhoods. These occur because residents in unstable neighbourhoods know one another less well. Moreover, high residential turnover may promote further mobility, as suggested by the link found between the desire of residents to move and the perceptions that residents in the

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neighbourhood move frequently or are not "close-knit" (Clark and Ledwith, 2006). These considerations affect the price that players are willing to pay or receive for the property.

Although residential mobility can be a path to greater opportunity and satisfaction, many low-income families move not to better their circumstances due to unstable housing arrangements. Such moves may have negative consequences. Movement from one geographical area to another has been potentially significant on the life changes available to individuals and families. Apart from disrupting social ties, relocation may undermine a family's capital (Briggs, 1997). It has a particularly disruptive effect on children when parents provide only modest emotional support and involvement (Hagan *et al.,* 1996). Haveman *et al.* (1991) believe that residential mobility at the individual level affects the individuals who lose touch with some kin and friends and affects their children's emotional well-being and performance in school. The knowledge of these factors is particularly pertinent for understanding the property market in any city or neighbourhood.

4. Research Methodology

The research covered settlements within the territory known as Uyo Capital City Development Area (UCCDA). Households settling within Uyo Capital City Development Area constitute the study population. The study considered both owning and renting households. Data were elicited using a questionnaire with about 900 respondents drawn from Uyo Capital City Development Authority households. To avoid location bias, the respondents were reached at their places of work while the information elicited was about places where they lived. Only 857 responses were retrieved. Follow-up interviews and discussions were held with many respondents to confirm their understanding of the conflicting information provided. Simple descriptive statistics were used to determine each event's occurrence and the relationship with other events in the questionnaire. Inferences were drawn based on simple descriptive statistics of the data analyzed.

5. Results and Findings

The sample population was distributed across different classes of Uyo residents ranging from self-employed (22.1%) to civil/public servants (42.7%) and private-sector workers (35.2%). The respondents were further classified into various designations according to their status, namely: junior staff, senior staff, management staff, managing directors/chief executive officers and other unclassified designations along with their salary grade levels.

These respondents were then classified according to the year they moved into the town. The results show that 83.5% of the respondents moved into Uyo between 1993 and 2017. This

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indicates that since Uyo was designated a State capital in 1987, the city has grown spatially and demographically. Analysis of the migration rate of people's migration to the town shows a steady increase over the years, as indicated in Table I.

Table I: Classification of Respondents according to Year they came to live in Uyo

Year	**Frequency**	**Percent**	**Valid percent**
Born in Uyo	32	3.7	3.9
1963-1972	1	0.1	0.1
1972-1982	23	2.7	2.8
1983-1992	79	9.2	9.6
1993-2002	183	21.4	22.3
2003-2012	324	37.8	39.6
2013 till date	177	20.7	21.6
Total	819	95.6	100
Missing values	38	4.4	
Total	857	100.0	

Table I suggests the need to expand residential accommodation and urban infrastructure to keep pace with future population explosions.

It was observed that many of the dwellers reside and move within neighbourhoods that are not designed as residential estates. This is shown in table II.

Table II: Movement from Former to Present Locality (n = 788)

Former Locality	**Present Locality**	**Frequency**	**Percentage**
Estate	Estate	11	1.4
	Non-Estate	29	3.7
Non Estate	Estate	50	6.3
	Non-Estate	596	75.6
Other Areas	Estate	10	1.3
	Non-Estate	92	11.7
	Total	788	100

Table II shows that 75.6% of the respondents moved from non-estate to non-estate neighbourhoods while only 6.3% moved from non-estate to estate neighbourhoods. Out of a

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total of 5.5% of the movers that relocated from their previous accommodation in the neighbourhood made of a planned estate, only 1.4% moved into the estate neighbourhood. In comparison, 3.7% moved into a non-estate neighbourhood. About 91% of the respondents moved from their former locations to non-estate neighbourhoods, while only 9% moved to planned estates.

Further results show that residential mobility is highest among tenants of tenement rooming accommodation mainly patronized by low- and medium-income earners (junior and senior staff), representing about 67% of the respondents. These respondents are on a monthly salary below N100,000 per month.

Table III: Movement from Former to Present Accommodation (n=811)

Former Accommodation	Present Accommodation	Frequency	Percent	Former Accommodation	Present Accommodation	Frequency	Percent
One Room	One room	141	17.4	Three bedroom flat	Two-room	8	1.0
	Two rooms	77	9.5		Two rooms	2	0.2
	Self-contained	43	5.3		Self-contained	8	1.0
	Two bedroom flat	39	4.8		Two bedroom flat	3	0.4
	Three bedroom flat	35	4.3		Three bedroom flat	31	3.8
	One bedroom flat	5	0.6		One bedroom flat	4	0.5
	Four bedroom flat	1	0.1		Four bedroom flat	3	0.4
	Five bedroom flat	2	0.2		Five bedroom flat	1	0.1
	family house	4	0.5	One bedroom flat	One room	1	0.1
2 Rooms	One room	18	2.2		Two rooms	1	0.1
	Two rooms	28	3.5		Self-contained	4	0.5
	Self-contained	11	1.4		Two bedroom flat	3	0.4
	Two bedroom flat	49	6.0		Three bedroom flat	4	0.5
	Three bedroom flat	22	2.7		One bedroom flat	7	0.9
	One bedroom flat	8	1.0	family house	One room	3	0.4
	Four bedroom flat	7	0.9		Self-contained	1	0.1

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	Five bedroom flat	1	0.1		Two bedroom flat	1	0.1
	family house	2	0.2		family house	3	0.4
Self-contained	One room	36	4.4	Five bedroom flat	One room	1	0.1
	Two rooms	10	1.2		Self-contained	1	0.1
	Self-contained	89	11.0		Five bedroom flat	2	0.2
	Two bedroom flat	22	2.7	**Total**		**811**	**100**
	Three bedroom flat	13	1.6				
	One bedroom flat	3	0.4				
	Four bedroom flat	2	0.2				
	family house	2	0.2				
Two bedroom flat	One room	4	0.5				
	Two rooms	7	0.9				
	Self-contained	1	0.1				
	Two bedroom flat	12	1.5				
	Three bedroom flat	21	2.6				
	One bedroom flat	2	0.2				
	Four bedroom flat	1	0.1				
	family house	1	0.1				

From Table III, 42.7% of the respondents lived in single room accommodation before their last relocation, 21.78% lived in self-contained accommodation, while 18% lived in two-bedroom tenement buildings. In all, they make up 60.7% of occupiers of tenement rooming apartments (these accommodations comprise of one room and two rooms, with shared facilities).

Out of the total movements made by the respondents, a total of 41.5% moved into either a single room tenement building (26.1%) or a two-room tenement building (15.4%). This shows that there is a relatively high demand for residential accommodations classified as tenement rooms. This is closely followed by Self-contained apartments (rooms with toilet and kitchen en-suite) (19.5%). Two and 3-bedroom flats rank high in demand (15.9% and 15.5%, respectively). In contrast, 2.6%, 1.6% and 0.6% of the respondents have attracted to

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1-bedroom flats, four-bedroom flats five-bedroom flats, respectively. These results give a fair representation of the nature of demand for residential accommodation in the Uyo property market.

Under the current resident status of the respondents, the findings show that 24.4% moved from their previous accommodations as tenants to own their own houses. Another 72.4% moved from their previous locations as tenants to their new locations while remaining as tenants. A further 3.1% turned out to be squatters. Proportionally, the result shows a high ratio of tenants to landlords ratio (approximately 3:1). This suggests a high propensity of growth in demand for rented accommodation as the population grows.

These results show that of the 857 respondents, 94.63% had moved from one accommodation to another. The breakdown indicates that 30.2% had moved once, 30.8% moved twice, 24.6% moved three times, and 9.5% and 5.15% had moved four and five times, respectively. This is shown in Table IV.

Table IV: Residential Status and Number of Change of Residence

Number of Times	Status in Current Residence	Frequency	Percent
Once	Landlord	50	7.8
	Tenant	138	21.6
	Squatter	5	0.8
Twice	Landlord	45	7.1
	Tenant	143	22.4
	Squatter	8	1.3
Three Times	Landlord	34	5.3
	Tenant	122	19.1
	Squatter	1	0.2
Four Times	Landlord	10	1.6
	Tenant	49	7.7
	Squatter	1	0.2
Five Times	Landlord	15	2.4
	Tenant	16	2.5
	Squatter	1	0.2
	Total	638	100

About 56% of the respondents had moved from one location to another about two to three times. This suggests a relatively high residential housing mobility in Uyo. The respondents' location/neighbourhood preferences show that 53.8% preferred living in housing estates to non-housing estates, while 46.2% preferred to live in non-housing estates.

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Further, the results show that 58.7% of the self-employed, 51% of the civil/public servants and 54.3% private sector respondents would prefer to live in purpose-built residential estates to live in a neighbourhood not designed as a residential estate. This indicates that a greater percentage of the respondents across different occupations in Uyo would prefer to live in residential estates than living in a neighbourhood not designed as a residential estate. Although many of the movers relocated to a neighbourhood not designed as a residential estate, a greater proportion of these residents prefer to live in a neighbourhood designed as a residential estate. The responses may further construe that people may be constrained by affordability/availability of preferred accommodation and locations.

6. Conclusion and Recommendations

Residential housing mobility is an inevitable socio-economic activity in every city as only an insignificant percentage of city dwellers are saved the experience. In many cases, the quest for self-satisfaction moderated by economic and social factors often triggered residential housing mobility.

The frequency of residential housing mobility is high in Uyo, as shown by the study. To reduce the high direct and indirect costs associated with residential mobility, there should be an improvement in the accessibility within neighbourhoods, improvement of neighbourhood amenities and the environmental conditions within neighbourhoods. Government intervention in housing provisions through a private-public partnership would help moderate rents, residential housing mobility, and decongest crowded settlements to alleviate the rate of environmental degradation in overcrowded neighbourhoods. Ease of the procedural and administrative bottlenecks and reducing the costs of accessing housing loans and land would significantly encourage residential house ownership, which could undoubtedly moderate the rate of housing mobility in Uyo.

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DII-2021-029

Socio-Economic Status, Gender and Outcome Expectations of Career Choices of Students in Construction Programs in South Africa

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Abstract

This study examined differences in career choice outcome expectations based on gender and socio-economic groups. This study surveyed 229 conveniently sampled students (116 men, 113 women) enrolled in construction-related programs at two universities in South Africa. Participants were drawn from student cohorts enrolled in construction management, civil engineering, property development, land surveying, building and quantity surveying. Adopting Betz and Voyten's (1997) 13-item career decision outcome expectations scale, an exploratory factor analysis supported the 12-item outcome expectations scale. The EFA provided support for the internal validity and reliability of the scale. The Mann-Whitney U and Kruskal-Wallis test was conducted to test for gender and SES differences in the extent to which outcome expectations influenced a career choice in construction. Results indicated the absence of differences among the SES groups. The study revealed no significant differences in the levels of career-choice outcome expectations among men and women

Keywords: Career Choice, Construction Education, Gender, SES, Outcome expectations, South Africa

1. Introduction

Career development theories concerning children validate the fundamental principle that the historical and cultural environment moulds the development of an individual (Watson *et al.,* 2011). Children's self-identity develops through interaction with the environment, primarily exposure to adult career roles (Becares and Priest, 2015). Various social and cultural factors such as family could affect children's career development and aspirations (Schultheiss, 2003; Whiston and Keller, 2004). Patton and Creed (2007) identified systemic social and environmental influences on the career development of children. The aspirations of children are influenced by the prevailing social and cultural environment in which they develop. Personality interests, family, school, media, socio-economic and geographic settings were found to impact the professional aspirations of children (Watson *et al.,*2011; Porfeli *et al.,*2008).

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Making a career choice in construction has not been a prevalent decision by women in South Africa (Enshassi and Mohammaden, 2012; Ozumba and Ozumba, 2012). Despite an extensive range of global legislation developed to promote women’s participation in construction, women are still underrepresented in the construction industry, and more so among students in construction (Male *et al.*, 2017; English and Le Jeune, 2012; Akinlolu and Haupt, 2019). Gender-related studies have revealed that social and cultural role expectations (Powell *et al.*,2009). Owing to its history, many women are brought up to understand that they cannot undertake non-traditional careers such as construction and are advised to follow instead ‘soft skills’ occupations (Sangweni, 2015).

Subsequent research has widened the consensus regarding gender and SES as strong predictors of educational and career outcomes in South Africa- a highly unequal society (Taylor and Yu, 2009). Unterhalter *et al.* (2010) noted that issues of social exclusion concerning the socioeconomic background, family composition and gender, strongly influenced educational attainment and career decisions of boys and girls. Becares and Priest (2015) investigated the inequalities of educational opportunity and found that family and socio-economic background determined academic and career outcomes substantially. The academic level of parents influenced their gender role perceptions. Families from high social classes have less traditional perceptions of gender roles for boys and girls. Trusty *et al.* (2000a); Trusty *et al.,* (2000b); Diemer and Hsieh (2008) opined that students from lower SES backgrounds compared to those from higher SES backgrounds might have limited access to information, career guidance and financial resources, which could limit their choice of careers. Findings from Wynn and Correll (2017) suggested that men and women have different perceptions of the factors that influence their career decisions in male-dominated professions such as construction, as these professions have been resistant to the participation of women. Saiffudin *et al.* (2013) examined the role of gender in the persistence of undergraduate university students in engineering. Gender differences in career decisions and outcomes were found for students in engineering.

Applying SCCT, the current study examined the role of outcome expectations in the career choice process. This study examines the gender and SES differences in outcome expectations related to career choices among a group of undergraduate students enrolled in construction programs. Studies on career choices in male-dominated occupations have been found to include samples from low SES categories rarely. It is crucial to consider examples from a diverse range of SES backgrounds to examine SES differences adequately.

The current study's findings have meaningful implications for career choice and development practice in male-dominated occupations among diverse groups.

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2. Theoretical Framework

This study was framed by the (SCCT) related to the construction industry's students' career choices. SCCT (Lent *et al.*, 1994) is a direct application of the social cognitive theory by Bandura (1989) and elaborates exclusively on the educational interest formation, career development, performance, and persistence of individuals in their career endeavours. Processes whereby individuals' academic and professional interests are developed; the influence of interests and other socio-cognitive mechanisms on career choices, and the attainment of different levels of career performance and persistence are outlined in the SCCT (Lent *et al.*,1994; Ali and McWhirter, 2006). Of interest to the present study is the cognitive process of outcome expectations.

Applying the Social Cognitive Career Theory (SCCT), the current study focused on the role of outcome expectations on career choice. Outcome expectations refer to a person's beliefs relating to probable response outcomes and consequences of performing specific actions (Lent and Brown, 2006). Career choice behaviour is perceived to be significantly dependent on the subjective likelihood that a particular action will yield a certain outcome and the value a person places on those outcomes (Locke *et al.*, 1986; Wanous *et al.*, 1983). According to Bandura (1989), "people act on their judgments of what they can do, as well as on their beliefs with regards to the likely consequences of their actions." Physical outcomes (money), social outcomes (approval), and self-evaluative outcomes were highlighted as the types of outcome expectations (Bandura, 1989). Outcome expectations have been identified as one of the most salient predictors of career choice behaviour as individuals have positive expectations from engaging in the behaviour (Kelly, 2009). Career development theories emphasizing the consequences of decision making have also acknowledged the significance of outcome expectations (Peña-Calvo *et al.*, 2016). Locke *et al.* (1986) perceived career choice behaviour as highly dependent on certain actions' likelihood to produce outcomes.

Several researchers have identified outcome expectations as the strongest correlate of career choice (Alexander *et al.*, 2011; Kelly, 2009; Ochs and Roessler, 2004). For example, (Ali and McWhirter, 2006; Kelly,2009; Lent and Brown, 2012; Lent and Brown, 2006; Lent and Brown, 1996) reported that aside from having the strongest relationship with career choice, outcome expectations are a major career choice predictor particular for people who have difficulties making career choices.

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2. Methodology

A quantitative research method was adopted for the study. The study used a close-ended questionnaire to survey university students enrolled in construction-related programs in South Africa. Based on the advantages of the non-probability sampling method, the study used a conveniently selected sample from two public universities in the KwaZulu-Natal province of South Africa to participate in the study. The two universities were conveniently chosen because of their proximity to the researcher. Convenience sampling involves selecting the closest and more convenient participants to access (Sekaran and Bougie, 2010). This sampling method was preferred to select two universities most relative to the research domicile conveniently. Undergraduate students enrolled in construction-related programmes such as construction management, land surveying, building, civil engineering, quantity surveying and architecture in South African Universities were chosen as the sample frame. A sample size of 229 was used for the analysis.

The survey questionnaire was administered for five weeks. The questionnaires were designed using Google forms and administered electronically by sending out hyperlinks to the questionnaire via email and the WhatsApp platform. Google forms is a cloud-based and online tool used to create and customize questionnaires.

Table I presents the demographic distribution of the respondents. There were 116 men (50.7%) in the sample. First-year students had the most significant number of participants, with 94 students (41%), followed by 2nd-year students at 87 (38%). This participation rate is possible because the 1st year cohort of students at South African Universities is usually larger than the later years or more advanced levels of study.

Most respondents were enrolled in Construction Management (n= 110; 48%), which accounted for the largest number of participants because both participating universities offer the programme. Architecture had the lowest number of students (n=1; 0.4%) in the sample because only one of the universities offered the programme and typically had smaller students than the other disciplines and programmes.

Table I: Demographic Distribution

Gender	**No**	**Percent**
Man	116	50.7%

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Woman	113	49.3%
Total	**229**	**100.00%**
Year of Study		
1st year	94	41.0
2nd year	87	38.0
3rd year	30	13.1
4th year	18	7.9
Total	**229**	**100.00%**
Programme of Study		
Construction Management	110	48.0
Land Surveying	4	1.7
Quantity Surveying	50	21.8
Civil Engineering	17	7.4
Building	47	20.5
Architecture	1	0.4
Total	**229**	**100.00%**

To determine the respondents' socio-economic background, participants were required to indicate the current or last occupation and the highest qualification of the breadwinner of their household.

Table II: Socio-Economic Background

Occupation of the breadwinner of the household	**No**	**Percent**
Unskilled	161	70.3
Skilled	21	9.2
Graduate	39	17.0
Specialist	8	3.5
Highest qualification of the breadwinner of the household	**No**	Percent
Post- Matric	59	25.7

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Matric	54	23.7
High School	59	25.7
Primary School	57	24.9
Socio-economic Category	**No**	Percent
High SES	42	18.3
Medium SES	54	23.6
Low SES	133	58.1
Total	229	100.00%

Table II presents results relating to the socio-economic data of the participants. Most household breadwinners were unskilled workers such as housekeepers, farmers, waiters, and gardeners (n= 161; 70.3%), followed by graduate workers such as teachers, nurses, and police officers (n=39; 17%).

Concerning the highest qualification of the household breadwinner, 59 (25.7%) had post-matric education, 54 (23.7%) had matric education, 59(25.7%) had high school education, and 57 (24.9%) had primary school education. Based on the occupation and the highest qualification of the household's breadwinner, 133 (58.1%) of the students were categorized to be of low socioeconomic status.

Scale Measures

The questions for the questionnaire survey were captured on a 5-point Likert scale where 1= strongly disagree and 5= strongly agree. Respondents were required to indicate their level of agreement with statements about their career choices. Betz and Voyten's (1997) 9- item career decision outcome expectations scale was used to assess the personal belief of the students towards accomplishment for their career choices.

3. Data Analysis

Exploratory Factor Analysis (EFA) was used to test the reliability and validity of the variables assessed in the study. The EFA aims to reduce data by finding the most miniature manageable set of common components that will account for a set of variables (Pallant, 2011). The steps involved in the EFA include assessing the suitability of the data for factor analysis, determining numbers for factor extraction, retaining and rotation, interpretation of

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resulting factors. The analysis included the evaluation of reliability (Cronbach alpha and composite) and the discriminate and convergent validity of the survey instrument.

To determine the strength of intercorrelation among the variables, Bartlett's Test of Sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy test was used to assess the data's factor suitability (Pallant, 2011). Factor analysis is deemed appropriate when the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) value is higher than the acceptable minimum limit of 0.6 and a limit of 1 (Tabachnick and Fidell, 2013). The cut-off value of .05 for Bartlett's Test of Sphericity indicates the significance and appropriateness of the factor model (Hair *et al.*, 2010). The dimensionality and significance of factors were determined using maximum likelihood. Maximum likelihood factoring is beneficial for confirmatory analysis and calculates population values for factor loadings that maximize sampling the observed correlation matrix from a population (Pallant, 2011). The Kaiser's criterion or the eigenvalue rule was adopted to determine the number of factors to retain (Pallant, 2011; Tabachnick and Fidell, 2013).

Table III: KMO and Bartlett's Test for all Outcome Expectations Elements

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.949
Bartlett's Test of Sphericity	Approx. Chi-Square	2988.880
	Df	78
	Sig.	.000

a. Cronbach's alpha =0.962

Exploratory Factor Analysis of Outcome Expectations

The KMO for the outcome expectations items was 0.949, and Bartlett's test of sphericity was obtained with a significance of $p<0.000$, as shown in Table III. Table IV shows that factor loadings for all the thirteen items were above the cut-off value of 0.30. Inspections of the corrected item-total correlation values were above 0.3, indicating that the items were a good measure of the self-efficacy construct. The results confirmed that the data met the criteria for factor analysis. A Cronbach's alpha of 0.962 was obtained for the self-efficacy scale, indicating adequate internal reliability. An analysis of the commonalities in Table IV showed

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that item OTX12 was problematic because of high commonalities. The resulting solution was then interpreted with caution.

Table IV: Outcome Expectations Factor Statistics

Item	Element	Factor Loading	Corrected item-total correlation	Communalities	
				Initial	Extraction
OTX 1	I expect to earn a good and satisfactory salary	.552	.569	.484	.470
OTX 2	I expect to get experience and get better jobs in future	.853	.849	.763	.762
OTX3	I expect to get promoted and get regular salary increases	.714	.717	.593	.593
OTX4	I expect to work in a decent and satisfying work environment	.748	.753	.638	.628
OTX5	I expect to have a stable and secure job	.897	.887	.849	.867
OTX6	I expect to have a stable career and guaranteed employment	.831	.827	.767	.778
OTX7	I expect to have a positive image and contribute to the society	.830	.818	.714	.690
OTX8	I expect to have a satisfying lifestyle	.793	.778	.649	.631
OTX9	I expect to have a happy future	.756	.714	.632	.621
OTX10	I expect to feel productive and have a sense of purpose and worth	.806	.790	.699	.652
OTX11	I expect to achieve my career goals	.888	.850	.807	.818
OTX12	I expect to be successful in my career	.946	.903	.885	**.923**
OTX13	I expect to learn new skills and be able to use these skills and talents in my job	.909	.866	.834	.862

Extraction Method: Maximum Likelihood **High communalities in bold text**

Table V shows that two factors with eigenvalues greater than 1 emerged, explaining 76% of the variance. This result suggests the likely multidimensionality of the sub-scale.

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To obtain a clear factor solution of the outcome expectations construct, item OTX12 (I expect to be successful in my career) was deleted, and the EFA was reiterated. Table VI shows that after eliminating item OTX12, the KMO outcome expectation items were 0.942, and Bartlett’s test of Sphericity was obtained with a significance of p<0.000. Table VII shows that none of the items indicated high communalities.

Table V: Initial Eigenvalues for all Outcome Expectations Elements

Total Variance Explained							
Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	8.949	68.840	68.840	8.644	66.493	66.493	8.159
2	1.012	7.785	76.625	.650	5.002	71.495	7.507
3	.498	3.831	80.455				
4	.425	3.269	83.724				
5	.381	2.929	86.654				
6	.368	2.829	89.482				
7	.324	2.490	91.972				
8	.267	2.051	94.023				
9	.225	1.735	95.758				
10	.210	1.612	97.370				
11	.150	1.153	98.523				
12	.106	.816	99.340				
13	.086	.660	100.000				

Table VI: KMO and Bartlett’s test for Outcome Expectations after the deletion of item OTX12

KMO and Bartlett's Test

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Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.942
Bartlett's Test of Sphericity	Approx. Chi-Square	2510.407
	Df	66
	Sig.	.000

In Table VIII, one factor emerged with an eigenvalue greater than 1, explaining 67.5% of the variance. There was a need for further rotation of the solution since only one factor was extracted. Therefore, the solution was considered unidimensional and adequate evidence of convergent and discriminant validity was achieved for the outcome expectations construct. The correlation values in Table IX indicate that all items of the outcome expectations scale except between OTX9 and OTX1. The highest correlation was between item OTX 6 and OTX5. Correlation values for the seven items for goal representations were high and above the recommended cut-off value of 0.30, confirming discriminant validity.

Table VIII:

Item	Element	Factor Loading	Corrected item-total correlation	Communalities	
				Initial	Extraction
OTX1	I expect to earn a good and satisfactory salary	.585	.577	.480	.342
OTX2	I expect to get experience and get better jobs in future	.864	.849	.758	.746
OTX3	I expect to get promoted and get regular salary increases	.730	.719	.591	.533
OTX4	I expect to work in a decent and satisfying work environment	.767	.756	.638	.588
OTX5	I expect to have a stable and secure job	.907	.887	.848	.822
OTX6	I expect to have a stable career and guaranteed employment	.849	.830	.767	.722
OTX7	I expect to have a positive image and contribute to the society	.832	.814	.710	.691

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OTX8	I expect to have a satisfying lifestyle	.791	.773	.640	.626
OTX9	I expect to have a happy future	.737	.704	.630	.543
OTX10	I expect to feel productive and have a sense of purpose and worth	.808	.786	.699	.653
OTX11	I expect to achieve my career goals	.862	.838	.775	.743
OTX13	I expect to learn new skills and be able to use these skills and talents in my job	.879	.853	.798	.773

Extraction Method: Maximum Likelihood Rotation Method: Promax with Kaiser Normalization

Table VIII: Initial Eigenvalues for Outcome Expectations items after the deletion of item OTX12

Total Variance Explained						
Factor	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**		
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	8.109	67.578	67.578	7.783	64.856	64.856
2	.972	8.104	75.682			
3	.498	4.149	79.830			
4	.425	3.539	83.370			
5	.381	3.172	86.541			
6	.367	3.058	89.599			
7	.311	2.591	92.191			
8	.262	2.183	94.373			
9	.219	1.828	96.201			
10	.204	1.697	97.899			

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11	.149	1.242	99.141				
12	.103	.859	100.000				

Table IX: Correlation Coefficient for Outcome Expectations

	OTX1	OTX2	OTX3	OTX4	OTX5	OTX6	OTX7	OTX8	OTX9	OTX10	0TX11	OTX13
TX1	1.000											
TX2	.599	.000										
TX3	.552	688	1.000									
TX4	.568	639	.619	.000								
TX5	.548	818	.708	738	1.000							
TX6	.556	744	.645	691	.849	1.000						
TX7	.487	683	.564	682	.728	.660	.000					
TX8	.413	672	.591	547	.694	.638	694	1.000				
TX9	.271	624	.461	502	.631	.578	607	.656	1.000			
TX10	.440	683	.510	603	.668	.703	727	.672	.593	1.000		
TX11	.434	719	.609	605	.757	.687	716	.690	.744	.731	1.000	
TX13	.427	739	.574	644	.769	.691	779	.715	.716	.758	.829	1.000

Gender differences in the influence of Outcome Expectations on Career Choice

The Mann-Whitney U test was conducted to test for significant differences between men and women regarding the thirteen assessed outcome expectation variables. Table X shows the mean scores for the career choice predictor, their rank orders for men group, women group and men and women combined. The Z-value and the Sig. Values obtained from the Mann-Whitney U test were also presented. Men reported a mean score of 57.57, while women reported 56.44.

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The Mann-Whitney U test revealed no significant differences among the gender groups regarding their perception of the influence of outcome expectations (Z value =-0.296, p=0.767, as the Sig. Value was above the cut-off value of 0.05.

Table X: Test Statistics for Gender and Outcome Expectations

	Men	Women	Mann-Whitney U	
	MIS	**MIS**		
			Z-value	Sig.
Outcome Expectations	57.75	56.44	-0.296	0.767

Differences among SES Categories

Table XI shows the mean scores for outcome expectations, the rank orders for the high SES, medium SES, and low SES groups. The Chi-square value, degree of freedom (df) and Sig. Value obtained was also presented.

To test for the significant differences in the influence of outcome expectations between the SES groups, the Kruskal Wallis test was conducted. As the Sig, no significant differences were found among the SES groups (Chi-square =5.464, p=0.065). The value were greater than the alpha value of 0.05.

Table XI: Test Statistics for SES and Outcome Expectations

	High SES	Medium SES	Low SES	Kruskal-Wallis		
	MIS	**MIS**	**MIS**	**Test Static**	**Df**	Sig.
Outcome Expectations	54.26	57.88	57.68	5.464	2	0.065

4.Discussion of Results

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The cognitive process of outcome expectations is a major predictor for people who have difficulties making career choices. This study tried to verify the influence of these expectations on the choice of careers. After conducting various statistical analyses on the 13 outcome expectation elements, these were reduced to 12 elements. Therefore, *I expected to succeed in my career* and was eliminated from further analysis to obtain a clear factor solution of the outcome expectations construct.

Contrary to what was expected from the literature review and previous studies, the study found no significant gender differences relative to their perception of the influence of outcome expectations on their choice of careers. Therefore, whether a person is male or female did not influence their own final choices about careers.

Similarly, the study also found no significant differences between the influence of socioeconomic status on the choice of careers. Therefore, whether the breadwinner in the family was classified as having a high, medium or low socioeconomic background based on their highest academic qualification or experience did not affect decisions about their own career choices.

5. Conclusion and Recommendations

The study sought by applying Social Cognitive Career Theory (SCCT) to understand the influence of outcome expectations on career choice. Outcome expectations relate to the beliefs and judgments of persons concerning probable response outcomes and consequences of performing certain actions and the value placed on those response outcomes. The study found that contrary to common belief as suggested by literature and previous similar studies, neither gender nor socioeconomic status or background of the family's breadwinners had any significant influence on the final choice of careers.

Therefore, it is recommended that further studies be conducted on other sample groups to determine the extent to which social exclusion concerning the socioeconomic background, family composition, and gender influenced educational attainment and career decisions within the South African context.

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DII-2021-028

Skills Development in The Construction Industry Through Road Maintenance Activities

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Abstract

This paper examines the role of road maintenance activities in the transfer of skills. South Africa is faced with a high level of infrastructure and skill deficits. While several new road infrastructures are being built, existing infrastructure is falling into disrepair. South Africa has a record of poor maintenance for its road infrastructure. Well-maintained road infrastructure is crucial as they improve the delivery of public goods and service and develop access to economic activities. The study rationale is that road maintenance as an ongoing activity can create employment and skill transfer opportunities. There is a relationship between lack of skill and unemployment. Simultaneously, road maintenance projects will afford workers the opportunities to deepen their skills and improve their earning potential. A review of the extant literature is undertaken to determine how road maintenance contributes to skills transfer and the feasibility of road maintenance projects, specifically fostering skills transfers. Data were collected using personal interviews and focus groups. It emerged from the study that road maintenance activities have the potential for skills development. Based on these findings, the study concludes that skills will be developed and transferred if there is an investment in road maintenance activities. The study recommends that the South African government at all levels should package road maintenance projects targeted at skills development while improving the existing infrastructure. The study's limitations are that the study was conducted based on road maintenance, and the finding may not be generalised to new road construction.

Keywords: Infrastructure, Qualitative Research, Road maintenance, Skill development, Skillstransfer, Sustainability

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1. Introduction

This study examines how road maintenance projects contribute to transferring technical, administrative, and managerial skills. South Africa is facing a high unemployment rate of 32% (StatsSA, 2021). According to the National development plan (2012), South Africa seeks to foster an economy that addresses challenges such as high unemployment; poor education, especially for disadvantaged communities, which potentially result in lower skill levels (Mamabolo *et al.*,2017).

There is a challenge of poor maintenance of road infrastructure, of which lack of skills is an issue (Matshidze *et al.*,2016). Studies cite a correlation between high unemployment rates and poor skills (Mamabolo *et al.*,2017), with employers reporting a 'skills gap' (Dainty *et al.*,2004).

High levels of unemployment are particularly concentrated among the Historical Disadvantaged Individual (HDI). These have been seen as part of a historical legacy of apartheid policies, which intentionally under-developed black settlements and used them as cheap labour reservoirs (Wolpe, 1972). The apartheid government's approach was to underdevelop the economy in black settlements to force blacks to men to provide basic labour to the mines and cities (Yudelman and Jeeves, 1986; Turok, 2012). The critical focus of apartheid industrial development policy led to greater marginalization, where those who acquired skills were trained at the lowest skills level. This makes it difficult for beneficiaries to migrate to a higher skills segment, necessary for industrialisation and international competitiveness (Kraak, 2005; McGrath, 2004).

Besides human capital challenges, the country also faces a higher infrastructure gap, which is much higher in black settlements (McGrath and Akojee, 2010). This infrastructure gap is more evident in poor road networks, as identified by (Mamabolo 2016). Roads play a crucial role in economic development as they provide access to public goods and link people to markets (Escobal and Ponce, 2002) and employment opportunities (Porter, 2014). During road maintenance projects, a road also provides work opportunities.

To address the skill gap, the South African government has launched several interventions. Some of these included educational and skills reforms, while others focused on providing skills through work opportunities. Human Capital Theory (HCT) has placed education and training at the centre and considered it the source of economic development (Tan, 2014). There is a relationship between economic growth and investments in upskilling their

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populations (Masiliūnas, 2019). South Africa has been trying to shift focus towards technical and vocational education. These are necessary as they provide primary and secondary skills crucial to address unemployment and support economic development (Terblanche and Bitzer, 2018). Their issue of skill mapping requires more consultations, as those skills are less supported by the public, usually receive less financial support (Kuruvilla, 1996).

One of the initiatives to create employment and transfer skills has been the Expanded Public Works Project (EPWP). However, EPWP has been widely used on new road construction, unlike road maintenance. These provide short-term opportunities to provide skills and employment. However, the process of providing skills requires a long-term programme. Road maintenance, unlike new road build, is an ongoing activity without a set timeframe. Thus, road maintenance activities will produce a sustained and ongoing workload that provides a degree of workflow predictability necessary for creating permanent employment while upskilling the low-skilled to deepen their skills (Segal and Moore, 2002).

However, there is limited research into the levels of mentorship and skills transfer opportunities provided by road maintenance projects. It is unknown whether these road maintenance projects' sustained and ongoing workload contributes to a higher level of mentorship, skills transfer than short-term new road construction projects.

2. Literature Review

2.1. Skills development

The skill remains a key focus for researchers, while it remains a core focus of public policy intervention in the modern era (Green, 2011). A large body of research supports that various skillsets develop individuals, employers, regions, and most nations and regions' economic activities(Green, 2011). However, there remains no agreement among social scientists about the meaning of the concept of skill (Green, 2011). Simply said, skill does aid persons to achieve a task at a higher quality, efficiently (Cuthrie, 1952). Knowledge, learning, and training (Laosirihongthong and Lim, 2009). The availability of a skilled workforce remains a challenge for South Africa and many other developing nations (Hanushek and Woessmann, 2008; Daniels, 2007). There is an argument on the source lack of skills in South Africa. However, the following as commonly cited migration, apartheid's legacy, ageing, and retirement of skilled workers (Juan and Visser, 2017; Daniels, 2007). Highly skilled workers employed by the public services are also likely to exist in favour of better

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employment conditions and compensation offered by the private sector (Mateus *et al.*,2014). South Africa is in low education and high employment trap. The government is developing policies to address this (Sharaunga, 2019).

2.2. Classification of skills

Skills can be classified as technical, cognitive, and socio-emotional (Allais, 2012). However, according to Beauregard (2010), these are the following main domains of competence intrapersonal, interpersonal, and cognitive. Besides technical skills, a human requires other skills to function as a rational adult. These skills are necessarily integrating humans into society. These include being an effective team player, grit, the ability to exercise self-control, and lead.

According to Gottfredson (1997), cognitive skills are necessary as they give us the ability to understand to learn from experiences, adapt effectively to an environment, and understand complex ideas. Several scholars have cited cognitive skills having a bearing in the success and effectiveness of a leader (Jackson, 1997; McVey, 1995; Mumford *et al.*, 2017). Our ability of the depth and speed to process information while engaging in complex problems lies with intelligence (Tyler, 1964). Byrnes (2009) classified technical skills as expertise, acquired knowledge, and interactions needed to perform a specific job, including the mastery of the tools and materials. Technical skills usually include quantitative attributes that deal more with technology and specific discipline-based knowledge (Uni-obuda.hu, 2018). This study focuses on the skills needed to be transferred through road maintenance activities. These include technical, which will aid in performing specific tasks, cognitive to understand the project environment, and socio-emotional for leadership.

2.3. Processes in skill acquisition and transfer

According to Honken (2013), there are five stages during skills acquisition (1) novice, (2) advanced beginner, (3) achieving competence, (4) showing proficiency, and (5) having expertise. During the initial stage or novice, the instructor focuses on removing context from the task at hand and relocating it into something familiar to aid beginners with understanding. This is where the understanding and competency are at the lowest level, as they are yet to be exposed to the skill (Agénor and Alpaslan, 2018). The novice is usually unable to comprehend the knowledge deficit from the new skill and the further required learning to master the skills as they lack awareness (Tumen, 2015). At this stage, learned are keen to learn.

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The next stage is the advanced beginner stage. At this stage, learners develop an understanding of context and consciousness on the knowledge gap. The instructor aid trainee as able to contextualise the task and differentiate them using different examples. They also possess knowledge and awareness, enabling them to notice errors (Duncan and DePew, 2011). The trainee learns to understand the limitation of their knowledge to a specific skill through gaining more experience (Tumen, 2015).

When learners gain competency, they develop confidence and become pragmatic when solving challenges and performing their assignments. They are also to develop strategies independently to perform their assignment competently (Levey and Polirstok, 2011). While experts, due to training and experience acquired through previous assignments, can recognise the task at hand and apply the correct methodology to achieve results. Experts usually can apply different methodologies to achieve results. They are also able to know which method will achieve the best results (Gobet, 2016). To succeed in the industry, there is also a requirement to learn soft skills such as personality traits, social gracefulness, and fluency in language, personal habits, friendliness, and optimism are crucial to career development (Pachauri and Yadav, 2014).

2.4. The necessity of skills acquisition

Besides quantities of skilled personnel in economic progress, there is also a question of quality in terms of skills supply, the level of skills, and the adaptability of skilled personnel to respond and contribute in a technological changing society (Lall, 2001). Wirth and Perkins (2008) agree that early knowledge is necessary to leverage and use it to build more advanced skills. The key emphasis of education policy should be to help students develop capacity and apply their knowledge to task-specific, in different areas (Newell-Jones *et al.,* 2005). There is an argument of the co-relation of low skills and persistent poverty; skilled populations can pull themselves out of poverty by raising their income (Mishra, 2016).

Developing nations face low skills and skills development as a panacea to assist their population with low skills and unemployment trap, which deepens poverty (Tumen, 2015; Wallenborn, 2009). There is also a correlation between highly skilled labour and higher productivity, which lower the costs for producing goods and services (Lange *et al.*, 2000). Highly skilled workers improve their earning potential and have better labour mobility (Pena, 2015; Sjöberg, 2007; Sutton, 2018). Skills people have a better status in society and authority in the workplace while improving their income (Schnurr *et al.*, 2016). There is a relationship between the cost of skills and their importance (Ma *et al.,* 2019). Learn usually

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reject acquiring skills of low or uncertain quality (Ma *et al.,* 2019). There are other barriers, which prevent learners from acquiring skills. These are relevance, dropout, and quality (Mishra, 2016).

While to acquire a skill, one will have to understand the language of instruction, location to the venue, and costs associated with skills acquisition (Clokie and Fourie, 2016; Kohnke, 2011). Higher cost remains the greatest inhibit to skills acquisition. However, the government also has some hindrances (Veneziani and Luca Zamparelli, 2018). Location of skills service providers remains an issue. Those who travel to training centres may struggle to find suitable accommodation at lower costs. These have the potential to increase overall costs (Veneziani and Luca Zamparelli, 2018). In South Africa, skill service providers often use English learning and teaching, which is a barrier. There is always a requirement for learners to possess a certain level of competence in spoken or written English (Kohnke, 2011).

The question of the relevance of skill with the locality. There is a higher drop rate of those who enrol for skills and fail to complete (Acharya, 2016). There are several reasons leading-learners to drop out from acquiring a skill. Costs, relevance, and perceived quality of the skills taught are reasons when learners drop out (Clokie and Fourie, 2016; Kohnke, 2011; Veneziani and Luca Zamparelli, 2018).

2.5. South African skills development policy

According Department of Higher Education (DHET) (2006), the guiding objective behind the Skills Development Framework (SDF) is that the South African workforce, primarily been the employees in the education development and training sectors, should possess competitive and relevant skills. This is necessary for employee development, enhancing performance to the organisation, and actively contributing to South Africa's development and its economy (DHET, 2006). According to Tladinyane (2016), the foundation of the policy was the acknowledgement of South Africa’s lack of skill which in turn hampered the country's international competitiveness. Increased investment in education and training was one of the policy's key objectives: forge partnerships with employers and encourage continuous learning within employment (DHET, 2006). The focus was also to redress the past imbalances of apartheid policies, assist the newly trained legacies workforce with employment opportunities, and improve quality education and training (DHET, 2006).

According to Cosser *et al.* (2010), South Africa introduced a policy on skills development

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levy through the skills development Levies Act. The basis behind the development of the skill development Levy Act was a national plan to address the skills gap. The objective was to increase learning access, improve employment opportunities, and increase productivity (Rauner, 2010). To assist the employer by creating a reservoir of productive and skilled workforce, read to participate in formal employment (Rehman and Mughal, 2013). The fund will allocate money to registered Sector Education and Training Authorities (SETAs). SETAs model was conceptualized to address South Africa's chronic skills shortage. However, besides all these initiatives, the South African skills challenge remains.

2.6 Road maintenance project activities and their contribution to skills development

There is a need to conduct road maintenance promptly, decreasing the costs involved and limiting the loss of asset value to the road (Do and Jung, 2018). This is necessary to reduce potential high costs of repair when a road surface deteriorates (Ornston, 2014). Most road maintenance activities require basic skills, and unskilled labour could implement labour-based methods after receiving some basic training (Miller *et al.*, 2013; Townshend, 2020). South Africa has debated employing more labour-intensive methods in construction to address skills shortages and unemployment. However, the question remains on the economic feasibility of labour-intensive construction methods in road build. There is an argument that some activities in road maintenance may not necessarily require heavy equipment. According to Thwala (2008), to address unemployment and transfer skills, there is a need to shift towards labour-intensive construction methods whenever feasible.

3. Research Methodology

Qualitative data were collected through a semi-structured interview. Data required for this study was not readily available to the public. Therefore, participants with relevant experience were selected to participate in this study. Interviews enable the researcher to be chosen as the best option to collect data. The study adopted a qualitative research approach because the information required is not normally distributed in the population. Unlike questionnaires, interviews provide a researcher with retailed and rich qualitative data and help participants explain their experiences and give disruption and meaning to their experience (Rubin and Bellamy, 2012). However, structured interviews miss out as they do not private follow-up and probing questions, which increases the richness of the data

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through participants' own experience (Raiden *et al.*, 2008). The qualitative and semi-structured method was appreciated as it gave participants a platform to share their experiences from their perspectives.

Interviews play a central role while also using multiple data sources, in keeping with grounded theory (Goulding, 1998; Cresswell, 1998). Unlike questionnaires, interviews allow a researcher to select relevant participants and ask specific questions to understand their experience, feelings, and knowledge (Hussey and Hussey, 1997; Naoum, 1998). The focus on road maintenance clients was to understand their strategy and how it can assist in transferring skills. The feasibility of road maintenance projects as a bedrock for skills transfer. The focus on the contractors was their roles in aiding skills transfer through road maintenance activities. Participants were selected based on certain criteria, which included education and experience. Interviews afforded participants to share their experience, knowledge, and feelings (Creswell, 2015).

Qualitative data was collected through a two-stage process. Stage one was a focus group with seven selected experts with keen knowledge on skills transfer. This was an open date on the subject of skill transfer. The researcher acted as a moderator to guide and direct the discussion. Stage two involved fourteen experts in a face-to-face semi-structured interview. These interviews lasted between twenty-five minutes to an hour. This study mainly focused on the contractors, consultants, and clients in road maintenance and skills development. They were selected based on possessing certain experience within the industry. All participants held a university degree.

The plan was to conduct all interviews in person, where it was not feasible to do so. Some interviews were conducted electronically through Microsoft Teams and Skype. Interview protocols were mailed to the participants to prepare them, and a suitable time was arranged for the call. Follow-up questions (more probing) were asked later to improve the validity.

4. Results and Discussions

This study sought to understand if clients, contractors, and consultants understand the South African skills development policy. The level of compliance by the contractors to this important government initiative. Participants were aware of the policy and were fully committed to assisting the government in creating a skilled workforce. They also raised issues of risks and the failure of the government to effectively communicate their policy and initiatives with the public in general. The risk was using unskilled workers while

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achieving the highest quality and completing a project within the timeframe. Contractors agree that the risk can be minimised through allocating work packages based on risk profile and workers' experience.

Government departments were vested and well implementing the skills development program through their road maintenance projects. The government department also has a scorecard to evaluate the effectiveness of their program. Government departments also engage skills service providers to provide skills to the learners. This is done to ensure that learners receive skills fit for their purpose.

The findings support those road maintenance activities as suitable for skills transfer. Road maintenance, unlike road construction, is an ongoing activity that provides trainees and learners with long-term arrangements.

This study, supported by literature, has emerged that road maintenance actives are suitable in supporting skills transfer. According to Thwala (2008) and Shirai and Kimura (2005), road maintenance has several activities such as layers works, concrete repairs works, road marking, and laying curbing, which may be conducted with greater involvement of human labour. Primary data collected for this study supports that road maintenance activities are suitable for skills transfer.

5. Conclusions

The main objective of the study was to investigate the role of road maintenance activities in skills transfer. From the study, it emerged that there several types of skilled vital towards personal development. Engaging more labour-intensive initiatives in road maintenance projects can increase the participation of those excluded due to lack of skills. South Africa has been supporting more labour-intensive methods to increase the participation of the unskilled while decreasing unemployment. The study recommends that the South African government at all levels should package road maintenance projects targeted at skills development while improving the existing infrastructure.

Unlike road construction, road maintenance activities require basic skills and minimal types of equipment. With basic training, most unskilled personnel may participate meaningfully in road maintenance activities. South Africa has debated employing more labour-intensive methods in construction to address skills shortages and unemployment. To address

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unemployment and transfer skills, there is a need to shift towards labour-intensive construction methods whenever feasible. This study recommends that the government at all levels should package road maintenance projects targeted at skills development while improving the existing infrastructure.

6. Acknowledgement

This work is supported by NRF (Grant Number-120843). Opinions and conclusions are those of the authors and are not necessarily attributable to the NRF.

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DII-2021-016

The Impact of An Industry Summit on Health and Safety (H&S) Practitioners' Industry 4.0 Perceptions

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Abstract

Given the historic health and safety (H&S) challenges, in terms of a range of issues that continue to be experienced, the advent of Industry 4.0, and the opportunity in the form of a two-day construction H&S summit, delegates were surveyed to determine their perceptions, whether the presentations had an impact on their understanding and appreciation of the H&S challenges. The potential of Industry 4.0 technologies to improve H&S. The paper reports on the findings emanating from a quantitative study that entailed completing a self-administered questionnaire survey conducted among delegates at the summit's inception and closure. The findings indicate that a range of H&S challenges is experienced in construction. Industry 4.0 technologies can contribute to addressing the H&S challenges. The presentations impacted their understanding and appreciation of the H&S challenges. The findings are primarily based upon perceptions of the potential of Industry 4.0 technologies to contribute to addressing the H&S challenges. The study reports on findings from one of a limited number of Industry 4.0 studies conducted in construction. The results indicate the level of awareness concerning Industry 4.0 and the likelihood of implementing such technologies as, initially, practitioners are likely to act upon perceptions.

Keywords: Construction, Health and Safety, Industry 4.0, Performance.

1. Introduction

The South African construction industry does not have a favourable H&S record, which has been noted in various industry reports, among other things, by the Construction Industry Development Board (CIDB) (2009). This is reflected in a high level of non-compliance, a disabling injury incidence rate (DIIR) of 0.98, and a fatality rate (FR) of 25.5 per 100 000 workers. Furthermore, there are financial implications, both direct and indirect, arising from accidents, which contribute to the cost of construction. The high level of H&S non-compliance in South African construction is attributed to inadequate integration of H&S into the early stages of projects by the design team and inadequate management and supervision of H&S on sites (CIDB, 2009). Construction sites are complex in terms of the nature and range of activities undertaken throughout the construction process, which is compounded by

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the challenges of monitoring and inspecting the activities to, among other things, mitigate hazards and risks (Park *et al.*,2016).

However, according to Zeiba (2019), contractors in the United States of America (USA) have adopted Industry 4.0 technologies to mitigate accidents and improve H&S performance. Furthermore, Swallow and Zulu (2019) state that effective H&S management requires planning and coordination of the construction team and a holistic view and understanding of a project. The study they conducted to determine the benefits of and barriers to adopting 4D modelling to support H&S management identified many benefits. These include enhanced hazard identification courtesy of the visualised planning approach relative to plant, logistics, and high-risk work such as working at heights.

Given the standard of H&S in South African construction, the challenges related to traditionally managing H&S, and the cited potential of Industry 4.0 to contribute to improving H&S performance. A questionnaire survey was administered to delegates attending a two-day construction H&S summit to determine their perceptions and whether the presentations impacted their understanding and appreciation of the challenges and the potential of Industry 4.0 technologies to improve H&S.

2. Literature Review

2.1 The manual approach to health and safety

Martinez *et al.* (2019) conducted a case study in Chile to compare an unmanned aerial vehicle (UAV)-facilitated H&S monitoring process versus the outcome of the traditional manual process using 2D plans and schedules. The study determined that the UAV approach, which entailed generating visual content such as photos, videos, point cloud data (PCD), and 3D models, enabled H&S managers to identify more hazards and enhance their perception of probability severity and risk level relative to the hazards.

2.2 The role of Industry 4.0 technologies

The Dodge Safety Report cites the findings of a study conducted among contractors in the USA to determine their current use of Industry 4.0 technologies to enhance H&S on-site and the potential of such technologies to improve H&S on site in the next three years (Dodge Data & Analytics, 2020). The percentages are recorded within parentheses, current use first, followed by potential: wearable devices (11%; 63%); virtual reality for training (5%; 36%); visual monitoring with artificial intelligence (AI) (3%; 33%); drones (18%; 30%); automated equipment / robotics (4%; 22%); optical head-mounted display (4%; 19%); laser scanning

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(11%; 17%); augmented reality (3%; 14%), and photogrammetry (3%; 6%). It is notable that in the case of all technologies, the percentage potential of a technology to improve H&S exceeds the percentage of current use, and in the case of wearable technologies by as much as 52%.

According to Zhang *et al.* (2019), traditional H&S training has entailed a classroom environment and a facilitator using text-based or imaged-aided training material. Such training has received negative critique due to its passive and 'one-way' nature and limited engagement. Visualisation technologies such as augmented reality (AR), virtual reality (VR), mixed reality (MR), and gaming facilitate simulation and engagement and enable behavioural modelling.

3. Research Method and Sample Stratum

A one-question questionnaire consisting of twenty-nine Likert Scale type sub-questions was administered to delegates attending a two-day Association of Construction Health and Safety Management (ACHASM) construction H&S summit in Durban, South Africa, 2 – 3 October 2019, at the inception. The closure of the two-day Summit to determine their perceptions and whether the presentations impacted their understanding and appreciation of the challenges and the potential of Industry 4.0 technologies to improve H&S. The sample is best described as a convenience sample. 24 Responses were included in the analysis of the data. This entailed the computation of frequencies and a measure of central tendency in a mean score (MS) between 1.00 and 5.00, based upon the percentage responses to the points on the scale to enable interpretation of the responses.

4. Research Findings

Table I indicates the 'pre-summit extent to which the respondents concur with 29 statements regarding percentage responses to a scale of strongly disagree to strongly agree and an MS between 1.00 and 5.00. Based upon the literature review, all the statements were positively stated or true, and therefore, the MSs should indicate agreement instead of disagreement.

Notably, no pre-MSs are > 4.20 ≤ 5.00, which indicates concurrence between agree to agree strongly agree / strongly.

16 / 29 (MSs) are > 3.40 ≤ 4.20, which indicates concurrence between neutral to agree / agree. Notably, 15 / 16 statements are 'Industry 4.0 technologies can contribute to ………'-related. The highest degree of concurrence (4.00) is relative to 'visualising a construction

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activity and thus the related hazards' and 'gathering data', followed by 'visualising the construction process and thus the related hazards' (3.92). Notably, two of the top three statements are visualising related. These are followed by two '3.88' MS statements, namely 'monitoring H&S non-compliance, 'determining the cost of accidents', 'linking H&S requirements to construction activities' (3.87), and 'integrating H&S into the construction process' (3.83). Monitoring H&S compliance is a challenge due to the nature of construction and determining the cost of accidents. The latter due to the indirect cost of accidents, which are difficult to quantify. However, drones can provide surveillance footage at the time of accidents, thus quantifying the indirect cost of accidents. Integrating H&S into the design process is a challenge as designers are invariably not H&S specialists, and therefore historical drone footage, IoT, AR, and VR can assist (Zeiba, 2019). This argument applies to 'linking H&S requirements to construction activities' and 'integrating H&S into the construction process' as H&S practitioners are not 'constructors'.

A cluster of six statements falls within a range of 0.04 (3.79 to 3.75), namely 'linking H&S information to construction activities', 'integrating construction H&S into the design process', 'mitigating hazards to which workers are exposed', 'determining the cost of H&S', 'linking a range of H&S requirements relative to a construction activity', and 'monitoring the process and activities of construction (in terms of H&S)'. One of many challenges is the number, or volume of issues, relative to H&S, hence the concurrence relative to the first three, and 'linking a range of H&S requirements relative to a construction activity'. 'Determining the cost of H&S' and 'monitoring the process and activities of construction (in terms of H&S)' constitute challenges due to the nature, extent, and complexity of the construction process and its activities. Hence, the degree of concurrence, i.e. it is simply not possible to do so manually (Park et al.., 2016). The only 'It is challenging to ……' statement that features in this range is 'determine the cost of accidents' (3.43).

All 12 / 29 statements with MSs $> 2.60 \leq 3.40$, which indicates the concurrence is between disagree and neutral/neutral, are 'It is challenging to ……' statements. A further 2 / 29 have MSs $> 1.80 \leq 2.60$, which indicates the concurrence is between strongly disagree to disagree/disagree. However, the respective MSs are marginally below the upper end of the range.

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Table I: Pre-summit degree of consensus with statements

Statement	Response (%)						Mean score
	Unsure	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
Industry 4.0 technologies can contribute to visualising a construction activity and thus the related hazards	0.0	4.2	0.0	4.2	75.0	16.7	4.00
Industry 4.0 technologies can contribute to gathering data	0.0	4.2	0.0	8.3	66.7	20.8	4.00
Industry 4.0 technologies can contribute to visualising the construction process and thus the related hazards	0.0	4.2	0.0	8.3	75.0	12.5	3.92
Industry 4.0 technologies can contribute to integrating H&S into construction activities	0.0	4.2	4.2	4.2	75.0	12.5	3.88
Industry 4.0 technologies can contribute to monitoring H&S non-compliance	0.0	4.2	4.2	12.5	58.3	20.8	3.88
Industry 4.0 technologies can contribute to determining the cost of accidents	0.0	4.2	0.0	16.7	62.5	16.7	3.88
Industry 4.0 technologies can contribute to linking H&S requirements to construction activities	0.0	4.3	0.0	13.0	69.6	13.0	3.87
Industry 4.0 technologies can contribute to integrating H&S into the construction process	0.0	4.2	4.2	8.3	70.8	12.5	3.83
Industry 4.0 technologies can contribute to linking H&S information to construction activities	0.0	4.2	8.3	4.2	70.8	12.5	3.79
Industry 4.0 technologies can contribute to integrating construction H&S into the design process	4.2	4.2	4.2	8.3	70.8	8.3	3.78
Industry 4.0 technologies can contribute to mitigating hazards to which workers are exposed	4.2	4.2	4.2	8.3	70.8	8.3	3.78
Industry 4.0 technologies can contribute to determining the cost of H&S	4.2	4.2	8.3	4.2	66.7	12.5	3.78
Industry 4.0 technologies can contribute to linking a range of H&S requirements relative to a construction activity	0.0	4.2	0.0	20.8	66.7	8.3	3.75
Industry 4.0 technologies can contribute to monitoring the process and activities of construction (in terms of H&S)	0.0	4.2	8.3	8.3	66.7	12.5	3.75
It is challenging to determine the cost of accidents	0.0	8.7	17.4	4.3	60.9	8.7	3.43
It is challenging to determine the cost of H&S	0.0	4.3	26.1	13.0	43.5	13.0	3.35

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It is challenging to integrate construction H&S into the design process	8.3	12.5	20.8	8.3	41.7	8.3	3.14
It is challenging to manually link a range of related H&S requirements relative to a construction activity	0.0	8.7	21.7	21.7	43.5	4.3	3.13
It is challenging to gather H&S data	0.0	4.5	31.8	18.2	40.9	4.5	3.09
It is challenging to manually link H&S information to construction activities	0.0	13.0	30.4	8.7	43.5	4.3	2.96
It is challenging to physically monitor H&S non-compliance	4.3	8.7	30.4	13.0	43.5	0.0	2.95
It is challenging to integrate construction H&S into the procurement process	12.5	12.5	25.0	16.7	29.2	4.2	2.86
It is challenging to assure the integration of H&S into construction activities	0.0	13.0	43.5	0.0	34.8	8.7	2.83
It is challenging to physically monitor the process and activities of construction (in terms of H&S)	0.0	8.7	34.8	21.7	34.8	0.0	2.83
It is challenging to manually link H&S requirements to construction activities	0.0	13.6	31.8	13.6	40.9	0.0	2.82
It is challenging to visualise a construction activity and thus the related hazards	0.0	8.7	39.1	17.4	34.8	0.0	2.78
It is challenging to visualise the construction process and thus the related hazards	0.0	9.1	45.5	9.1	36.4	0.0	2.73
It is challenging to mitigate hazards to which workers are exposed	4.3	8.7	52.2	8.7	26.1	0.0	2.55
It is challenging to assure the integration of H&S into the construction process	0.0	21.7	39.1	4.3	34.8	0.0	2.52

Table II indicates the 'post-summit extent to which the respondents concur with 29 statements regarding percentage responses to a scale of strongly disagree to strongly agree and a MS between 1.00 and 5.00. Based upon the literature review, all the statements were positively stated or true, and therefore, the MSs should indicate agreement instead of disagreement.

It is notable that although no pre-MSs are > 4.20 ≤ 5.00, 8 / 29 (27.6%) post-MSs are, which indicates concurrence between agree to strongly agree / strongly agree. These are all 'Industry 4.0 technologies can contribute to .... ' statements, namely: visualising the construction process and thus the related hazards; linking H&S information to construction activities; linking H&S requirements to construction activities; mitigating hazards to which workers are exposed; integrating H&S into the construction process; linking a range of H&S requirements relative to construction activity; visualising a construction

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activity and thus the related hazards, and monitoring the process and activities of construction (in terms of H&S).

5 / 29 (17.2%) MSs are > 3.40 ≤ 4.20, which indicates concurrence between neutral to agree / agree. These are all 'Industry 4.0 technologies can contribute to ………' statements: integrating construction H&S into the design process; integrating H&S into construction activities; determining the cost of H&S; monitoring H&S non-compliance, and determining the cost of accidents.

As in the case of the 'pre-summit MSs, all 12 / 29 (41.4%) statements with MSs > 2.60 ≤ 3.40, which indicates the concurrence between disagreeing and neutral/neutral, are 'It is challenging to ……' statements.

A further 3 / 29 (10.4%) statements have MSs > 1.80 ≤ 2.60, which indicates the concurrence is between strongly disagree to disagree/disagree. These are 'It is challenging to ……' statements.

Table II: Post-summit degree of consensus with statements

Statement	**Response (%)**						**Mean score**
	Unsure	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**	
Industry 4.0 technologies can contribute to visualising the construction process and thus the related hazards	0.0	0.0	4.2	0.0	58.3	37.5	4.29
Industry 4.0 technologies can contribute to linking H&S information to construction activities	0.0	0.0	4.2	0.0	62.5	33.3	4.25
Industry 4.0 technologies can contribute to linking H&S requirements to construction activities	0.0	0.0	4.2	0.0	62.5	33.3	4.25
Industry 4.0 technologies can contribute to mitigating hazards to which workers are exposed	0.0	0.0	4.2	0.0	62.5	33.3	4.25
Industry 4.0 technologies can contribute to integrating H&S into the construction process	0.0	0.0	4.2	0.0	66.7	29.2	4.21
Industry 4.0 technologies can contribute to linking a range of H&S requirements relative to a construction activity	0.0	0.0	4.2	0.0	66.7	29.2	4.21
Industry 4.0 technologies can contribute to visualising a construction activity and thus the related hazards	0.0	0.0	4.2	0.0	66.7	29.2	4.21
Industry 4.0 technologies can contribute to monitoring the process and activities of construction (in terms of H&S)	0.0	0.0	4.2	4.2	58.3	33.3	4.21

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Industry 4.0 technologies can contribute to integrating construction H&S into the design process	0.0	0.0	4.2	4.2	62.5	29.2	4.17
Industry 4.0 technologies can contribute to integrating H&S into construction activities	0.0	0.0	4.2	0.0	70.8	25.0	4.17
Industry 4.0 technologies can contribute to determining the cost of H&S	0.0	0.0	4.3	0.0	69.6	26.1	4.17
Industry 4.0 technologies can contribute to monitoring H&S non-compliance	4.2	0.0	8.3	0.0	62.5	25.0	4.09
Industry 4.0 technologies can contribute to determining the cost of accidents	0.0	0.0	4.2	12.5	62.5	20.8	4.00
It is challenging to integrate construction H&S into the design process	0.0	8.3	29.2	0.0	50.0	12.5	3.29
It is challenging to gather H&S data	0.0	8.7	21.7	17.4	43.5	8.7	3.22
It is challenging to integrate construction H&S into the procurement process	0.0	8.3	29.2	8.3	45.8	8.3	3.17
It is challenging to determine the cost of accidents	0.0	8.3	33.3	8.3	37.5	12.5	3.13
It is challenging to manually link H&S requirements to construction activities	0.0	12.5	29.2	8.3	50.0	0.0	2.96
It is challenging to determine the cost of H&S	0.0	8.3	37.5	12.5	33.3	8.3	2.96
It is challenging to manually link H&S information to construction activities	0.0	8.3	37.5	8.3	45.8	0.0	2.92
It is challenging to manually link a range of related H&S requirements relative to a construction activity	0.0	8.3	37.5	16.7	37.5	0.0	2.83
It is challenging to visualise the construction process and thus the related hazards	0.0	12.5	45.8	8.3	20.8	12.5	2.75
It is challenging to assure the integration of H&S into the construction process	0.0	12.5	45.8	8.3	25.0	8.3	2.71
It is challenging to assure the integration of H&S into construction activities	0.0	12.5	37.5	16.7	33.3	0.0	2.71
It is challenging to physically monitor H&S non-compliance	0.0	8.3	54.2	4.2	33.3	0.0	2.63
It is challenging to visualise a construction activity and thus the related hazards	0.0	12.5	45.8	20.8	12.5	8.3	2.58
It is challenging to mitigate hazards to which workers are exposed	0.0	8.3	54.2	20.8	12.5	4.2	2.50
It is challenging to physically monitor the process and activities of construction (in terms of H&S)	0.0	12.5	45.8	25.0	16.7	0.0	2.46

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Table III presents a comparison of the pre- and post-summit degree of consensus with statements in terms of MSs, and the percentage post-MSs are greater than pre-MSs.

The top five statements that recorded the greatest percentage increase in terms of the post-MS versus the pre-MS are: ‘Industry 4.0 technologies can contribute to mitigating hazards to which workers are exposed’; ‘It is challenging to integrate construction H&S into the procurement process’; ‘Industry 4.0 technologies can contribute to linking a range of H&S requirements relative to a construction activity’; ‘Industry 4.0 technologies can contribute to monitoring the process and activities of construction (in terms of H&S)’, and ‘Industry 4.0 technologies can contribute to linking H&S information to construction activities’.

The top five statements that recorded the greatest percentage decrease in terms of the post-MS versus the pre-MS are: ‘It is challenging to physically monitor the process and activities of construction (in terms of H&S)’; ‘It is challenging to determine the cost of H&S’; ‘It is challenging to monitor H&S non-compliance physically’; ‘It is challenging to manually link a range of related H&S requirements relative to a construction activity’, and ‘It is challenging to determine the cost of accidents’.

Table III: Comparison of the pre- and post-summit degree of consensus with statements

Statement	**Pre MS**	**Post MS**	**% Post > Pre**
Industry 4.0 technologies can contribute to mitigating hazards to which workers are exposed	3.78	4.25	16.9
It is challenging to integrate construction H&S into the procurement process	2.86	3.17	16.7
Industry 4.0 technologies can contribute to linking a range of H&S requirements relative to a construction activity	3.75	4.21	16.7
Industry 4.0 technologies can contribute to monitoring the process and activities of construction (in terms of H&S)	3.75	4.21	16.7
Industry 4.0 technologies can contribute to linking H&S information to construction activities	3.79	4.25	16.5
Industry 4.0 technologies can contribute to integrating construction H&S into the design process	3.78	4.17	14.0
Industry 4.0 technologies can contribute to determining the cost of H&S	3.78	4.17	14.0
Industry 4.0 technologies can contribute to integrating H&S into the construction process	3.83	4.21	13.4
Industry 4.0 technologies can contribute to linking H&S requirements to construction activities	3.87	4.25	13.2
Industry 4.0 technologies can contribute to visualising the construction process and thus the related hazards	3.92	4.29	12.7

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It is challenging to assure the integration of H&S into the construction process	2.52	2.71	12.5
Industry 4.0 technologies can contribute to integrating H&S into construction activities	3.88	4.17	10.1
It is challenging to link H&S requirements to construction activities manually	2.82	2.96	7.7
Industry 4.0 technologies can contribute to monitoring H&S non-compliance	3.88	4.09	7.3
It is challenging to integrate construction H&S into the design process	3.14	3.29	7.0
Industry 4.0 technologies can contribute to visualising a construction activity and thus the related hazards	4.00	4.21	7.0
It is challenging to gather H&S data	3.09	3.22	6.2
Industry 4.0 technologies can contribute to gathering data	4.00	4.13	4.3
Industry 4.0 technologies can contribute to determining the cost of accidents	3.88	4.00	4.2
It is challenging to visualise the construction process and thus the related hazards	2.73	2.75	1.2
It is challenging to link H&S information to construction activities manually	2.96	2.92	(2.0)
It is challenging to mitigate hazards to which workers are exposed	2.55	2.50	(3.2)
It is challenging to assure the integration of H&S into construction activities	2.83	2.71	(6.6)
It is challenging to visualise a construction activity and thus the related hazards	2.78	2.58	(11.2)
It is challenging to determine the cost of accidents	3.43	3.13	(12.3)
It is challenging to manually link a range of related H&S requirements relative to a construction activity	3.13	2.83	(14.1)
It is challenging to monitor H&S non-compliance physically	2.95	2.63	(16.4)
It is challenging to determine the cost of H&S	3.35	2.96	(16.6)
It is challenging to physically monitor the process and activities of construction (in terms of H&S)	2.83	2.46	(20.2)

5 Discussions

The research findings reflect the literature review, namely that construction workers are frequently faced with hazards and risks throughout the entire construction process (Seo *et al.*,2015). That construction work is physically demanding (Nath *et al.*,2017). Furthermore,

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the traditional approach to monitoring and measuring H&S-related issues, largely manual, exacerbates the situation (Awolusi *et al.*, 2018).

The use of drones for real-time monitoring and control of onsite practices and the development of mitigation strategies is well documented (Gheisari and Esmaeili, 2016; Alizadehsalehi *et al.*, 2017). Wearable technologies can enable the continuous monitoring of a wide range of vital signals through positioning and sensor technologies (Ananthanarayan and Siek, 2010; HSE, 2019). The virtues of visualisation technologies such as AR and VR have been espoused to improve H&S by improving on-site tasks such as data visualisation, work inspection, and checking for omissions (Le *et al.*,2015; Park *et al.*, 2013).

With respect to the research, 8 / 29 (27.6%) post-MSs are > 4.20 ≤ 5.00 (agree to strongly agree / strongly agree) are relative to 'Industry 4.0 technologies can contribute to …………….' statements, namely: visualising the construction process and thus the related hazards; linking H&S information to construction activities; linking H&S requirements to construction activities; mitigating hazards to which workers are exposed; integrating H&S into the construction process; linking a range of H&S requirements relative to construction activity; visualising a construction activity and thus the related hazards, and monitoring the process and activities of construction (in terms of H&S). A further 5 / 29 (17.2%) MSs are > 3.40 ≤ 4.20 (neutral to agree/agree) are relative to 'Industry 4.0 technologies can contribute to ………' statements, namely: integrating construction H&S into the design process; integrating H&S into construction activities; determining the cost of H&S; monitoring H&S non-compliance, and determining the cost of accidents.

It should be noted that although 12 / 29 (41.4%) statements that have MSs > 2.60 ≤ 3.40 (disagree to neutral/neutral) and a further 3 / 29 (10.4%) statements have MSs > 1.80 ≤ 2.60 (between strongly disagree to disagree/disagree) are 'It is challenging to ……' statements, it is challenging to manage H&S in the traditional manual manner, which is underscored by the potential of Industry 4.0 technologies to resolve the challenges.

6 Conclusions

Given the pre-seminar MSs, delegates did understand and appreciate the degree to which Industry 4.0 technologies can contribute to addressing a range of H&S issues and the degree to which it is challenging to address a range of issues traditionally. The latter also underscores the findings reflected in the literature. However, they attended the symposium, likely to constitute the more committed and possibly more knowledgeable H&S practitioners.

The summit did have an impact in terms of enhancing understanding and appreciation of the degree to which Industry 4.0 technologies can contribute to addressing a range of H&S issues; however, the difference between post and pre-MSs was greater than 10% in the case

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of only 12 / 29 (41.4%) statements. This could be attributed to the delegates having an average or above-average understanding and appreciation before the symposium. Furthermore, there was a negative difference or decrease in the post-MSs relative to 9 / 29 (31.0%) ‘it is challenging to address a range of issues in the traditional manner’ statements. In the case of ‘It is challenging to physically monitor the process and activities of construction (in terms of H&S),’ the difference was – 20.2%, ‘It is challenging to determine the cost of H&S’ (- 16.6%), and ‘It is challenging to monitor H&S non-compliance (- 16.4%) physically. This negative difference could be attributable to the delegates being influenced by how Industry 4.0 technologies can address H&S issues during the symposium.

It is important to quantify the impact of summits and training interventions as they are intended to enhance understanding and appreciation of the subject areas addressed, just as it is important to assess the impact of H&S induction in the workplace.

7 Recommendations

All tertiary built environment education should address ‘The role of Industry 4.0 in construction H&S’ and highlight the role of H&S in overall project performance. Statutory and professional councils’ accreditation panels should review the extent to which construction H&S and ‘The role of Industry 4.0 in construction H&S’ is addressed in such programmes.

‘The role of Industry 4.0 in construction H&S’ should continue to be addressed during continuing professional development (CPD) for the foreseeable future.

Statutory and professional councils should evolve ‘Industry 4.0 and construction H&S’ practice notes’ and promote CPD relative thereto.

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DII-2021-036

Machine Accidents and Project Delivery in Kwazulu-Natal Construction Industry

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Abstract

This paper identifies machines accidents, the number of days lost, cost impact and related accidents in the Construction Industry in the KwaZulu-Natal province of South Africa. Accidents in the construction business encounter severe challenges as the occurrence of accidents is faced in the business. The critical parameters for assessing project deliveries are health and safety, cost, time and project quality. The events of accidents on construction premises sabotages these critical parameters of delivery. The main focus of this paper is to determine the significance of lost days and the number of accidents on the cost per accident, using the accident data of KwaZulu-Natal from the year 2000 to 2020. Statistical tests were conducted to determine the significance of the lost days and the number of accidents (independent variables) on the cost per accident (dependent variable). Five statistical tests were used in the analysis of the data. The five statistical tests were grouped into three classes; Regression, correlation and paired sample tests. Regression is subdivided into ANOVA, correlation and model summary test. All 5 tests display the significance of testing variables. The results reveal that there is a significant relationship between the dependent and the independent variables. There is also a positive relationship between lost days and the average cost per accident. At the same time, there is a negative relationship between the number of accidents and the average cost per accident. The positive B value of lost days means it directly influences the average cost per accident. This means for every increase in days lost to accidents on the site, the costs increase and vice versa. The negative B of the number of days indicates that accidents do not directly influence the average cost per accident. Further, the machine accidents that most cause fatalities are: motorised equipment, truck, lorries, dumpers, building structures, roof work, scaffoldings and staging and wall projections. It is recommended that workers pay more attention to these sources of accidents while working on site.

Keywords: Accidents, Effects, Project delivery, Construction Industry

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1 Introduction

Most often the costs of construction accidents depend on the impact during and after the incident. It can be concluded that the more the severity of the accident, the longer the time to return to normalcy and the more the cost incurred in the process. Though insuring projects and workers is as important as executing the project, it is important to acknowledge that insurance will not be responsible for all pay-outs but only cover for severe injuries and damage in line with the insured costs.

Adequate knowledge of construction logistics will help a project manager or an employer handle building construction work with minimal or less severe accidents. Identifying the cause of accidents and the key workers that could be hurt is vital. Once these are done, preventive health and safety measures should be designed, implemented, and monitored to ensure the measures are adhered to at all-time in that specific construction project. This paper covers factors causing machine accidents on construction sites, delay in building construction due to site mishaps, cost effect overview, effects of loss of days on construction works, effects of accidents on the construction industry and effect of loss of days, number of accidents on the average cost per accident.

The main objective of this paper is to determine the effects of lost days and the number of accidents in construction on the average cost per accident. This will inform both workers and project managers to prepare carefully toward ensuring accident-free work.

2 Literature Review

2.1. Losses in construction

Unsafe behaviour is responsible for close to 80% to 90% of construction accidents *(*Oswalda *et al.*, 2015). Upon all safety and precautionary measures put in place, the building construction industry continues to experience a rise in cases of machine-related accidents (Tang et al., 1997). Consequently, it has not stopped. Construction accidents account for about 67% of all industry related occupational accidents (Tang *et al.*, 2004). The more investment in safety, the safer the sector. Some project managers always allocate between 0.25% and 0.5% of the contract sum to ensure a safe construction environment. They developed a generic method to compute the minor financial safety investment to consider in every construction project.

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Tang (2003) defines financial costs in building construction accidents as all losses attributed to accidents in the building construction industry; while economic losses were classified as:

i. Loss from the injured person: Under this category, the injured site worker is compensated for each day of being absent due to the injury sustained on the site up to two-third of his daily wage. The second category under (i) is a case of compensation resulting from a disability that the injured staff suffers as a result of an accident in the cause of duty.

ii Loss due to just resumed, recuperating worker, who cannot perform efficiently at 100% capacity as expected. Equation 1 is used to determine this kind of loss.
Loss = Wage of injured worker × (Day loss × 1/10 + % of disability)...................................... (1)

iii Loss as a result of medical fees of the injured person and the cost of conveying injured worker to the hospital.

Iv Loss from fines and legal expenses as a result of workers' accidents in cases where the project manager is fined due to legal claims.

v Loss as a result of inefficiency of other employees due to the occurrence of accidents. This comes in the form of colleagues attending to affected workers, reporting as the case may be, and sometimes weariness from the shock of the accident may lead to some workers stopping work for a moment.

vi Machine and equipment-related losses include loss due to broken-down equipment due to accident, loss due to work destroyed during the accident, loss when equipment and machines were left idle. At the same time, other workers regain their strength from accident shock.

The overall costs of building construction accidents are a function of the safety performance (Tang *et al.,* 1997). A high accident cost means the safety performance is poor and vice versa. The accident loss ratio (ALR) measures the ratio of the costs of different accidents to contract sum at separate periods.

2.2. Construction accident costs on the economy

Accidents cause delay; delays promote reduced productivity, resulting in increased construction costs (Owolabi *et al.,* 2014). Construction sites accident costs can be grouped under direct and indirect costs (Wan Azmi and Misnan, 2013, Williams *et al.,* 2017b).

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Financial losses due to time and equipment damage resulting from accidents are indirect costs, while medical treatment bills and injury compensations (Agwu and Olele, 2014). The proportion of indirect to direct cost is computed to be 11:1 (Holt, 2008, Pillay and Haupt, 2008). In South Africa, the costs of accidents in construction in the construction industry constitute about 5% of the whole construction value, while the United Kingdom and the United States contribute 8.5% and 6.5%, respectively (CIDB, 2009). Contractors are contributing factors to construction accidents by not meeting the requirement in providing on-site safety information and safety personnel (Kemei *et al.*, 2015).

Table I: Expected employer costs from accidents

Cost Variable	Descriptions
Fatalities, injuries and absenteeism	Cost of lost work time, production, fines and legal payments
Staff turnover	Replacement training and recruitment costs
Early retirement and disability	Costs associated with retirement, fines and payments to the injured person
Non-medical rehabilitation	Counselling, retraining and workplace changes
Administration duties	Time and effort spent investigating the accident
Damaged equipment	Repair and replacement costs
Insurance premiums	Any increases, refusal, changes in cover or conditions attached
Legal liabilities	Fines, regulatory activity, settlements and associated costs
Lost production time	Losses in production
Opportunity losses	Lost orders, inability to start or finish orders on time
Present time income losses	Loss of income from present and second jobs
Loss of potential future earnings	Loss of income from present and second jobs
Expenses not covered	Medical, travel, new clothing

Source: (Hrymak and Pérezgonzález, 2007, Mossink and de Greef, 2002)

2.3. Effects of accidents in the construction industry

In a report in 2004, about 45 550 cases of workplace accidents and ill health were recorded in three days, and also, workplace accidents losses account for about €3.3 to €3.6 billion in a year (Hrymak and Pérezgonzález, 2007). Table I describes essential variables that affect construction costs as a result of accidents. Thirty-three questionnaires collected from three sectors of labour, agriculture, mines and quarries, and construction industries indicated that the costs reported in construction-related accidents had the highest proportion of all accidents, up to 61% (Hrymak and Pérezgonzález, 2007). In a 2005 report of workplace accidents in the UK, more than 1 million cases were reported. About 40 million days of work were lost, making about 25 000 workforce unable to continue working due to disabilities from accidents (Hrymak and Pérezgonzález, 2007). These coughed out up to £3.3 billion to

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£6.5 billion from employers, while £910 million to £3710 million were paid as settlement for property and equipment damage during the recorded accidents.

Construction accidents cost a lot more than the recorded or the visible (Mossink and de Greef, 2002). It is difficult to accurately estimate the costs of workplace accidents and ill health (Hrymak and Pérezgonzález, 2007). It causes negative corporate image, loss of days, labour boycott, administrative costs, and many more. The European Union in 1998 suffered losses approximated between 1 to 3 % of the gross net product (GNP) to workplace accidents (Mossink and de Greef, 2002). Losses also include up to 150 million days, and in 2002, workplace accidents cost the EU and the United States up to €20 billion and €171 billion, respectively.

Compared to occupational accidents in South Africa, construction-related accidents have a considerable impact due to many workers getting injured and killed than in other occupational accidents (Pillay and Haupt, 2008). Globally, accidents in the construction sector gulp up to 4% of Gross Domestic Product (GDP), while in South Africa, it gulps almost 3.5%, which can be quantified as approximately US$4.2 billion. This financial commitment did not account for costs resulting from rising absenteeism at work due to accidents, schedule delays, and poor work attitude when morale is low (Pillay and Haupt, 2008).

The contribution of the construction industry to economic development is substantial as it contributes a gross domestic product (GDP) of about 7-10% in developed nations and about 3-6% in underdeveloped nations (Osei, 2013, Giang and Pheng, 2011, Murie, 2007) Construction industry in Turkey has a national employment capacity of about 7.4% and contributes 11.5% to the GNP in 2013 (Yılmaz and Kanıt, 2018). South Africa construction sector contributes about 4% to the country's GDP (Africa., 2014a). The construction sector is classified as the second biggest employer of labour globally, with developing countries' proportion of up to 75% of the global record (Okoro *et al.*, 2016). In South Africa, the construction sector employs about 8% working force and global data accounts for 7% (Africa, 2014b). Therefore, it is a sector that provides diverse job opportunities to the many unskilled workers, thereby enhancing the standard of living (Okoro *et al.*, 2016).

The thought of every contractor at the beginning of every construction project is to complete the project without cases of accidents. Still, along the way, accidents happen, and the extent of the impact is not predictable. They only depend on the reactions of the people involved.

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Construction site accidents can be prevented, minimising waste and boosting performance (Pillay and Haupt, 2008).

2.4. Overview of the cost-effectiveness of construction accidents

Work-related accidents and injuries are burdensome to the employers and affect employees and society in general (Hoła *et al.*, 2017). The South African Department of Labour paid out about R319 million (about $50 million U.S.) as compensations and medical bills of occupational hazards resulting from work accidents (Pillay and Haupt, 2008).

The ratio of direct cost to indirect costs in construction accidents differs from place to place and the severity of the accidents. It could be 1:67 (Haupt and Pillay, 2016), as high as 1:20 and as low as 1:1 (Hinze and Appelgate, 1991); in South Africa, it is estimated to be 1:14.2 (Smallwood, 1999).

In South Africa Construction Industry, the three most common machines or equipment related accidents are:

i. accidents where workers are trapped, cut, and or caught in between

ii. accidents involving being struck by or against, and

iii. accidents due to falls from a height.

(Pillay and Haupt, 2008), published the costs for some kinds of construction industry accidents as paid by the South African Compensation Commission in 2008, they are;

i. Fatal accidents R1.500 000

ii. Wasted workday R30 000

iii. Medical attention R3 500

iv. First Aid attention R1 000

In construction accidents, indirect costs, which address relief from injuries and pains, account for about 58% of the financial implications, and production loss, including process delays that takes about 8.4% (Pillay and Haupt, 2008).

As per building and construction activities, work is always expressed as input and output. Input resources include costs expended in executing a construction project and man-hours (Intergraph, 2012). Technology is a significant factor in ensuring better productivity in building construction works (Intergraph, 2012). Effective labour, accurate planning and data capturing, visualization of site activities and many more, which enhance timely and cost-effective project delivery, can be achieved using the latest technologies.

Due to the inherent insignificant nature of construction productivity losses, it is always difficult to accurately account for all losses. (Hrymak and Pérezgonzález, 2007), Researched

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in Ireland, where the costs and effects of occupational accidents were investigated using twenty case studies. The research indicated that construction accidents culminate in the extended fall in the finance of some of the investigated organizations up to 50% (Hrymak and Pérezgonzález, 2007). Employers also put some methods in place to measure how productivity is affected by costs, as cases of lost days due to site accidents were reported. There are always cases of replacement staff for the injured worker, which incur extra wage while medical expenses are still made for the injured.

Construction accidents have more impact on the finance of small and medium organizations because the organizations do not have enough staff to cover for the injured (Hrymak and Pérezgonzález, 2007). Another reason to prevent accidents in construction companies is that stakeholders spend quite a long time investigating accidents according to the procedure. Over 33% of workers involved in construction accident cases were not involved in any financial commitment, while they were still compensated financially (Hrymak and Pérezgonzález, 2007).

2.5. Causes of machine accidents in the construction industry

Due to the nature of activities, construction environment, equipment capacity and speed, the limited number of highly trained personnel for operating the equipment, and other causes, machine-related accidents are increasing (Niskanen and Saarsalmi, 1983). Many steps are being taken to minimize accidents in the construction industry. Only little is achieved yet (Zhang and D., 2013). About 82% of machine accidents on construction sites were due to lack of necessary training, 80% were due to falling from heights, and 60% were due to electrical equipment, making the construction industry a high-risk industry (Prasad and Rao, 2013, Abukhashabah *et al.*, 2020b, Pinto *et al.*, 2011).

22% of the 7.7% of the population of America that makes the construction workforce has died as a result of work-related accidents (Kalatpour and Khavaji, 2016, Helander, 1991). The UK's death rate of construction workers rose by 3.7% (Abukhashabah *et al.*, 2020a, Enshassi and Mohammad, 2012). The construction industry integrates different delicate technical operations and triggers accidents when handled properly (Mosly, 2015, Gürcanli and Müngen, 2009). It also comprises different people working on a job at different concentrations, training, experience and state of mind (Hare *et al*., 2006, Im *et al.*, 2009).

The two major types of accidents in the construction industry are moving vehicles and stationary machines (Mohan and Zech, 2005).

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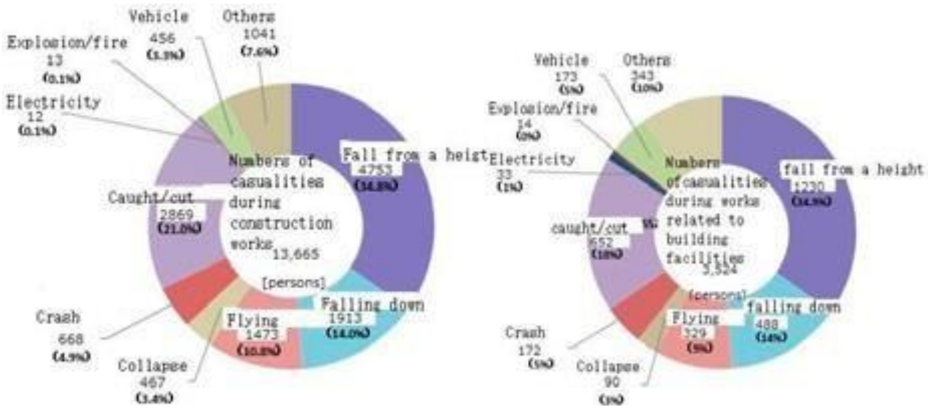

Figure 1. Causes of construction casualties in 2013 (Tamura and Tanaka, 2016).

Machine-related accidents in construction occur while workers carry out their respective responsibilities (Tamura and Tanaka, 2016), meaning the more activities, the more the chances of getting injured. Figure 1 illustrates different accidents recorded between 2004 and 2013. It also revealed the causes and the proportion of each in the account of the overall accident.

3. Methodology

A method to relate lost days and the number of accidents to the cost lost during machine-related accidents in KwaZulu-Natal is considered in this paper. Data were analysed using SPSS, where values were derived for key determinant components discussed in the next section of this paper.

The combined effect of both independent factors is tested against the dependent factor, the average cost of accidents. The analysis will also show that if there is an association between the two factors and the average cost of the accident, what kind of association exist? To test for this, a linear regression model is employed. The linear regression model is used to test a linear relationship between lost days and the number of accidents.

Five related statistical tests were used in the analysis of the data. The data collated include records of lost days, the numbers of accidents and the average cost of an accident. The lost days and the accident numbers are the independent variables, while the average cost of an accident is the dependent variable. The five statistical tests were grouped into three classes;

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Regression, correlation and paired sample tests. Regression is subdivided into ANOVA, correlation and model summary test. All 5 tests display the significance of testing variables.

Correlation is used to determine whether the relationship between parameters shows significance, weak or moderate, high or low. The paired sample test will show the independent factors (variables) effect on the dependent factor (variable). The three regression tests, ANOVA, coefficient test, and a model summary, will test a significant relationship between the predictors and the dependent variable and explain how to fit the model variation on the dependent variable is.

4. Findings and Discussion

Table II presents the recorded data of machine-related accidents in the construction industry in the KwaZulu-Natal Province of South Africa. The table below was extracted from the data of the year 2014 as provided by the statistics of Federated Employer's Mutual Assurance Company (FEM). The impact of the loss of days and the number of accidents was carried out using the accident record from 2000 to 2020.

Table II: Correlation table showing the correlation between variables.

Correlations					
			Lost days	Number of accidents	Average cost per accident
Spearman's rho	Lost days	Correlation co-efficient	1.000	.827**	.633**
		Sig. (2-tailed)		.000	.000
		N	543	543	541
	Number of accidents	Correlation co-efficient	.827**	1.000	.512**
		Sig.(2-tailed)	.000		.000
		N	543		541
	Average cost per accident	Correlation co-efficient	.633**	.512**	1.000
		Sig.(2-tailed)	.000	.000	
		N	541	541	

** Correlation is significant at the 0.01 level (2-tailed).

Table II shows that the correlating lost days with the average cost per accident gives 0.633**. This means the correlation is significant at 0.01. The correlation between the number of

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accidents and the average cost per accident is 0.512**. The result means a stronger correlation between lost days and cost of an accident at 63.3% than between the number of accidents and an average cost of an accident at 51.2%. Since the p-value is significant, it correlates with the outcomes presented in Table VII that the relationship between the parameters is significant.

Table IV: Paired samples test table displaying the significant difference of the predictors on average cost per accident

	Paired sampled Tests								
		Paired difference							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		T	Df	Sig. (2-tailed)
					Lower	upper			
Pair 1	Lost days average cost per accident	-27466.543824	79745.151377	3428.511845	-34201.39	-20731.68906868	-8.011	540	0.000
Pair 2	Number of accidents	-27648.457741	79830.281720	3432.17184171884	-34390.502157	-20906.413325	-8.056	540	.000

Since results presented in Table III confirm a significant correlation between the dependent and the independent variables, a paired sample test is further done to investigate a significant difference between the test variables. Here also, the p-value shows the difference is significant. In Table IV, the tested null hypothesis was no association between lost days and an average cost of accidents. Since the p-value is less than 0.05, the null hypothesis is rejected and concluded that there is a significant difference between the lost days and the average accident cost. The second tested null hypothesis was no association between the number of accidents and the average cost of accidents. Still, since the p-value is less than 0.05, the null hypothesis is rejected. It is concluded that there is a significant difference between the number of accidents and the average accident cost.

Table V: Model summary table showing the significance of the independent variable.

Model Summary									
					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.363ᵃ	.132	.128	74525.792944	.132	40.799	2	538	.000

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a. Predictors: (Constant), NUMBER OF ACCIDENTS, LOST DAYS

13.2% of the variation in the dependent variable (average cost of accidents) was explained by the model. This value is weak to determine the accuracy of dependence. The result of the combined effects of both independent factors is tested against the dependent factor. The average cost of accidents is indicated in Table V. This explains how both variables collectively affect the costs of accidents. From the model summary in Table V, a p-value of 0.000 is obtained, which is less than 0.05, suggesting a linear relationship between lost days and the number of accidents with the cost of accidents.

If there is an association between the two factors and the cost of the accident, what kind of association exist? To test for this, a linear regression model is employed. The linear regression model was used to test if the linear relationship between lost days and the number of accidents. The model summary table shows a p-value of 0.00, which is less than 0.05. Therefore there is a linear relationship between the lost days and the number of accidents.

Table VI: ANOVA table of the variables.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	453198261800.469	2	226599130900.235	40.799	.000[b]
	Residual	2988102471867.005	538	5554093813.879		
	Total	3441300733667.475	540			

a. Dependent Variable: AVERAGE COST PER ACCIDENT
b. Predictors: (Constant), NUMBER OF ACCIDENTS, LOST DAYS

From Table VI, the ANOVA test also shows a significant relationship between the predictors and the dependent variable. Since this relationship is established, the coefficient test will reveal the degree of dependence of the significance in the association, which then fits into hypothesis testing.

Table VII: Coefficient test to present the effect of the predictors on the dependent variable.

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Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	28824.929	3852.362		7.482	.000
	LOST DAYS	111.568	12.389	.542	9.005	.000
	NUMBER OF ACCIDENTS	-1661.291	231.409	-.432	-7.179	.000

a. Dependent Variable: AVERAGE COST PER ACCIDENT

To determine the degree of dependence of each of the independent factors (lost days and number of accidents) over the dependent variable, average cost of accidents, the coefficient test was further carried out and the results revealed in the coefficient table shows a beta value of 111.568 for lost days, which implies that a positive linear relationship exists between lost days and cost of per accident. In contrast, the number of accidents has a beta value of -1661.291, implying a negative linear relationship. In Table VII, the positive B value of lost days means it has a proportional influence on the average cost per accident. For every increase in days lost to the accident on the site, the costs increase and vice versa. The negative B of the number of days indicates that accidents do not directly influence the average cost per accident.

Table II: Indicates selected causes of machine accidents on construction sites, 2019.

CAUSES	ACCIDENTS PERCENTAGE	FATAL ACCIDENTS	LOST DAYS	NUMBER OF ACCIDENTS	AVERAGE COST PER ACCIDENT (R
BRICK, ROCK AND STONE	4.46	0	286	64	18108
BUILDING STRUCTURE	0.21	1	20	3	266,994
DOORS, WINDOWS & GATES	0.98	0	153	14	28,561
EXCAVATIONS NEC	0.28	0	107	4	75,530
GRINDING WHEELS	0.56	0	117	8	36,315
HOISTING APP.CHAIN AND BUCKET,ETC.	0	0	0	0	0
HOISTING APPARATUS - CRANES AND GANTRIES	0.28	0	308	4	397,036
HOISTING APPARATUS - MECHANICAL	0.42	0	216	6	210,706
MISC. - CUTTER , N.E.C.	0.28	0	4	4	2,551
MISC. - MACHINES, N.E.C.	3.55	0	415	51	63,374
MOTORISED EQUIPMENT - TRUCKS, LORRIES, DUMPERS	3.62	4	103	52	60,977
NAILS,SPIKES,FISHBONES	0.63	0	5	9	3,077
OBJECTS FALLING	0.14	0	0	2	31,837
OBJECTS N.O.D.	1.05	0	119	15	85,130
PAINTS,VARNISHES,ETC	0.07	0	126	1	365,195
ROOF	1.25	1	570	18	307,994
ROPES, CABLES & DRUMS	1.53	0	317	22	33,638
SAWS (BAND) WOOD	0.07	0	0	1	41,315
SAW, N.E.C.	0.49	0	12	7	13,575
SAWS (CIRCULAR) WOOD	0	0	0	0	0
SCAFFOLDS & STAGINGS	2.65	1	1080	38	66,098
STEPS & STAIRS	1.74	0	177	25	17,945
TIMBER	0.21	0	0	3	5,661
WALLS (PROJECTION)	0.28	1	101	4	268,544

This explains that the accident's impact determines how many days will be lost and how much is lost during the project. In Table II, four cases of accidents were recorded when using Hoisting apparatus - cranes and gantries, R397 036 and 308 days were lost. In contrast,

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Motorise equipment recorded 103 days lost to accidents. In 52 cases, like R60, 977 was the average cost per accident. The negative value of t and B values in the number of accidents gives us a piece of strong evidence to reject the null hypothesis and conclude that there is a linear relationship between the loss of days and the average cost per accident.

5. Conclusion

Analysing accident cause with emphasis on cost effects on the organisation's management is a fundamental step in ensuring health and safety measures are considered in construction projects execution. The analysis has proven that days of no-work due to accidents significantly impact the overall cost. The analysis has also revealed that the number of accidents plays a prominent part in days without work, which invariably affects the cost of construction work. The interpretation of negative t and B values obtained in Table VII means emphasis should be on the impact of an accident as the number of accidents do not necessarily affect the cost. This means only accident of great severity that keeps workers out of a job for days affects cost significantly. Therefore, high severity accidents should be avoided at all costs in the construction business, especially those involving cranes and gantries, as seen in Table II. The findings from this exploratory analysis prove that loss of days impacts the value of average cost per accident.

A further and detailed record of data is important to make adequate and prompt steps to minimise accidents in the building construction industry.

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DII-2021-037

Occupational Health and Safety Hazards in the Kwazulu- Natal Construction Industry: Causes and Measures

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Abstract

Despite the many safety precautions and improvements, the construction industry has the highest rate of injuries and fatalities in the Occupational Health and Safety industry. Achieving a safe working environment is a global challenge. Therefore, this study examines the causes of injuries and deaths within the construction industry and the preventive measures that can be implemented. A total of fifty (50) construction professionals were surveyed using simple random techniques. The data collection was analyzed using SPSS version 27. Mean values and standard deviation values were computed. Findings suggest that the lack of health and safety procedures and poor implementation procedures cause injuries and fatalities in the construction industry. This study was limited to construction professionals within the Kwazulu-Natal region. The findings guide construction companies that are responsive to the needs of their employees.

Keywords: Fatalities, Improvements, Precautions, Occupational Industry

1. Introduction

The construction industry is a key contributor to the economy of any country. The construction industry presents many challenges such as productivity and profitability, underperforming projects, labour/skills shortage and sustainability. However, the industry plays a major contribution to the development of the economy of South Africa. It is largely regarded as a profitable sector as it delivers the foundations and infrastructure for the economy by providing large scale employment (Sousa *et al.*, 2014 Tixier *et al.*, 2017). Despite the importance of the construction industry in the South African economy, it remains one of the most hazardous working environments in the occupational health and safety industry (Ayhan *et al.*, 2020). The construction industry records the greatest injuries and fatalities from several accidents reported annually (Zhang *et al.*, 2017 and Kang *et al.*,2017). Construction Health & Safety (H&S) is critical in the delivery of projects. Most construction firms give great attention to H&S, South African Construction Industry not being an

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exception. This continuous effort to improve H&S has led to significant improvement in the elimination of accidents, prompt delivery, project meeting budgets, improvements in the entrants into the industry, and a reflection of a good image. Consequently, inductions in the construction industry have minimal fatalities and injuries and compliance with H&S legislation.

2. Literature Review

2.1. Causes of Fatalities and Injuries within the Construction Industry

It has been proven that the Construction Industry contributes to high injury and fatality rates (Cheng *et al.,* 2012; Choudhry and Fang, 2008). The industry is a highly fragmented and hazardous operation. As a result, the construction sector significantly contributes to approximately 50 (fifty) construction worker deaths annually (CRC Construction Innovation, 2007). Further, Construction labour force susceptibility to fatalities and injuries is three times the national average workplace rate, with injury rates 50% higher than those of other sectors (Charles *et al.*, 2007).

2.2. Lack of Safety Awareness and Training

According to Abraha and Liyanage (2015), the lack of information and training contributes to accidents occurring on a construction site. Insufficient knowledge and dangerous construction activities have been identified as the root of construction accidents (Mitropoulos and Namboodiri 2011).

2.3. Occupational Safety and Health Law Non-Compliance

According to Yiu *et al.* (2018), H&S regulations are vital in reducing construction work accidents. In South Africa, the Occupational Health and Safety (OHS) Act No. 85 of 1993 is legislation that every organization must comply with the rules and regulations. This then becomes an operational guideline that assists in enforcing OHS practices. Su *et al.* (2019) stated that in a number of cases, the company's negligence and poor safety habits led to unsafe behaviour of workers, resulting in site accidents.

2.3. Working at Heights in Construction

Workers work at different levels on a project. High level places of work are synonymous with multi-level projects and constitute high-risk areas of accidents. Multi-level/high-level

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construction works are associated with accidents and injuries such as falls from heights, responsible for approximately 50% of fatal injuries (HSE, 2009b). Further, factors identified that contribute to falls from heights include project demands, inclement weather, and cognitive slips (Nadhim *et al.*,2016).

2.4. Subcontracting

Subcontracting is now a large portion of construction work. Approximately 90% of work undertaken in the construction industry are subcontracted (Choe and Leite 2017). There is developing evidence that the use of subcontracting companies has negative H&S effects on workers as monitoring and enforcement of OHS becomes more difficult at workplaces. Subcontracting has been identified within and outside the UK construction industry as a key factor contributing to construction accidents (Manu *et al.*,2013).

2.5. Climatic conditions

Exposure to extreme weather conditions can increase the risk of illnesses such as heat rash, heat cramps, fainting, heat fatigue, or heat stroke. A risk originating from being exposed to the natural environment for long periods, heatstroke as a direct consequence of heat stress can be fatal (Tao *et al.,* 2017). Consequences of heat stress results in risks related to productivity, low worker morale, and legal risk for the organization from subsequent accidents (Feng *et al.*, 2015; Patel and Jha, 2015).

2.6. Effects of injuries and fatalities relative to project delivery

Injuries and fatalities create major implications for project delivery. In addition to the significant expenses associated with various construction accidents. Further, loss of productivity is a cause of delays in the construction industry (Badri *et al.*, 2012 and Choi *et al.*, 2020).

2.8. Minimizing injuries and fatalities in the construction industry

Several methods and procedures can reduce the number of injuries and fatalities on a construction site.

Safety Training and Learning
According to Hallowel (2012), there are common approaches used by construction companies to transfer safety knowledge, such as induction and training sessions, toolbox

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talks, informal safety communication among workers, and formal presentations by safety managers. Han *et al.* (2011) reflect that low skill levels, insufficient technical knowledge, and a steep learning curve are the factors that adversely affects the overall safety performance of workers in the Construction Industry. Islam *et al.* (2019) suggest that the most effective way to assist workers in learning is to explain by providing numerous visual examples and scenarios over time. Further, proactive strategies and precautionary measures emphasize safety training and education. This can be carried out by implementing multi-level fall protection training programs and designing short training courses. Companies can use these strategies for the improvement of safety behaviours (Choe and Leite, 2020).

Management Commitment to Health and Safety Trainings

The degree of Management commitment and involvement to the safety of humans and machines on site is a major contributing factor to the success of an organization's safety programs. These commitment and involvement manifests through job training programs, management participation in safety committees, consideration of safety in job design, and review of the project timeline. Therefore, it is imperative to discuss safety issues by supervisors, and else it will be perceived that safety is unimportant. Ultimately, workers may not place a strong emphasis on safety (Cunningham and Jacobson 2018).

Application of Safety Incentive Schemes

Safety incentives are the most widely used initiative that companies use to promote the safety of workers in the industry (Rozenfeld *et al.*, 2010). Further, incentive schemes can significantly improve company performance and motivate the workforce. According to Cunningham and Jacobson (2018), safety incentive plans can be considered a psychological approach in which employees can be rewarded for safe work practice.

Clients Play Their Role in Safety

The client's participation in reducing accidents and fatalities in construction safety by emphasizing safe contractors, addressing safety issues in design, and active participation in safety management during the construction stage (Turkkan and Pala 2016). Further, fewer accidents were noted when clients played an active role in construction safety and ensured the selection of contractors was based on the companies safety performance (Waziri and Bustani 2017).

Prioritizing Safety in Contractor Selection

Safety performance on projects is guaranteed through selecting safety compliant contractors. An author such as Tixier *et al. (2017) enumerated criteria for selecting and prioritising*

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safety contractors. One of such criteria is screening contractors in terms of their expected safety performance (Cunningham and Jacobson 2018).

Exercise and Stress Management

Exercise programs have a significant success rate for decreasing stress-related injuries in physically demanding projects (Biron *et al.,* 2010). Further, exercise programs can positively reduce work-related injuries and illnesses among employees and improve mental health (Biron *et al.*, 2010).

3. Methodology

Based on literature a questionnaire was developed, and hence this study adopted a quantitative research approach. An exploratory study was developed and issued to 50 construction professionals. The data was collected via a quantitative questionnaire survey comprised of several sections such as causes of injuries and fatalities, effects of the injury and fatality relative to project delivery and precautionary measures that can be used to prevent injuries and fatalities from recurring. Almost all questions took the form of statements around the various themes which required a scaled response of agreement. A 5 point Likert scale was used to rate the responses. Descriptive statistics were derived using SPSS version 27 and presented, including measures of central tendency and dispersion. A limitation to the study was the geographical aspect of the sampling as the survey was conducted in the city of Durban, KwaZulu-Natal province of South Africa.

4. Findings

The tables below present the results of the data analyses and interpretation thereof.

Table I: The causes of injuries and fatalities in the South African construction industry

Factor	Mean score	Std. Dev	Ranking
Lack of safety awareness and training	3.44	0.15	1
Occupational safety and health law non-compliance	3.16	0.11	2
Subcontracting	2.59	0.03	3
Workers' behaviour-related factors contributing to accidents	2.37	0.00	4

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High way collisions	2.28	0.01	5
Climatic conditions	2.22	0.02	6
Falling from heights	2.18	0.03	7
Being caught in or between objects	1.98	0.06	8
Powered industrial truck accidents	1.83	0.08	9
Being struck by objects	1.74	0.09	10

Table I presents the causes of injuries and fatalities in the construction industry. From Table II, it is evident that the most significant cause of injuries and fatalities in the construction industry is lack of safety awareness and training (MS=3.44) is because organisations do not emphasize the importance of safety on a construction site, adequate training is not provided and explained in detail to the workforce (Abraha and Liyanage 2015). Next to lack of safety awareness and training in occupational safety and health law non-compliance (MS=3.16), there is a shortage of H&S professionals to enforce the H&S legislation in organisations. Next to occupational safety and health law non-compliance is subcontracting (MS= 2.59). This is because subcontractors are generally small organisations, so they do not have the correct training regarding H&S (Yiu *et al.*, 2018).

In most cases, a subcontractor will be briefed by the main contractor prior to commencement on site; however, this is not sufficient. The least rated factor is being struck by objects (MS=1.74). This is the least significant because the workforce wears the correct safety gear and trades separately, therefore fewer trade clashes.

Table II: The effects of injuries and fatalities relative to project delivery on a construction site

Factor	Mean score	Std. Dev	Ranking
Company reputation	3.23	0.10	1
Loss of productivity	3.13	0.05	2
Additional project cost	3.01	0.04	3
Inspection/investigation costs	2.87	0.02	4
Medical Expense	2.82	0.01	5
Replacement staff	2.72	0.01	6
Project scope	2.65	0.02	7
Impact on national safety indexes	2.61	0.02	8
Additional project time	2.54	0.03	9

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Compensation claims	2.39	0.05	10

Table II presents the effects of injuries and fatalities relative to project delivery on a construction site. The most significant factor is company reputation (MS=3.23). This is because injuries and fatalities have a negative impact on an organization and affect future tenders and for the organization (Waziri and Bustani 2017). Next to company reputation is loss of productivity (MS=3.13). When there is an injury or fatality, work stops not only by the affected person but also by team members (Choi *et al.*, 2020). Next to loss of productivity is additional project cost (MS=3.01), there will be additional costs to transport and to treat the injured, work stopping will cause a delay and there create a cost implication further, there will be a cost to hire additional staff to complete the works until the injured has recovered (Badri *et al.*, 2012). The least significant factor is between compensation and insurance claims (MS=2.39) because a construction site is insured for injuries.

Table III: The precautions to prevent accidents and fatalities from recurring on a South African construction site.

Factor	Mean score	Std. Dev	Ranking
Hold frequent crew safety meetings	4.07	0.18	1
Follow OHS guidelines and report any dangerous working conditions	3.70	0.14	2
Prevent falls by using a harness	3.69	0.13	3
Safety training and learning	3.30	0.07	4
Use equipment in the manner prescribed	3.20	0.06	5
Recognizing the hazards and making a plan	3.13	0.05	6
Hiring practices	2.35	0.06	7
Owners/clients take their role in safety	2.32	0.07	8
Indicators of heat strain	2.22	0.08	9
Application of safety incentive schemes	2.09	0.10	10
Considering safety in contractor selection	2.05	0.11	11
Exercise and stress management	1.77	0.15	12

Table III presents the precautions taken place to prevent accidents and fatalities from recurring on a South African construction site. The most significant factor is to hold frequent crew safety meetings (MS=4.07). This indicates the meetings are constant reminders; therefore, employees are always aware of H&S regulations (Choe and Leite 2020). Next to hold frequent crew safety meetings is to Follow OHS guidelines and report any dangerous

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working conditions (MS=3.70). By reporting dangerous working conditions, employees are always on the lookout for unsafe conditions. Next to follow OSHA guidelines and report any dangerous working conditions is to prevent falls by using a harness (MS=3.69). Using safety equipment will prevent accidents due to negligence (Nadhim *et al.*, 2016). The least significant factor is exercise and stress management (MS= 1.77). This is because organizations barely emphasize the importance of good mental health that aids in preventing unforeseen accidents that can occur on a construction site (Tao *et al.*, 2017).

5. Discussion

In a recent study undertaken in Gauteng, South Africa by Mashwama *et al.* (2019), it has been identified that the lack of skills, experience and education, lack of knowledge of pricing documentation, effective communication skills, lack of H&S education, poor quality of regular inspections on construction sites, inadequate technical skills, the ignorance of regulatory obligation, deficiency of finance and lack of entrepreneurial skills were among some of the factors that contribute to injuries and fatalities in the South African construction industry. Further, a study undertaken in the Middle East by Awwad *et al.* (2016) revealed the existence of construction labour safety law, the absence of its enforcement, the initiation of safety programs and the lack of any monitoring or follow-up, and a lack of safety education and commitment from all parties involved contribute to injuries and fatalities in the construction industry. Similarly, in this study undertaken in Kwazulu Natal, it has been identified that the lack of safety awareness and training, occupational safety and health law non-compliance, subcontracting, and workers behaviours contribute to construction fatalities and injuries.

6. Conclusion

To improve the quality of H&S for all construction employees, companies should institute a systematic, comprehensive H&S training program for new employees, annually for current employees, provide a mentor for the employees, and use a buddy system to help orientate employees in the H&S and quality systems. Further, companies should institute a system to reiterate the education and retraining of employees in current H&S issues and emphasize the term “I am my brother’s keeper”, which means employees look out for one another on a construction site, especially in unsafe working conditions.

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DII-2021-043

Team Integration and Adaptability in Project Team Cohesion in the Namibian Built Environment

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Abstract

Conflict within construction project teams due to lack of cohesion and integration are adversely influencing project outcomes. Although everyone involved is professional, not all groups will automatically function as cohesive and efficient groups. Therefore, this study has investigated the behavioural adaptability required of individual team members in forming a coherent and integrated project team. The study explored how to identify the different roles in a project team by using Belbin's team roles and how to apply these team roles to project team selection. A survey was conducted using a questionnaire distributed to professional consultants within the Namibian construction industry. This study used a quantitative research approach. Simple random sampling was employed to select the target population for this study. The questionnaire was web-based and circulated to respondents via email. The descriptive statistic method was used to analyse the data collected for this study. The critical finding obtained and analysed showed that most construction professionals agree that working within a cohesive and integrated project team will increase success. The study concluded that taking into consideration the economic downturn within the Namibian construction industry, the immense shortage of new projects and the willingness for adaptability displayed by the construction professionals in the questionnaire, every effort should be made to form more cohesive and integrated project teams, as this will be to the benefit of the industry and economy

KEYWORDS: Adaptability, Built Environment, Cohesion, Project Team Integration.

1. Introduction and Background

Due to the high-stress environment and short project completion times, it is beneficial for any project to have the most efficient and rounded project team (Dellinger, 2019). In recent years construction professionals tend to focus more on specialising in a particular field that contributes only to one part, role, or position of an integrated project team. This result in a decline in project efficiency because each member is just focussing on their particular field

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instead of being the team player that an effective and efficient project team needs (Khan & Hussain, 2016).

Integrating the composition of the team with the right individuals exhibiting the correct behavioural qualities and personality traits will enable an experienced group of construction professionals to, for example, give continuing and timely input to the design teams. Thereby eliminating possible project cost and time overruns by standardizing aspects of the design and minimizing accessibility problems (Khan and Hussain, 2016).

Effective teamwork is subject to team members being able to adapt their behaviour in the group is willing or voluntary deferment to each other, depending on each level of experience, role and responsibility in the group, while at the same time limiting or managing any conflict that may or may not arise in the group (Sherstyuk *et al.,*2016). The problem is to define the roles and positions in the project team then and adequately to recruit the right individuals with the necessary qualities for each role, while at the same time optimising the efficiency of the overall cohesion in the group (Oke *et al.*, 2016; Bao, 2019). Therefore, this study investigates if behavioural changes to existing project team integration and adaptability of individuals in the team will aid in forming a more cohesive project team and increase construction efficiency within the Namibian built environment.

2. Integration, Team Roles and Cohesive Project Teams

2.1. Integration and Adaptability

In the twenty-first-century work environment, employees expect their work environment to be enjoyable (Mao *et al.,* 2017). The conventional approach to procurement by selecting team members does not facilitate the necessary collaboration, teamwork and intercommunication between project team members to resolve this fragmentation (Ibrahim *et al.,* 2011). The fragmentation is that the various team members of a construction project are not necessarily capable of delivering projects effectively. The inconsistency of conventional chosen project teams has a negative effect on team cohesion and channels multiple team actions to achieve agreed goals instead of determining unified collaborative approaches to complete a project (Nawi *et al.*, 2016). The research identified several integration practices that will assist with the successful team integration: focusing on goals and objectives, seamless operation with no defined organisational boundaries, trust and respect, Communication, Sharing information, Integrated ICT systems (Ibrahim *et al.*, 2011).

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The essence of team building is the development of an efficient workgroup performing interconnected activities while understanding the importance of each member to achieve the shared goals and objectives of those tasks or activities (Pandey and Karve, 2018), creating the feeling of belonging to a team and thereby developing team spirit and forming a cohesive unit (Simona, 2012). It has been highlighted that the level of empowerment or restriction experienced by firms within the structure will influence the team’s overall integrative capabilities and overall performance (Young-Hyman, 2016).

Previous research has found that team adaptability moderates the link between constructive actions and team success (Franck *et al.,* 2011). The adaptability of teams refers to how participants can manage unexpected occurrences that could impact their work performance (Aubé *et al.,* 2018). A company should hire and retain outstanding people. Their ability to invent, analyse and build internal and external expertise will provide distinct competitive advantages for most Namibian construction firms (Rosman *et al.*,2018; Franck *et al.*, 2011). Motivated employees are more inclined to generate teamwork, and combined with the right personalities, experience, and skills, will lead to greater and best possible individual and group performance (Abbas and Nawaz, 2019).

2.2.Team Roles and Project Team Composition

The aim is to provide a cohesive team for optimum team success (Ruch, Gander, Platt & Hofmann, 2016), created by team members who successfully combine personality, experience and skills and keep each other accountable (Taylor, 2010). A team is a group of individuals working together to achieve shared project and organisational outcomes (Notgrass *et al.*, 2016) in a cohesive and mutually beneficial way (Oke *et al.*, 2016). Integration of project teams can therefore be characterised as when separate disciplines or organisations with different priorities, expectations and cultures converge into a single group that is cohesive and mutually supportive with collaborative process and culture alignment towards a single shared purpose (Khan and Hussain, 2016).

Belbin describes a team role as a propensity to act, participate and interrelate in specific distinctive ways with others at work (Oke *et al.*, 2016; Belbin, 2011). Previous studies have identified a positive relationship between member attributes and team performance by assuming each member brings a set of talents, background, and experiences to the team role they are fulfilling (Delong and Elbeck, 2019). These studies also favoured using Belbin's

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model to define the roles in the project team, as they require various parameters, behaviours, and responsibilities to be used by project participants in the process of fulfilling their team roles within a project team during the classification of the roles (Sherstyuk *et al.,* 2016).

Belbin agreed that while there are nine positions, the optimal community is five to seven people because fewer could create voids, and more could have a surplus of team positions which could cause tension with a team (Titterington, 2010). The nine Belbin team roles are summarised: plant, resource investigator, coordinator, shaper, monitor evaluator, team worker, implementer, completer/ finisher and specialist (Oke *et al.*, 2016; van Dierendonck and Groen, 2011; Belbin, 2020; Paulamäki, 2018). A team member would usually have more than one team role, but there is always a dominant position to succeed in any project (Oke *et al*., 2016).

Team members can benefit from knowing each other's Belbin Team Role and the effect of their positions on teamwork (Mostert, 2015). Due to Belbin's theory of team roles, a successful team should have balanced roles. Each member fulfils the different needs without competing with other roles to resolve the limitations and maximise play. Good team size, open communication, constructive input, dedication to team performance and mutual objectives are important qualities for selecting participants who will benefit from ensuring the successful execution of the project and delivery on time and within the budget at each point of the project (Oke *et al*., 2016).

2.3 Cohesive Project Teams and Efficiency

Cohesiveness can also be defined as the degree to which team members are drawn and encouraged to be part of a project team (Rovira-Asenjo *et al.*, 2017). Impersonal interactions between individuals can have significant implications for the team because they restrict or facilitate the movement of information between and within teams (Rovira-Asenjo *et al.*, 2017). There are various correlations between group satisfaction and -unity, -productivity, -commitment, final performance rating and team decision-making. Numerous studies investigating group satisfaction as a predictor of workgroup results are noticeably absent from the existing literature, including extra effort from individual group members (Notgrass *et al.,* 2016).

A project's success can be described as the degree to which the time, cost, and feasibility of the project goals are achieved. Costs and time are important metrics for construction projects

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(Detzen *et al.*, 2018). Integration of teams in construction projects is essential for the effective execution of projects. A team should work together within the specified time frame and budget to complete the project from the client's perspective. It could be noted that none of the research works clarified in-depth the effect of the composition of team members on the progress of construction projects and the consequence of failure of some of the project team members. (Oke *et al*., 2016)

3. Methodology

Quantitative research will be the most suitable research method to utilize for the sort of information this study wished to gather since the goal of quantitative research is to collect numerical data from a group of respondents that can be generalised to a larger group of people to explain a phenomenon (Bhatia, 2018). Simple random sampling was employed to select the target population for this study. This study's target population comprised professionals from the various professional councils' databases within Namibia, including professional institutes such as NCAQS and ECN. The data collection for the research paper was done through a questionnaire. The questionnaire was web-based and circulated to 180 possible participates via e-mail, of which 113 were completed and received back. The descriptive statistic method was used to analyse the data collected for this study through tables and graphs.

4. Findings

4.1. Demographic Information

The demographic background of the 113 study participants comprised of the following:

Table I: Demographics of Study Participants

Profession	**Sample size**
Quantity Surveyors	31
Engineers	31
Architects	20
Project Managers	24
Town Planners	3
Land Surveyors	4
Total	**113**

Source: (Engelbrecht, 2020: Author's own compilation)

The academic qualifications of the participants are summarised Figure 1 below:

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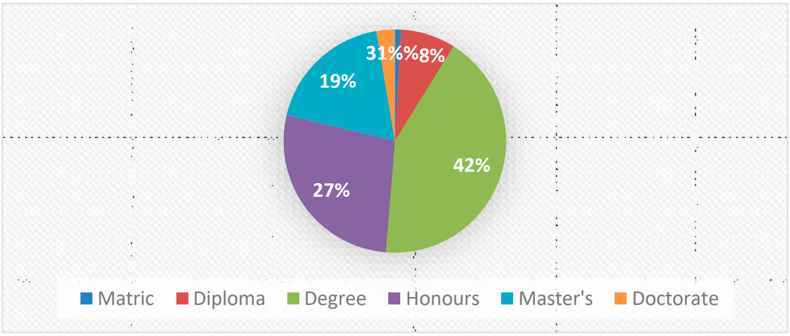

Figure 1: Highest Qualification of Study Participants
Source: (Engelbrecht, 2020: Author's own compilation)

The experience level of the participants in this study are indicated in Figure 2 below:

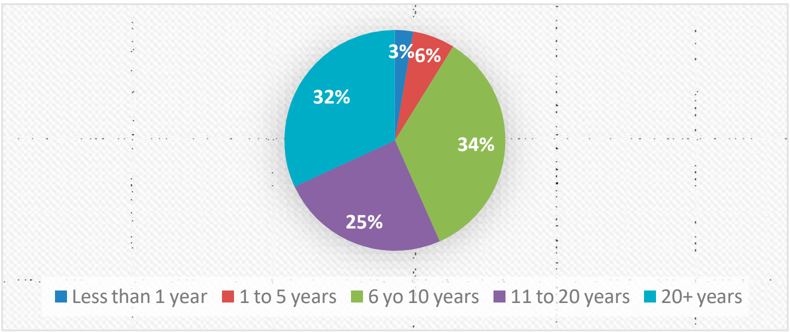

Figure 2: Experience level of Study Participants
Source: (Engelbrecht, 2020: Author's own compilation)

From the above demographic and statistical data (as indicated in Table I, Figure 1 and Figure 2), it becomes clear that the participants of this study are suited to provide knowledgeable input for the research purposes set out by this study.

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4..2 Factors applicable for determining integration and adaptability within project teams

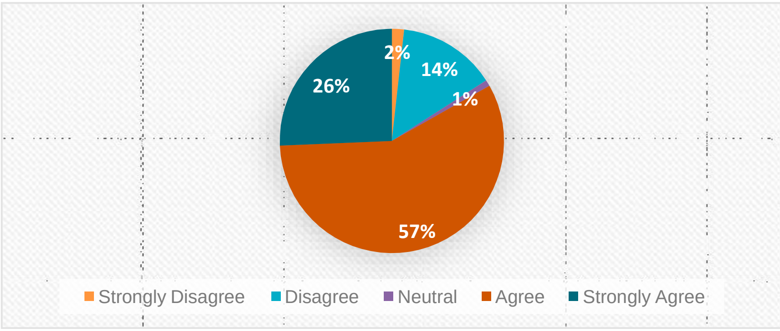

Figure 3: The attitude of the other members of a project team to influence your ability to form a cohesive bond with them
Source: (Engelbrecht, 2020: Author's own compilation)

Figure 3 represents the responses regarding how the attitude of the other members of a project team influences the respondent's ability to form a cohesive bond with their co-team members. 2% of the participants strongly disagreed with the statement, 14% disagreed, 1% neutral regarding the statement, 58% agreed, and 26% strongly agreed. A majority of 84% of the participants responded in agreement that their project team members' attitude influences the team's ability to form a cohesive bond which allows a team to work more productive together. This is a significant finding in terms of proving that the behaviour and attitude of fellow project team members influence the ability a team has of working together cohesively and form an overall bond within the project team.

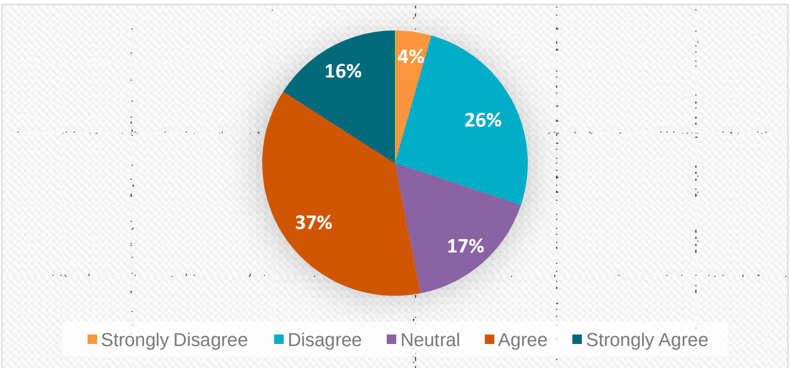

Figure 4: The attitude of the other members of a project team influence your performance level on a project

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Source: (Engelbrecht, 2020: Author’s own compilation)

Figure 4 reflects how the attitude of the other members of a project team influences a specific team member’s performance level on a project. With this statement, 4% of the participants strongly disagreed, 26% disagreed, 17% were neutral, 37% agreed, and 16% strongly agreed. Therefore 53%, feel that the attitude of the other project team members will affect their performance on a project team to a certain extend. Previous studies have identified a positive relationship between member attributes and team performance by assuming each member brings a set of talents, background, and experiences to the team role they are fulfilling (Delong and Elbeck, 2019).

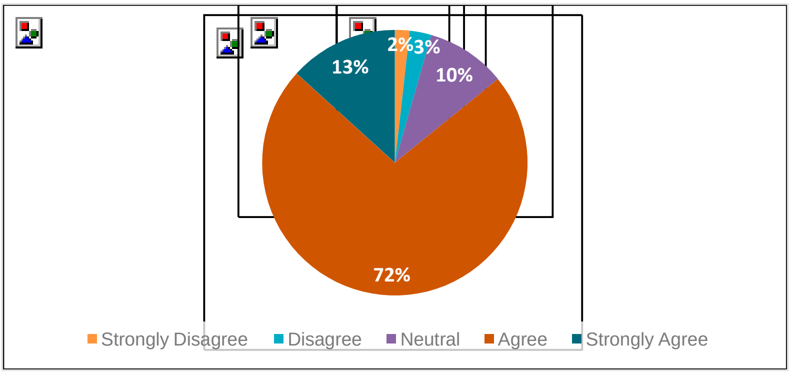

Figure 5: You are willing to defer to other team members for the overall benefit of the project even if they are less qualified than you
Source: (Engelbrecht, 2020: Author’s own compilation)

Figure 5 provides feedback on whether construction professionals are willing to defer to other team members for the project's overall benefit, even if they are more qualified than the other professional within the construction team. Of the responses received 2% strongly disagreed, 3% disagreed, 10% were neutral regarding the statement, 73% agreed, and 13% strongly agreed. The responses reflect an astounding 86% of the participants are willing to place the success of a project first. This supports the importance of the individual adaptability of construction professionals within a project team.

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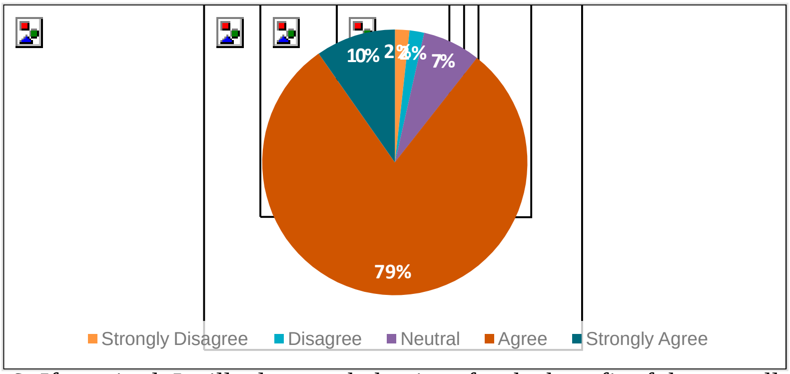

Figure 6: If required, I will adapt my behaviour for the benefit of the overall project success

Source: (Engelbrecht, 2020: Author's own compilation)

The results reflected in figure 6 interpret that participants of the construction industry are willing to adapt their behaviour to benefit the overall project success. 2% of the participants strongly disagreed with the statement, 2% disagreed, 7% were neutral, 80% agreed, and 10% strongly agreed that they would be willing to adapt their behaviour to benefit a successful project. Previous studies that have been conducted have found supporting results for this study by observing that adaptive behaviour and attitude adjustments towards co-workers will be the moderating link between constructive actions and team success (Franck *et al.*, 2011).

4.3 Factors applicable for evaluating cohesion within project teams

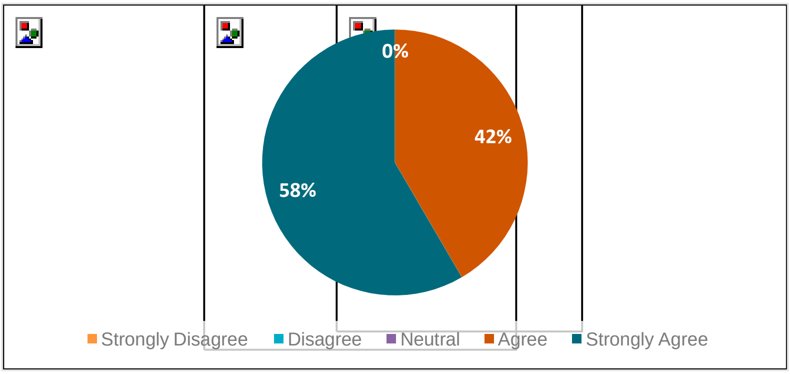

Figure 7: The cohesive relationship of a project team increase efficiency

Source: (Engelbrecht, 2020: Author's own compilation)

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The responses shown in Figure 7 reflect that 100% of the participants agreed that a cohesive relationship within the project team would increase the project team efficiency. However, the consensus of previous studies is still unclear regarding the relationship between the coherent relationship within a team and team success. Previous studies have found results both in favour and opposed that the cohesive relationship of a project team increase team performance (Rovira-Asenjo *et al.*, 2017). This study further supports those in-favour results.

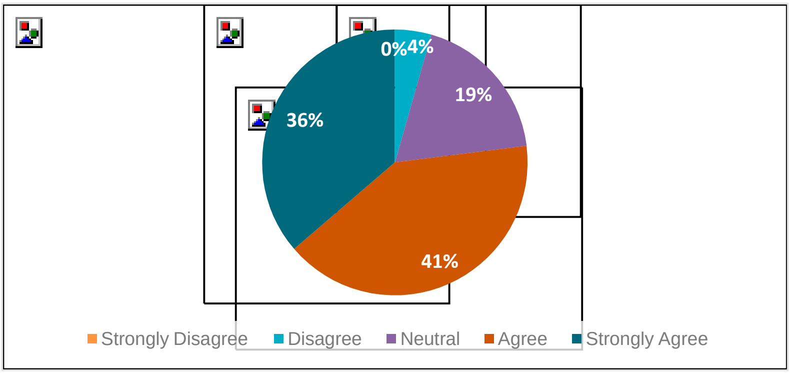

Figure 8: The cohesive relationship of a project team influences the success or failure of a project
Source: (Engelbrecht, 2020: Author's own compilation)

Figure 8 reflects the participants' opinions on whether the cohesive relationship influences success or failure. None of the participants strongly disagreed that team cohesion plays a role in the overall success or failure, 4% disagreed with the statement, 19% were neutral, 41% agreed, and 36% strongly agreed. Therefore 77% of the responses were optimistic that the cohesive relationship within a project team is likely to influence the success or failure of a construction project. As discussed in the literature review, integrated relationships have been regarded as reinforcing the project team's efficiency and affecting the overall project's success (Ibrahim *et al.*,2011; Franck *et al.*,2011).

4.4 Team roles applicability within project teams

Table II: Which of these roles best describes your abilities within a project team

Role	No of Responses	Percentage
Planner (Plant)	44	15%
Resource Investigator	17	6%
Co-ordinator	33	11%
Shaper	28	9%

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Monitor Evaluator	42	14%
Team Worker	38	13%
Implementer	46	15%
Completer/Finalizer	28	9%
Specialist	27	9%

Source: Engelbrecht (2020: Author’s own compilation)

Table II shows which of the Belbin team roles most of the participants were able to identify as being applicable to them within a project team. The responses have a mean of 5.00 and a standard deviation of 5.14. The percentage of responses and the ranking of each response can be observed in the above table. Of the 113 participants within this study, 303 team roles were selected to answer this question since the participants could choose more than one team role. These results show that most project teams can be well-rounded in terms of team roles, which will result in the most cohesive and adaptable project team since the professionals should have the ability to fulfil all of the team roles. Previous studies have used the Belbin team roles to describe a team role as a propensity to act, participate and interrelate in certain distinctive ways with others in a work environment (Oke *et al*., 2016; Belbin, 2011), and this study supports the idea that any team should be able to fill all of the different team roles, making well rounded and integrated project teams.

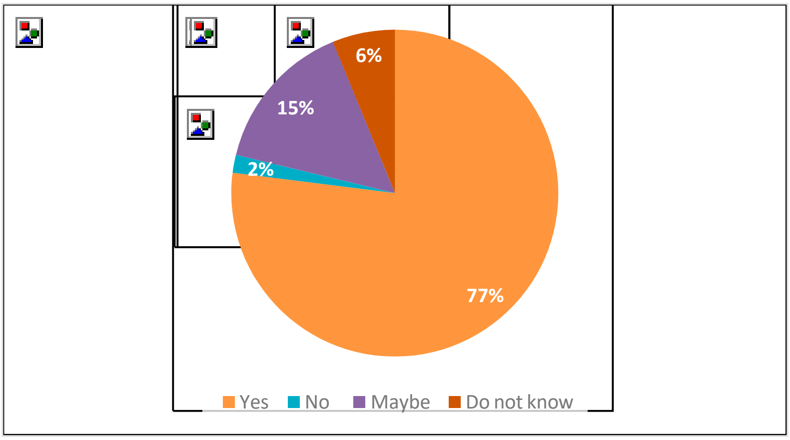

Figure 9: Do you think that it is necessary to consider the Belbin roles when recruiting staff

Source: (Engelbrecht, 2020: Author’s own compilation)

Figure 9 shows the participants' responses when asked whether they think it is necessary to consider the Belbin roles when recruiting staff. Of the participants, 77% said yes, 2% said

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no, 15% said maybe, and 6% did not know. The mere fact that professionals would consider the Belbin roles during recruitment suggests proving how the construction environment has changed and how aware professionals have become of the adaptability that their employees must have within the working environment to be part of a cohesive project team and the importance of a cohesive team on project success.

5. Conclusions

The study revealed the importance of a team of construction project professionals to have the ability to be adaptive towards other team members, as well as the importance of a project team to have a cohesive bond, which will result in better project outcomes. The study also identified that the individual behaviour of a project team member directly influences the behaviour of the other team members, quite possibly to the determent of the project. The importance of first impression when meeting new team members was identified as this will most possibly affect further team and project assignments. The Namibian construction industry is quite small, and the same team members will work together on projects more than once during their careers. The study investigated the role cohesion plays within project teams and found that a project team should be more efficient and will most likely deliver better project results with a cohesive relationship.

The study found that industry professionals strongly supported the influence of team integration and adaptability in forming a cohesive project team in the Namibian built environment. Most of the participants of this study were willing to adapt their behaviour and wanted to work within a cohesive project team. It, therefore, stands to reason that there should be no obstacles preventing this from happening, especially as the slowed economy has limited the number of new developments within the country. Therefore, all construction professionals are eager to find new projects to work on. Thus, the only barrier to cohesive project management is the construction professionals themselves and their ego's.

6. Recommendations

From the study performed, the following recommendations can be made to implement within the Namibian construction sector:

- Clients should consider appointing construction consultant teams by means of a tendering process which will allow the consultants who are already experienced with each other and who already have a cohesive and integrated working relationship to tender as a team. This

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will remove most of the initial obstacles of finding each other on a team and vastly reduce conflict since the team will already know how to operate together efficiently.

- CPD training for construction professionals should include courses on soft skills and project team role development to keep professionals up to date regarding techniques and skills, encouraging cohesive teamwork.
- University curriculums should consider including subject matter to empower and prepare future professionals to function within a team unit.
- Project managers should consider employing a human resource professional to help manage the human capital aspect of a professional construction team and consider the team's composition based on the team members' personalities and roles.

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DII-2021-049

Leadership Styles and Strategic Decisions impacting the Performance of Contracting Firms in South Africa

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Abstract

Five major contracting firms in South Africa failed recently. Different leadership styles and strategic decision-making have been examined and investigated in the literature. However, many of these studies are made in the educational sector, manufacturing industry, or marketing research domains, addressing their impact on the respective organizations. Limited studies have explored leadership and strategic decisions made in the context of the construction industry. Therefore, this research evaluated the effect of leadership styles and strategic decisions on the performance of contracting firms in South Africa. The study adopted a quantitative research approach that surveys 637 randomly selected contractors listed in Grades 7 to 9 of the CIDB Register of Contractors in South Africa using a questionnaire in data collection. Descriptive and inferential statistical techniques were used for the data analysis. The findings revealed that the combination of charismatic leadership style with strategic decisions towards change positively impacts all the performance indicators of contracting firms. Also, the research showed that several other varieties have a significant positive impact on selected performance indicators. Based on these findings, the study concluded that leadership styles and strategic decisions are two key contributors to performance for a firm. Their impact can be both beneficial and detrimental. The right combination results in positive performance. It is recommended that leaders move away from conventional styles in terms of decision-making and leadership because it would be beneficial for the firm's overall performance and is a way forward to dealing with the economic situation of South Africa.

Keywords – Change, Charismatic Leader, Leadership style, Organizational performance, Strategic Decision, Visionary Leader

1. Introduction

This study investigated the impact of leadership styles and strategic decisions on the organizational performance of contracting firms in South Africa. The 2020 revised forecast made by GlobalData has further decreased South African's construction output 2020 by 4.1% due to the negative impact of the COVID-19 pandemic, which compounds other challenges,

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primarily labour shortages and limited infrastructure amid a depressed economy (Sub-Saharan, 2020).

In the ever-evolving construction industry, a call for good leadership styles and strategic decision-making is essential to lead a successful construction firm (Limsila and Ogunlana, 2008). With the uniqueness of the construction industry, leadership tends to be more complex with various challenges compared to other industries (Ofori, 2008). Oyewobi *et al.* (2016) suggested that feasible strategic decision-making and leadership styles are required to address the uncertainty prevailing in contracting firms due to the fragmented nature of the industry. Strategic decisions paired with effective leadership styles from the management guide the business and shape its future (Çelik *et al.*, 2016). As the pace of change affecting organizations increases, the complexity of projects also rises and subsequently increases the need to adjust leadership styles and strategic decision-making (Drouin *et al.*, 2018)

The research objectives were to determine the various types of leadership styles used and strategic decisions made by leaders/CEOs in contracting firms and the changes in contracting firms' performance based on the leadership styles and strategic decisions implemented. This study evaluated the impact of leadership styles and strategic decisions on the performance of construction organizations. It assessed the extent of the paired impact of leadership styles and strategic decisions on the performance of construction organizations.

The objectives were fulfilled using literature review and primary data gathering using an online questionnaire survey sent out to senior executives of contracting firms listed in Grade 7 to Grade 9 on the cidb Register of contractors in South Africa. The data collected were then presented and analyzed using descriptive and inferential statistics to test the hypothesis formulated to guide the study direction. The data gathered reflected the idea of leadership styles and strategic decisions adopted by the contracting firms and their impact on their performance. Through online surveys of senior executives of contracting firms, a quantitative research approach was used in gathering empirical data that answered the research objectives.

The scope of the study was limited solely to Grade seven to nine contractors listed on the cidb RoC, which reduced the number of potential participants. This was reflected by the 13.85% response received from the online surveys. Another limitation was the inadequacy of doing physical interviews due to the Covid-19 restrictions. The online surveys also relied on the participants' willingness, creating a low response rate to the survey request. Moreover, confidential data of performance indicators for the firms were left unanswered by many respondents.

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The study suggested that to achieve higher organizational performance in contracting firms of South Africa, leadership styles and strategic decision-making should be combined and implemented. The senior executives have the task of choosing the adequate combination. This process will be beneficial for the construction industry and, more specifically, the contracting firms facing difficulties.

2. Literature Review

The unstable economic situation in South Africa made it difficult for contracting firms to survive in this ever-changing business environment (Oyewobi *et al.,* 2016). Contractors need to adopt sustainable strategic decisions and effective leadership styles —a holistic approach to the changes — to ensure their continued existence (Teck Heng Lim *et al.,* 2010).

2.1 Leadership Theory

A leader is defined as influencing power over group members to help them achieve a common goal (Sui Pheng and Leong Christopher, 2001). Influential leaders are said to stimulate their subordinates to increase their performance (Albloshi and Nawar, 2015). Hence, performance should start by adjusting and adopting the right leadership style (Wang *et al.,* 2010). The five most adopted leadership styles include the transformational, transactional, laissez-faire, charismatic and visionary leadership styles. The transformational leadership style can be described as a process where leaders widen and enhance the interest of their subordinates (Arham, 2014).

A transactional leader can identify what a follower must do to achieve desired objectives (Bass, 1985). The laissez-faire approach is characterized by leaders using their authority to abdicate responsibility and avoid taking actions (Opoku *et al.,* 2015). Charismatic leaders communicate their concept, boost their followers and hasten innovative processes, for example, sustainability (Opoku *et al.,* 2015). Visionary leadership is the process of establishing a vision, communicating that vision using words and empowerment through actions (Westley and Mintzberg, 1989). From the numerous literature review, it can be concluded that the most commonly used and effective leadership style is the transformational leadership style with a positive association with work performance (Limsila and Ogunlana Stephen, 2008; Arham, 2014; Albloshi and Nawar, 2015).

2.2 Leadership in construction

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Leadership is one of the managerial assets of an organization that interacts with the organization's human resources and has a substantial influence on the company's turnover rate (Chaudhry and Javed, 2012).

One of the main reasons leadership has been extensively researched is its perceived impact on organizational performance and project outcomes (Limsila and Ogunlana Stephen, 2008). Leaders are expected to use strategic decisions as a tool to have a considerable impact on organizational performance (Oyewobi Luqman *et al.,* 2016). In recent years, the construction industry has suffered a leadership crisis that has hindered its progress. This was caused by the lack of good leadership styles of leaders to lead subordinates and achieve goals (Yousif *et al.,* 2015). The construction industry is project-based, and an atypical construction project comprises several bodies involved in the same project (Shanmugam *et al.,* 2006). This inherent characteristic of the construction industry has a significant impact on the managerial and leadership styles adopted by the professionals in the industry (Shanmugam *et al.*, 2006). Lack of experience, knowledge or incompatible character traits to the nature of the work and an inadequate leadership style approach with subordinates may cause this ineffectiveness by project managers (Limsila and Ogunlana Stephen, 2008).

2.3 Strategic Decision Theory

A strategy is a group of decisions used by stakeholders to achieve short and long-term objectives (Hitt *et al.*, 2016). The fragmented nature of the construction industry, in which decisions are made under uncertain and risky situations, requires good decision making (Albaum *et al.*, 1995). Strategy is also described as decisions made by an organization for its resources and competencies to satisfy the stakeholders’ expectations (Johnson *et al.*, 2009). Thus, an organization must constantly develop and monitor the strategy of its firm (Temtime and Solomon, 2002). Moreover, an organization's strategy is fundamental for the future success of a contracting firm due to the high number of variables such as an increase in competition, change in consumer needs, and globalization (Goldman *et al.,* 2010).

Tatum *et al.* (2003) maintained that decision-makers, given the responsibility of providing solutions to problems, are influenced by the unpredictable nature of the construction industry. The amount of information and alternatives available to decision-makers are important variables towards decision-making styles (Tatum *et al.,* 2003). However, the variables are unique to the construction industry because they arise from non-routine situations (Johnson *et al.,* 2009).

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2.4 Strategic Decisions in Construction Industry

The decision-making styles depend on several factors, such as the context and characteristics of the organization and, more importantly, the decision-maker's preferences (Maheshwari, 1980). Decision-making styles can be classified into rational, dependent, spontaneous, intuitive, and avoidant decision-making styles (Scott and Bruce, 1995). The rational decision-making style is referred to an individual possessing all the required information to make an effective decision. The intuitive decision-making style denotes that the decision-makers depend only on their premonitions without adequate information to formulate a decision. The dependent style refers to the decision-makers high dependency on other individuals to make a critical decision. In contrast, the avoidant decision-maker either stays away from the decision-making process or postpones the process. Finally, the spontaneous decision-makers always try to complete the decision-making process as soon as possible, which often results in sudden and impulsive decisions (Omotola, 2012).

Moreover, an effective strategy is a key for achieving long-term goals for a firm (Çelik *et al.*, 2016). There are many strategic decision drivers in literature, and the four main drivers are strategic decisions towards change, competition, conflict, and basic strategies.

2.5 Organizational Performance

Organizational performance is defined as measuring profits, market share and product quality compared to other organizations in the relevant industry (Obiwuru *et al.*, 2011). Performance has been the ultimate variable to evaluate the influence of strategic decisions and effective allocation of resources towards performance (Bromiley and Papenhausen, 2003). As explained by previous studies, performance measurement does not help in anything on its own; what matters is when and how someone uses the latter (Behn, 2003). Research has demonstrated that when assessing corporate performance, the use of financial conditions solely was a poor indicator of overall business performance (Eccles and Pyburn, 1992). It has been highlighted that it is crucial to use different dimensions for measurement rather than a single one when measuring the performance of an organization (Serfontein and Hough, 2011). Hence, this study will look at the financial indicators– Profit Margin and Turn Over – as a measure of the performance of an organization together with non-financial indicators such as client retention rate and employee attendance on-site and at Head Office.

2.6 Theoretical Background and Conceptual Framework

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There is a dynamic relationship between leadership styles and strategic decisions on a firm's performance, positive or negative (Ireland and Hitt, 1999). The quality of the findings and leadership are viewed as crucial factors in maintaining a positive performance. Ireland and Hitt (1999) wrapped the relationship by stating that leaders must effectively deploy their strategic actions to achieve strategic competitiveness and above-average returns. For instance, a leader with supportive behaviour does not necessarily nurture an employee’s motivation and will to stay in an organization (Famakin and Abisuga, 2016).

The null and alternative hypotheses for this study were as follows:

H_0: Leadership styles and strategic decisions do not impact the performance of South African Contracting firms

H_1: Leadership styles and strategic decisions have a positive impact on the performance of South African Contracting firms

3. Research Methodology

To this research, a quantitative approach for data collection has been preferred. The quantitative approach has the main objective to figure out data sets from real life (Hara, 1995). Additionally, a quantitative research approach is used when specific variables need to be analyzed (Apuke, 2017), such as leadership style, strategic decision-making and organizational performance.

The focus of this study was on large construction organizations (Grade 7-9 on the CIDB Register of contractors) operating solely in South Africa. For this research, the probability-based random sampling technique was preferred. In this sampling method, also known as probability sampling, every individual item in the population of 1,108 contracting firms had an equal chance of being included in the sample (Kothari, 2004). This technique is best suited when the background and other specifics of the respondents are not fundamental. At 90 % confidence level and 10% error of margin, the sample size was 637 respondents. The sole method of data collection for this study was an online questionnaire administered through the SurveyMonkey platform.

A questionnaire has been proven to be a quick and efficient method of data collection (Munn and Drever, 1990). The questionnaire was sent to more than a thousand recipients from the database within minutes. The same questionnaire was sent to all the respondents, which

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created consistency in data collection. The questionnaire was divided into four sections: general, leadership styles, strategic decision, and performance. The leadership section consisted of six questions where participants were provided with a scenario where they had to choose from previously set possible answers. Those scenario questions were then followed by an open-ended question to reason for their previously chosen answer. This allowed a deeper and richer understanding of the data collected. This section also contained one Likert scale type of question to express their degree of agreement or disagreement.

The strategic decision-making sections followed the same setup as the leadership style sections. The last section required the participants to disclose data regarding their financial performance, number of clients and employee's attendance over the last five years. Out of the 637 randomly selected contractors to which the online questionnaire was sent, 46 responses were received - 37 participants responded partially, and 9 responded completely to the survey. Altogether, represents a response rate of 13.85%.

Descriptive statistics were used to analyze the data gathered from the responses obtained from the contractors in South Africa. Percentages helped identify the leadership style and strategic decision common amongst the participants and establish the organizations' performance. A pairwise Chi-Square Test was used for the data analysis to firstly link all the questions in each section, the leadership style section, and strategic decisions section to derive two sets of variables, and a Pearson's Chi-Square test of independence was used to evaluate the impact of both variables on a third set of variables which is performance. The Chi-Square test was used because it has the specific purpose of testing the hypothesis if no association or impact between two or more groups (Rana and Singhal, 2015).

For this research, the data analysis has been done using the software Statical Package for the Social Sciences (SPSS). The reliability of data has been tested using SPSS for a Cronbach's alpha test. The Cronbach's alpha test is not a statistical test but rather a coefficient of reliability. A study proved that a coefficient between 0.60 and 0.69 is deemed acceptable (Hair *et al.*, 1998), hence with a coefficient of 0.627, the findings were considered reliable. Before sending out the questionnaire, the ethical clearance was submitted and granted by the Construction Economics and Management Department of Cape Town.

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4. Findings and Discussion

The findings showed that the visionary leadership style was the most prominently used, while none of the respondents demonstrated the laissez-faire approach (see Figure 1). The data gathered through the online survey did not validate the literature review as the visionary leadership style was most common (47.4%), with the transactional leadership style as second most common (26.3%), which suggests that leaders often use a diverse leadership style. The respondents perceived the strategic decision-making towards change and risk-taking to contribute more to their organisation's performance with a mean score of 4.11 (see Table I). While the strategic decision-making towards conflict was the least ranked with a mean score of 2.44.

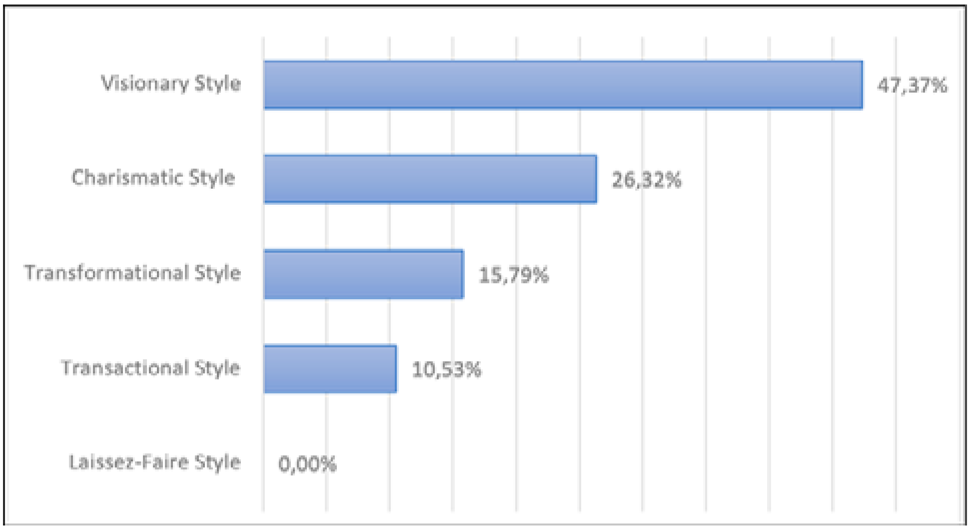

Figure 1: Leadership Style when leading a team

Table I: Strategic decisions perceived to contribute to organisational performance

Question	*Strategic Decision Style*	*Mean Score*

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Rank the strategic decision(s) from the most important to least important which you consider contributing to the overall performance of your firm over the last five years	Change	4.11
	Basic strategies	3.67
	Competition	3.56
	Innovation	3.33
	Risk-taking	2.89
	Conflict	2.44

The findings on organizational performance changes showed that profit margin and turnover were not constant over the five years of data provided by the respondents. The figures fluctuated over the five years, which shows the dynamic nature of the construction industry. Client retention varied amongst the companies, indicating the difficulty in forecasting performance indicators or setting defined goals for performance. Employees' attendance was high for most organizations suggesting high commitment from employees.

A chi-square test of independence has been performed to evaluate the impact of the leadership styles and strategic decisions on organizational performance. A chi-square test of independence has been performed where combinations of leadership styles and strategic decisions have been analysed against performance indicators. This indicated that the charismatic leadership style paired with the strategic decision towards change positively impacted all performance indicators at a significance level of 5%. From the data gathered, it was found that most of the participants agreed that strategic decision and leadership styles should be paired. This research gave additional support by undertaking a chi-square test to show the paired impact on the performance. The data analysis section gave compelling evidence that the combination of leadership styles and strategic decisions significantly impacted performance. A summary of the findings, with statistical data, of the impact of leadership style and strategic decisions on performance is shown in Table II.

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Table II: Leadership Style and Strategic Decisions Impact on Performance

Leadership Styles + Strategic Decisions (SD)		Profit Margin	Turnover	Client Retention	Site Attend	Office Attend
Transactional Leadership	SD towards Basic Strategies	**0.042**	0.169	0.042	0.174	0.161
	SD towards Risk Taking	**0.05**	0.265	0.231	0.268	0.248
Transformational Leadership	SD towards Change	0.374	0.389	**0.05**	0.427	0.317
	SD towards Competition	0.208	0.281	**0.023**	0.235	0.26
Charismatic Leadership	SD towards Change	**0.039**	**0.049**	**0.049**	**0.037**	**0.029**
	SD towards Risk Taking	**0.046**	0.091	**0.046**	0.064	0.104
Visionary Leadership	SD towards Change	0.65	0.575	**0.048**	0.699	0.719
	SD towards Basic Strategies	0.308	**0.046**	0.236	0.283	0.233

The leaders' visionary style was chosen most among the leadership style questions from the established leadership styles shown in Table II. With the construction industry's ever-changing and fast-changing characteristic, the visionary leader can add to the traditional transformational leadership approach by controlling changes and applying mitigating measures when needed while adapting their vision process correspondingly (Nanus, 1992). None of the respondents chose the laissez-faire leadership style. This is expected and corroborates with the findings from the literature review. The laissez-faire approach has been often frowned upon by leaders as it does not yield satisfactory performance (Antonakis *et al.*, 2003). Professionals in the building sector rarely adopt this leadership style (Chan and Chan, 2005). The majority of the participants rated the rational manner (anticipate the need to make decisions and equipped with all the necessary information suitable to make an effective decision) as the highest. This is logical because every senior executive wants to be equipped with the necessary information before deciding. However, the literature review shows that what managers wish to and what they do can be pretty different, and thus they use distinctive styles.

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It emerged that the common traits of the visionary leader help the company flourish and achieve positive financial performance. Combining an innovative leader with strategic decisions towards basic strategies resulted in a positive impact on turnover. The visionary leader adopts a prudent style and adapts their vision process according to the sociological dynamics of the industry (Westley and Mintzberg, 1989; Nanus, 1992). Moreover, evidence in the literature shows that the visionary leader is in line with strategic decisions towards basic strategies where contracting firms aim to sustain their business by using their available capital and vision (Çelik *et al.*, 2016). Moreover, visionary leaders make decisions on stable, growth and mixed strategies (Çelik *et al.*, 2016). Therefore, it is logical that paired with the strategic decision towards basic strategy. This results in a significant impact on turnover. Meanwhile, the transactional leadership style has no significant impact supported by literature stating that the transactional leadership style is less effective and generates lower work performance than transformational leadership (Limsila and Ogunlana, 2008).

5. Conclusion and Further Research

This study examined the impact of leadership styles and strategic decision-making on the organizational performance of contracting firms in South Africa. The study has been designed to identify the various leadership and strategic decision-making styles of senior executives of contracting firms. Furthermore, the changes and possible positive impact of leadership styles and strategic decisions on the performance of construction organizations have been evaluated. This study further assessed the extent of the paired, instead of isolated, leadership styles and strategic decisions on the performance of the construction organizations. An online questionnaire has been used to gather data from relevant groups.

The findings showed that the respondents' most prominently used leadership style was the visionary leadership style, which is more open to changes such as moving to new markets and preference for long-term goals and sustainability rather than short-term performance. It also emerged that respondents opted for strategic decisions towards change as their preference. Combining the two variables (leadership style and strategic decisions) resulted in a positive performance statistic for some combinations. For example, charismatic leadership style paired with the strategic decision made towards change positively impacted all performance indicators, whereas other combinations (transactional, transformational, and visionary) only positively impacted some of the performance indicators. The study suggested that the null hypothesis (H0 - leadership styles and strategic decisions do not affect the performance of South African contracting firms) is accepted for some combinations. The

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alternative hypothesis (H1 leadership styles and strategic decisions the performance of South African Contracting firms) is accepted for some combinations, and the charismatic leadership style and strategic decision towards change. Based on these findings, the study concludes that charismatic leaders can communicate their concept, boost the morale of their followers, and hasten innovative processes in their companies. For example, sustainability will have a positive impact on the performance of the construction company. Also, using only one leadership style or strategic decision-making is ineffective in the dynamic construction environment. The visionary stance leaders of construction companies will not bring about the firms' sustained and all-around performance. However, South Africa already faced an economic crisis before the Covid-19 outbreak, which impacted the construction industry failing big firms. However, the findings suggest that ineffective leadership and strategic decisions could be key contributors to this failure.

It is recommended that senior executives in leadership positions understand leadership and strategic decisions and adopt a leadership style and strategic decision-making that empowers and encourages employees to be productive. This research employed a quantitative research approach based solely on an online questionnaire survey. Given the low response rate for the survey, an exact test of goodness of fit could have been used instead of the Chi-Square test. However, with the extremely low response collected, the conclusion cannot be generalized, and further research should be undertaken to validate the findings of this study. Hence, further studies with a more significant number of participants should be conducted. Moreover, a qualitative approach with interviews to collect valuable and meaningful data should be undertaken. The analysis of the data collected and the findings will lay the necessary grounds for a more in-depth study where a generalized hypothesis can be found.

6. Acknowledgement

This work is supported by NRF (Grant Number-120843). However, the opinions and conclusions in the study are those of the authors and are not necessarily attributable to the NRF.

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DII-2021-002

Research Trends of Human-Robot Teams/Robotics in Construction: A Scientometric Analysis

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Abstract

Human-robot teams/robotics have emerged as an inevitable innovation in the drive of the fourth industrial revolution. While the construction industry is faced with debilitating issues on productivity and workforce-related challenges such as accidents/hazards, robotics and human-robot teams offer an enhanced tool to deliver smart and sustainable infrastructure to drive real economic growth. What is vital now is assessing the research trend in this area to establish the roadmap for further studies and highlight state of the art thus far. A total of 62 peer-reviewed journal articles centred on robotics and human-robot teams were reviewed using a quantitative approach using scientometric techniques. The study revealed light and small research output in this area though indicating immense research potentials. While the focus is on robotics and automation, fledging areas such as human-robot teams, trust in collaborative robots, and robotics perception and imperative to the success of the robotics implementation in Industry 4.0. The study is helpful for researchers and policymakers in designing areas of further studies and direction of funding needs. For organisations, it draws to the fore the potentials in an emerging field. It fills the gap in knowledge by bridging previous studies with the need for further directions.
Keywords: Research Agenda, Construction Robots, Robotics, Human-Robot Teams, Scientometric Analysis

1. Introduction

Diverse workforce-related challenges and productivity issues are currently a dilemma in the construction industry, partly due to its heavy dependence on human tasks, which are often debilitated by the shortage of skilled labour, high incidence of safety risks, potential accidents/injuries, time constraint, location and safety factors (Eiris and Gheisari, 2017; franz Bryan and Mahya, 2021). Emerging Industry 4.0 innovations such as the use of virtual human applications in AEC (Eiris and Gheisari, 2017), Remotely Piloted Aircraft for damage detection, health & Safety and site monitoring, amongst others (Golizadeh *et al.*, 2019), digital twin for optimizing construction data (Liu *et al.*, 2021), Cyber-Physical Systems,

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Robotics and Collaborative robots have provided an opportunity for a better-enhanced construction environment. Robotics have been identified as central to augmenting debilitating productivity issues associated to workers and retool conventional workflow techniques in the construction workplace (Bryan and Mahya, 2021). However, collaborating human skills and robotics be more socially sustainable and technically productive. It lowers construction costs through waste reduction (Mahbub, 2015), ensures a safer workplace (Fischer et al., 2020), and delivers infrastructure creatively within the time allotted.

Human-robot teams (HRTs) aim to improve construction productivity and resolve work-related challenges through human-robot collaboration. Wolf (2020) identified human-robot team types as; “Autonomous mixed team” (Collaboration between robots and humans in a shared space), “Human-/Robot -directed mixed team” (Workers carry out tasks in coordination with robotic partners), “Robot-directed human team” (a robot led the coordination of tasks) and “Human-directed Team” (an individual human worker supervising operations of robots). While research in human-robot teams is an emerging research area, it holds vital benefits. It plays a crucial role in the fourth industrial revolution through the “use of collaborative robots” (or” Cobots”), which are primarily designed as team robots to share tasks with humans. They are highly beneficial n increasing worksite safety by reducing overexertion, which reduces fatigue and accidents common amongst workers (Franz Bryan and Mahya, 2021), enhance team performance leading to more productivity as they are easy to train (Andre P Calitz, Poisat and Cullen, 2017), speed up construction processes, reduce lifecycle cost and improve designs.

These potential benefits have aroused an increasing level of interest and concerns (Hancock *et al.*, 2011), especially with regards to the art of safety as well as ergonomics (Gualtieri, Rauch and Vidoni, 2021), procedures to incorporate cobots and robotics in human-robot teams (Franz Bryan and Mahya, 2021), barriers to their adoption (Mahbub, 2015), trust amongst human-robot teams (Hancock *et al.*, 2011), their use in the future African workplace (Calitz *et al.*, 2017), Social robots in HRTS and HRTs in Organisations (Wolf, 2020). Given this level of interest and need for more research advancement in HRTs and robotics, a critical review of the extant literature is imperative to establish the direction of research for successful implementation of HRTs and robotics in the construction Jobsite and academic learning (Gualtieri, Rauch and Vidoni, 2021). Existing review studies on Robotics and Human-robot teams such as (Gualtieri *et al.*, 2021) is limited to ergonomics, while (Aghimien *et al.*, 2019) is narrowed to robotics and automation (Wolf 2020) used an input-process-output (IPO) approach to reviewing the literature. While these works are valuable to the body of knowledge, it is imperative to avail a comprehensive outlook of emerging research on the topic, outstanding research themes, the geographical distribution of active researchers and consequently aggregate a research direction for further studies through a

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quantitative approach at acutely dissecting the state of the art of Human-robot teams/robotics in the Architecture, Engineering and Construction Sector. Therefore, to successfully drive research in human-robot teams/robotics, this study aims to:

1. Broadly map the scope and trends of the extant literature on human-robot teams/robotics in the Archive, Engineering and Construction Sector;
2. Scientifically highlight key thematic areas trending in research and needed research studies vital to seamless adoption;
3. Identify the applications of human-robot teams in the Construction industry.

It is envisioned the study would serve as a pedestal to drive further ground-breaking studies and serve as a catalyst for more scholarly research themes to better pave the way for the use of human-robot teams/robotics in Construction.

2. Background

According to Perez *et al. (*2018), human-robot teams/robotics is hugely reinventing the shop floor of manufacturing companies and is the main technology of the fourth industrial revolution. Collaborative Robots or Cobots are designed with humans and can be easily trained on tasks (Afsari and Afkhamiaghda, 2020). Human-robot teams studies are an emerging interdisciplinary field that falls within a broader scope of human-robot interaction (HTI) (Follini *et al.,* 2021). Since the 70s, when robotics was first introduced into the construction industry for prefabrication in Japan (Afsari *et al.*, 2018), they have evolved rather much slowly (Davila Delgado *et al.*, 2019) in comparison with other sectors such as the manufacturing industry.

While the adoption has evolved slowly, studies are instructive as (Akinradewo *et al.*, 2021) posits robotics enhances accuracy through the use of lasers for analysis of dimensions, standardized methods to design specifications, effective lifecycle cost, improved working conditions and waste reduction. The Human-robot team/robotics research area is growing; studies across a wide range have focused on sustainability, Prefabrication, trust, Safety, Ergonomics, human-robot interaction and Artificial Intelligence. Pan *et al. (*2020) established a framework for using robotics in a sustainable building; Perez *et al. (*2018) investigated robotics and augmented Artificial Intelligence. A new pathway has also been charted in using Tower construction to examine the collaboration between a robot and groups of people in providing behavioural insights of humans around robots, as cost efficiency is imperative in adoption; studies have also examined guidelines for developing future human-robot teams economically (Akshatha *et al.*, 2017). Bugmann, Siegel and Burcin (2011) assessed the designs of cobots in using sustainable resources, Linner *et al. (*2020) structured the context for collaborative robots using an integrated scenario approach, while (Liu,

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Habibnezhad and Jebelli, 2021) further evaluated a human-centred collaborative framework that captures the brainwaves of workers using wearable electroencephalograph to study the robot's performance.

Studies such as (Tavares *et al.*, 2019) have shown the imperativeness of cobots in the future construction workplace. The study examined the use of a collaborative welding system that is flexible in helping human workers assemble beams with less strain/fatigue on humans. A vision-based real-time extrusion quality monitoring system is advanced in the study of (Kazemian *et al.*, 2019), and a novel approach investigated by (Kurien *et al.*, 2018) to develop cobots linked to mimic human tasks while workers are off-site. Yablonina *et al. (*2021) developed a soft office using human-robot teams for adaptive spatial configuration, (Dai *et al.*, 2020) examined the use of multi-functional robotic systems to utilize MQTT in data acquisition and transfer across a wireless network that is linked to a plasma cutting station for automated steel construction. A robotic-assisted system to aid the application of concrete in architectural panels was developed by (Liu *et al.*, 2021). To enable seamless use of human-robot teams, (Hancock *et al.*, 2011) conducted a meta-analysis of factors that could influence trust in using human-robot systems. This is important in how they perceive the system and can adopt a human-robot shared workspace.

3. Research Methodology

This study adopted a quantitative approach using scientometric techniques to analyse, visualize and review the predefined objectives for the research. The choice of technique was adopted to generate clusters, thematic areas and trends with descriptive illustrations and charts. The scientometric approach has been adopted in other reviews of emerging innovations in the construction industry, such as; scientometric analysis of remotely piloted aircraft's (Golizadeh *et al.*, 2019), scientometric analysis of Building Information Modelling (Saka and Chan, 2019), use of a bibliometric review in examining green buildings research (Olawumi *et al.*, 2017), bibliometric analysis of Construction automation and robotics in construction (Aghimien *et al.*, 2019).

4. Scientometric Review

According to Saka and Chan (2019), a scientometric review utilizes analysis and visualization of academic literature to avail the evolution of research in an academic field. Other approaches are through a Bibliometric review (Olawumi, Chan and Wong, 2017) or systematic literature review (Eiris and Gheisari, 2017). Several softwares for analysing scientometric research: VOSviewer, BibExcel, CiteSpace, CoPalRed, Sci2, VantagePoint (Golizadeh *et al.*, 2019). VOSViewer and Gephi were adopted in this study to analyse due to

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their features, high rate of adoption in academic review and ease of use (Wen and Gheisari, 2020). VOSViewer avails analysis through full counting methodology and fractional counting methodology for visualizing networks of documents (Jin *et al.*, 2018). For this study, fractional counting methodology to generate author network, co-citation network (co-author citation and document citation), and co-occurring keywords citation were adopted. Gephi is a leading graph visualization and Java-based exploration software. It is open-source, free, and useful for social network analysis (Golizadeh *et al.*, 2019).

4.1. Data Retrieval

The publications were retrieved within the Scopus database, as it has been identified as the major database used by research due to its massive reach of academic literature. While other databases such as Web of Science, Olawumi, Chan and Wong (2017) state there is no distinction between them. They are both identified as the two major science research databases. The key search query entered on the Scopus Database; “Human-robot teams” OR “Cobots” or “Collaborative robots” OR “Robotics” with the year limitation set to ten years (2011-2021). The documents were limited to papers published using English as a medium, and territory was left to include all countries. The document type was limited to Journal articles. They represent the most influential research studies in scientific mapping since little is gotten from conference papers due t their large numbers and extra amount of complexity it impacts analysis (Zhou and Gheisari, 2018). The document type was refined to Publications in Engineering which produced a dataset of 5 384 documents. It was further refined using the keyword “Construction” to query the “Abstract, Title and Keywords”, which produced a result of 1,483 documents and refined further to produce 308 documents. Golizadeh et al. (2019) stated that refining the keyword “Construction” still creates some form of ambiguity as it is a relative term applicable in other fields such as manufacturing and the AEC sector. Therefore, abstract filtering of all 308 documents was sighted to refine the datasets to strongly related documents, and studies relating to non-construction sectors were removed. The filtering yielded 62 documents relating strongly to the predefined objectives. While this sample size is relatively small, it is deemed adequate. A previous review by Aghimien et al. (2019) included “Automation” in its query and generated more datasets. However, 50 papers for scientometric analysis are well documented in the literature (Golizadeh *et al.*, 2019).

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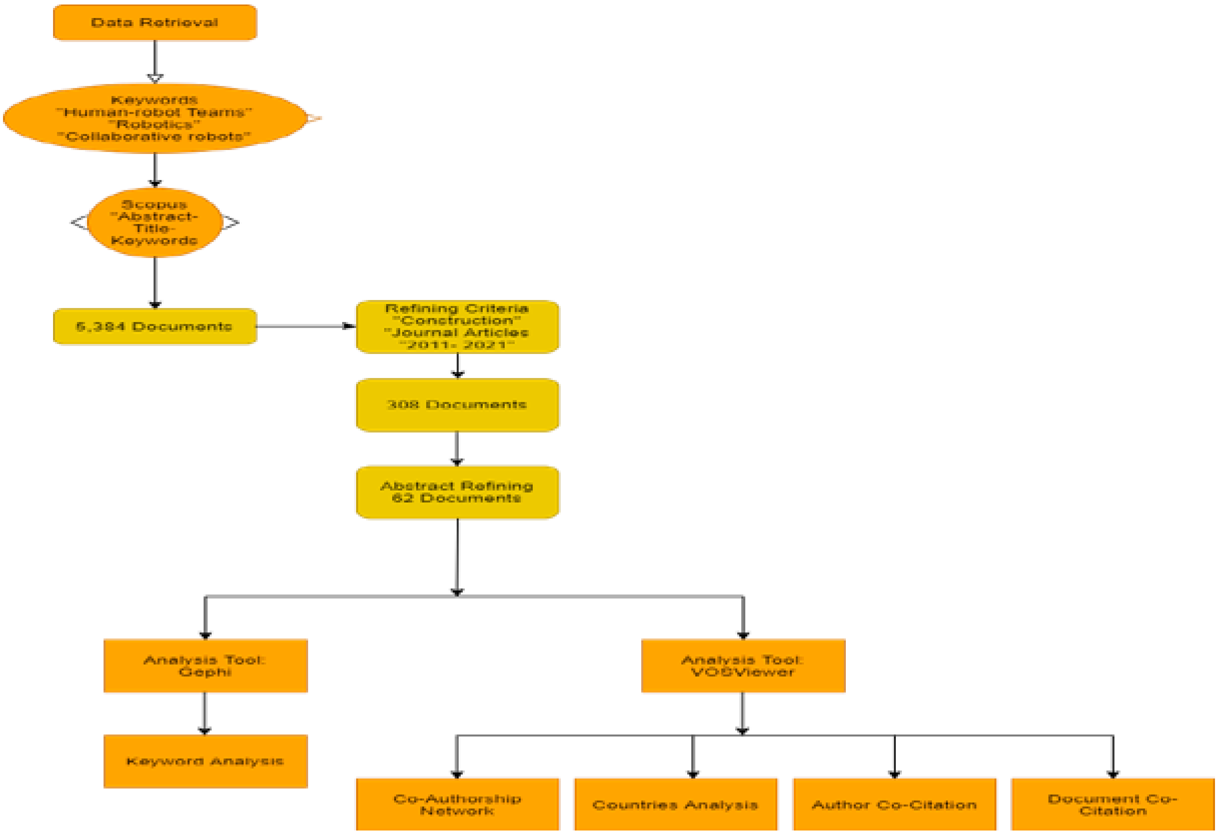

Figure 1: The Research Design

5. Results of Data Analysis

Main research areas (Co-occurrence of keywords analysis)

Research trends within a domain could be analyzed using the trending keywords as they indicate an outlook of the scholarly literature developed within a dataset (Su and Lee, 2010). Co-occurring keywords provides a thematic evolution of research in a domain. The network visualization for co-occurring keywords was analysed using Gephi, Java-based open-source network analysis and visualization software. The dataset from Scopus was categorized to reflect nodes and edges for easy analysis on Gephi. Network analysis in co-occurring keywords depends on linking the weight between two keywords based on the number of publications they occur in(Golizadeh *et al.*, 2019). Using Gephi, Comma was used as the separator for the dataset. At the same time, the Charset was left at the default of UTF-8. Both edges table and nodes table was utilized in the visualization. An undirected graph method

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was selected to give a bidirectional relationship between the datasets. Create missing nodes was set and the graph presented 20 nodes and 32 links as shown in Fig 1 below. Among the nodes, Robotics, Construction Robot and Automation and Robotics have the highest number of edges. Having research areas as the nodes, the visualization indicated that areas of research interests and focus is concentrated more on Robotics and Automation while Human-robot teams is a growing research field. This is supported by Wolf and Stock-Homburg, (2020), who identified Human-robot teams as a growing interdisciplinary field. Furthermore, the Gephi visualization depicting the edges indicates the research interest in human-robot teams is an offshoot from Robotics and other issues surrounding Robotics such as safety with robotics, human-machine interface integration, collaborative robots human-robot team trust. Also, there is growing interest in exoskeletons as a form of Robotics to enhance human performance on tasks.

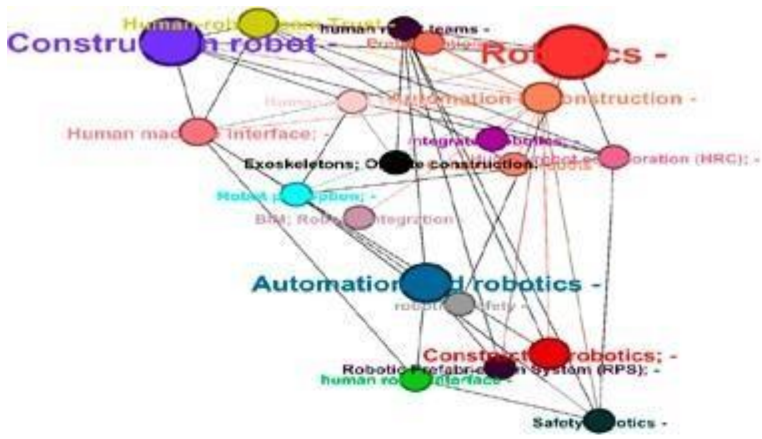

Figure 2. Main areas of research in Human-robot team/Robotics

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Co-Authorship Network

A co-authorship network is imperative to identify researchers who were driving the discussion and solving problems around human-robot teams/robotics in construction.

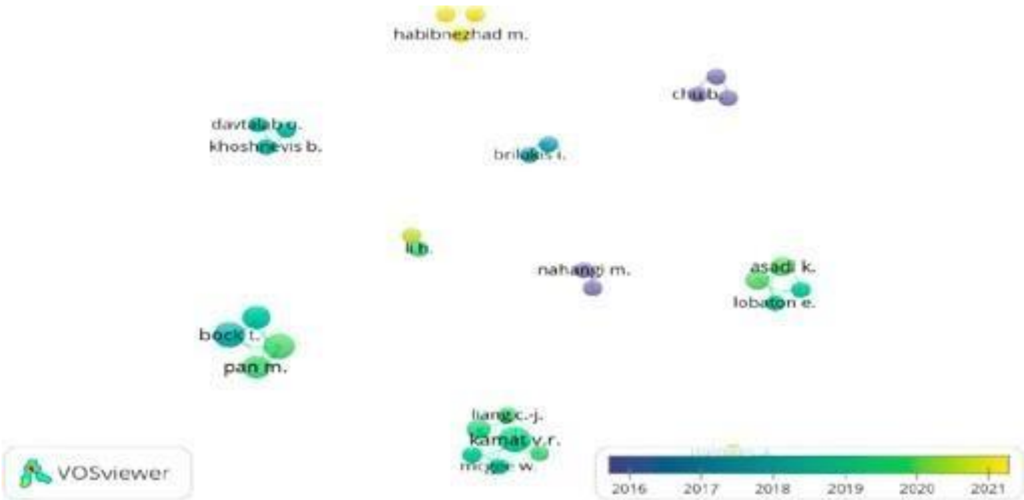

Figure 3. Co-Authorship Network

The analysis shown in figure 2 revealed the most productive authors as; Pan Wei, Kamar Vineet and Thomas Bock with five publications each. The limited clusters and collaboration depicted in the visualization are not surprising as the field is slowly emerging. However, for stronger research output, scientific collaboration through shared expertise, funding and specialities is key to driving this emerging area (Golizadeh *et al.*, 2019). The analysis was created based on bibliographic data generated from Scopus and set the type of analysis sent to “Co-authorship” as indicated in (Su and Lee, 2010; Olawumi *et al.*, 2017). The major clusters identified revolved around Pan Wei and Kamar, who also have the largest publication in the area. Remoteness has shown through the degree of disparity that the nodes can be reduced through extensive collaboration between researchers. The blue colour depicts studies carried out in the past five years, while the green colour depicts studies carried out in the past two to three years. The yellow colour scheme is indicative of emerging studies by (Liu *et al.*, 2021).

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Further analysis, as shown in Fig 3, shows the clusters of collaborating authors though disperse shows more weakness as they are limited to a few countries; the United States, Germany, Hong Kong, United Kingdom, South Korea and China. The absence of Africa from studies in this field is a challenge to African researchers on the imperativeness of extensive collaboration with developed economies. There must be a deliberate commitment between African researchers and counterparts in developed economies to information exchange in keeping up with the times.

Figure 4: Countries Producing Research in Human-robot/robotics

Author Co-Citation network

A total of 5205 authors were cited in the datasets, the minimum number of citations set to 6, with 149 authors meeting the threshold as shown in figure 4. The top-cited authors were Bock Thomas with 103 citations, Linner Thomas with 71 citations, Kohler Matthias with 54 and Kamat, V with 53 citations. The VOSviewer density visualization indicates the influential networks. Author co-citation network visualizes the influential documents in a dataset (Olawumi *et al.*, 2017). The density visualization is limited, showing the need for more extensive collaboration in this area.

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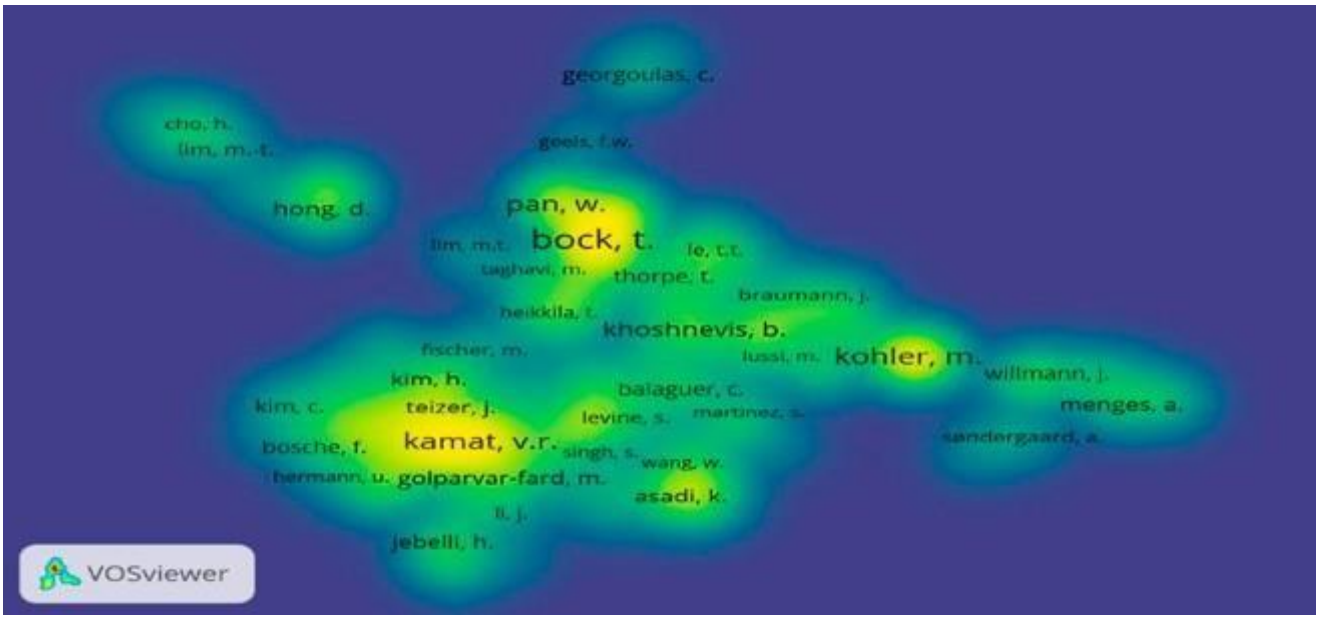

Figure 5: Author Co-Citation network

Document Co-citation network

The document co-citation network analyses the cited references within a dataset (Saka and Chan, 2019). The density visualization of the document co-citation network below indicates the top-cited documents in human-robot team/robotics research. A minimum number of two citations was set to visualize the network of 3032 references. (Bock, 2015) study on the future of construction automation is the most cited, followed by (Green *et al.*, 2008) on human-robot collaboration and (Bock 2017), respectively.

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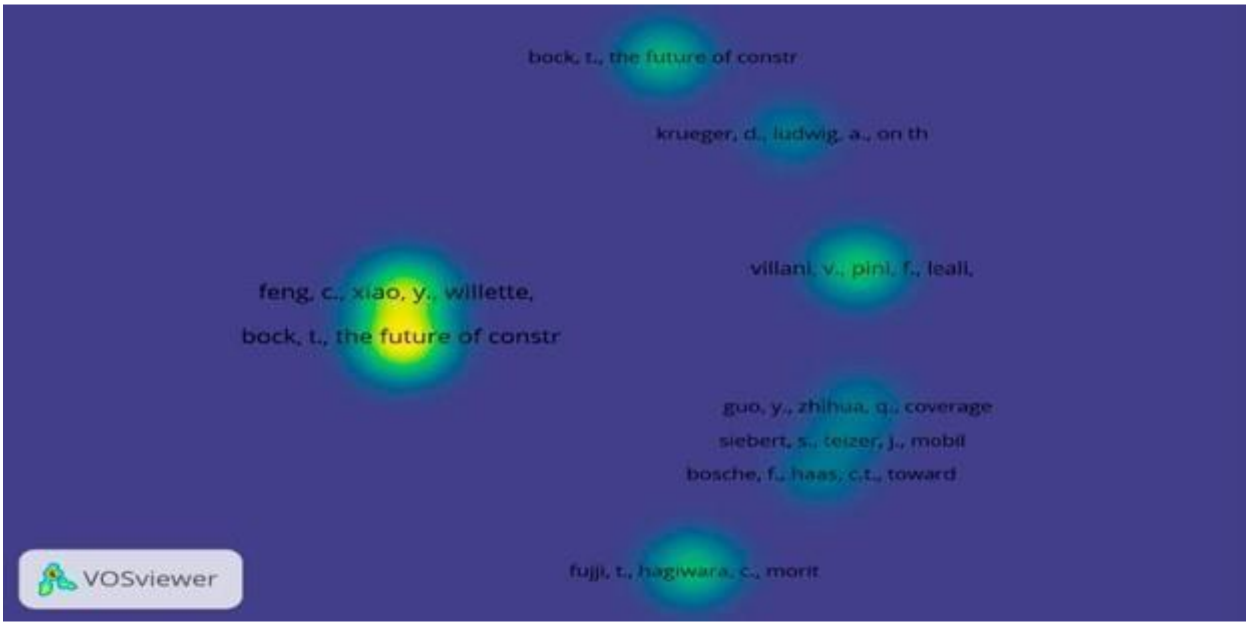

Figure 6: Document Co-citation network

6. Conclusion

Human-robot team/robotics is an emerging field in the Architecture, Engineering and Construction Sector with immense potentials for improving construction productivity. Research in the area is at an early stage but gradually improving. The study identified the research trends in human-robot teams/robotics in the construction industry and identified emerging and lacking aspects. The study utilized a quantitative approach using the scientometric approach to provide answers to predefined objectives. The study is the first literature review to combine Gephi and VOSviewer presenting research trends in the emerging area.

The findings reveal many studies on robotics and a narrow focus on human-robot teams/ collaborative robots. However, it is instructive for more studies to carry out in human-robot team trusts to critically evaluate the perception of humans to share the workplace with robots and consequent implications on workplace issues and psychological issues.

While there would be sparse studies in an emerging research area, there is the need to advocate for more inclusive and extensive research collaboration between institutions. There is a large disparity in robotics research and a heavy absence of an African network of research in this area. This could be a result of the unavailability of tools, expertise and funding. However, with the growing use of digital globally to simplify processes, improve the nature

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of work and adapt to the fourth industrial revolution, it is exigent for the African public sector to invest in technology that can enhance productivity and deliver more in terms of infrastructure to speed up the economic development of the region. Therefore, human-robot teams/Robotics presents an opportunity to increase economic delivery through enhanced infrastructure delivery and not be seen as a threat. While there are concerns in areas of changes in the workforce, human-robot teams offer the need to improve skills and expertise- an essentially inevitable reality for the future of work.

Despite the contributions of this research, the results only reflect datasets generate within the Scopus database and ten years. Further studies would be imperative in narrowing the focus to human-robot teams and considering other databases while employing different literature review approaches to enrich research in this area further.

Acknowledgement

This study is funded by the National Research Foundation (NRF), grant number: 129953. The views, however, are not of the NRF.

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DII-2021-019

Barriers to Successful BIM Applications: A Literature Review

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Abstract

Building Information Modelling (BIM) technology is gradually gaining more popularity among construction professionals due to its benefits throughout the lifecycle of a construction project. Despite its potential benefits, previous studies have indicated that BIM application comes with its share of various challenges limiting its successful adoption. Consequently, this paper reviews extensively and classifies the barriers encountered during BIM tools on construction projects. A state-of-the-art review and analysis of literature on barriers to BIM application was conducted. Selected journal articles, documents, and conference proceedings from different databases on the subject matter were examined and thoroughly analysed. After that, boundaries were drawn between barriers of BIM implementation concerning regions that are advanced with BIM adoption against those that have not yet started. Fifty-seven (57) barriers accustomed to BIM implementation were identified, out of which thirty-three (33) factors were peculiar to regions where BIM application was not yet fully adopted. The identified barriers were grouped under six (6) sub-divisions: professional workforce conditions, construction management conditions, Technological factors, environmental influence, financial issues, and legal matters. This paper contributes to the body of literature on BIM application, barrier, and classification. This paper further draws boundaries between BIM implementation challenges concerning advanced regions with BIM adoption and those that have not started. Possible solutions to mitigate the BIM application barriers were highlighted as an additional contribution to knowledge.

Keywords: Building information modelling technology, BIM application, barrier, construction professionals

1. Introduction

The importance of BIM technology since its advent cannot be over-emphasised. Professor Chuck Eastman originally proposed the BIM prototype in 1975. He offered to "build a computer-based description of a building", which transformed to the BIM technology that the construction professionals are enjoying its simplicity to date (Yongliang *et al.,* 2020*).* BIM represents a fundamental change to the traditional ways in which construction professionals function and communicate. It allows for collaboration and ease of data sharing among construction professionals (Eastman *et al.*, 2011). BIM has been defined as a digital

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representation of a facility's physical and functional characteristics (National Building Information Modeling Standards (NBIMS, 2010)). This definition is in line with that of (Azhar *et al.,* 2012). According to the authors, BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life cycle, from earliest conception to demolition. A basic premise of BIM is the collaboration between different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of such stakeholders (NBIMS, 2010). Succar (2009) establish BIM as the organization of real data, in its whole application, considering the dissimilar stages of the life sequence of a building, from planning stage to demolition stage, which can be held on a sole mutual technological setting. This idea is the foundation on which BIM technology operates from inception to date. BIM can be used as means of the progressive development of Computer-Aided Design (CAD). The use of BIM technology will enhance building industry competencies through improved collaboration amid professionals in the built environment; this will help to reduce clashes and replication of work on rectification and modifications (Migilinskas *et al.*, 2013). BIM technology as a tool functions around all aspects of a construction project from the preliminary phase, which entails the architectural design; the structural stages (structural analysis/design, study, and formation of detail structural drawings); extraction of required quantities, and budget of material; Scheduling schematic construction procedure and Primary use of the building (management and maintenance) in a future phase (Singh *et al.*, 2011). BIM has now become common technology used in the life cycle of a construction project (Puolitaival and Forsythe, 2016). BIM can function as a managerial instrument for construction works; BIM entailed various working areas and structures of construction work within a template, where all participants in a project (clients, construction professionals, main-contractors, sub-contractors, and materials/tools suppliers) can work together, more correctly and professionally than the old conventional procedures (Succar, 2009; Azhar *et al.*, 2012; Succar and Kassem, 2015). Haven identifies that BIM can function throughout the lifecycle of a project; presently, professionals have shown interest in the actualization of BIM among the built professionals. The Construction professionals of this century are no longer novices in BIM realization, administration, and the satisfaction derived from applying BIM on construction projects. Yongliang *et al.* (2020), noting the research conducted by Stanford University’s Center for Integrated Facilities Engineering (CIFE), indicate that the proper use of BIM on construction projects eliminate variation to the tune of 40%, produce about a 7% reduction in expected duration of the project execution time, lead to an 80% timesaving used within project costing valuation, create about 10% increase in contract value savings and produce a 3% profit margin for the whole project. Migilinskas *et al.* (2013) concluded that

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“Practically Construction project teams consist of professionals with different levels of BIM methodology knowledge. Therefore, BIM implementation process must break some borders and overcome barriers of different nature.” Those barriers are what hinder the successful application of BIM technology among construction professionals.

2. Research Methodology

An extensive review using the content analysis method was carried out to discover various challenges facing BIM implementation in construction projects. Criminale & Langar (2017), as cited in Hsieh and Shannon (2005), linked content analysis to literature. It was explained as a flexible method that can be exploited to analyse text data. Two significant processes were involved. The first process was the collection of relevant academic publications on BIM using related keywords. Three search conditions were used in other to locate relevant documents; the terms in the first search condition are “BIM application”, “BIM concept”, and “Building information modelling”. The second search condition includes “BIM barriers”; and “challenges of BIM application”. The third search condition consists of the “BIM approach”. Those search conditions were repeated in selected academic databases of Elsevier (Science direct), Francis and Taylor Researchgate, google scholar, and springer.

A total number of 50 papers were retrieved. The retrieved papers included journals, conferences, and case studies, excluding editorials, book chapters, and forums. The retrieved papers' abstracts were read to ascertain their relevance to the current research. Consequently, the initial 50 papers that were retrieved were filtered down to 43. Exclusion criteria such as the absence of author(s)’s details, missing year of publications, duplications/ repeated paper entries, and paper written in language order than English were adopted. Adopting the exclusion criteria in the filtration of the retrieved articles produced a final population of 43, considered in this paper. After the first grouped studies were generated using keywords, references of the contacted journals were used to get other relevant journals. The next pace involves analyzing appropriate materials retrieved during the search.

Furthermore, the barriers affecting the successful usage of BIM were highlighted, labelled, and grouped. Furthermore, the identified barriers were classified under regions advanced in BIM use and those yet or about to fully adopt BIM into their construction industry. The final phase encompasses the provision of possible suggestions that will eliminate those highlighted barriers.

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3. Research Discussion

Building Information Modelling (BIM) based tools

BIM-based tools are the various software used to actualize building information modelling. There are lots of software used to implement BIM models. The integration of the BIM model can be activated using different software by the various built environment professionals (Thomassen, 2011). The following are some of the various construction BIM software tools used by multiple professionals. Vectorworks Architect, ArchiCAD, Autodesk BIM 360, SketchUp, Revit, Navisworks, Revizto, Iris VR, BEXEL manager, Edificius, ArCADia BIM 11, VisualARQ, Midas Gen, Civil 3D, Buildertrend, Hevacomp, Sefaira, BIMx. Many developers develop BIM-based software; those include Autodesk, MIDAS, ACCA software, Graphisoft's etc. Currently, construction professionals use some of that BIM software at different stages of the project phase. The research conducted by McGraw-Hill Construction (2008) indicated that the most frequently used BIM software is Navisworks and Revit, 71% and 67%, respectively. Arayici (2015), in his research, was able to identify ArchiCAD and Tekla, with usage range of about 34% and 10%, respectively, as reported by (Karakurt, 2019).

BIM benefit

Previous studies have revealed that a lot of benefits accompanies the successful implementation of BIM. These benefits span all through the life circle of building projects. Azhar (2011) indicated that when BIM technology is successfully implemented, it will yield a very high return on investment and be beneficial to the construction industry. Al-Ashmori *et al*. (2020) researched BIM benefits in Malaysian. The findings from their studies highlighted 7 significant BIM benefits that various prompt companies to implement BIM concepts. The influential factors include high productivity and efficiency, easiness of assessing time and cost associated with design, monitoring and tracking construction progress, and eliminating design clashes. Those are the significant benefits acquired when BIM is fully implemented in a construction project.

BIM Adoption

Adopting BIM technology requires it to pass through some processes/stages to be fully integrated into a construction project. These processes, as highlighted in Li *et al.* (2014),

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include the creation of the structure of the building facility with the use of Autodesk Revit software; Integration of the changes done during the final design to generate a complete building information model; using structural analysis software to conduct structural analysis; Carry out a proper calculation of material required to execute the project based on the information generated from the 3D aided design and effectively coordinated corporation with sub-contractors primarily on the 3D model. The software used by Li *et al.* (2014) for their research work is not limited to that alone; many companies saddled with software products are now producing new ideas for BIM uses daily. Currently, numerous software support BIM technology. This has made the use of BIM software easy and also fast-track its adoption. Notwithstanding, several barriers are associated with the five processes of integrating BIM technology in a construction project throughout its life cycle.

Barriers limiting BIM application

Various scholars have done lots of research on barriers preventive the usage of BIM technology. Table I demonstrate an instant of the barriers acknowledged in the journals reviewed.

Table I: Barriers limiting BIM application

No.	Barriers Limiting BIM Application	Reference	Reference frequency sum
1	Low computer skills among some of the professionals in the construction industry	(Ozorhon and Karahan, 2016; Chen *et al.*, 2015; Ilozor and Kelly, 2012; Ray and Firdaus, 2020; Olanrewaju *et al.*, 2020; Jin *et al.*, 2017; Azhar *et al.*, 2012; Al-Ashmori *et al.*, 2020; McAuley *et al.*, 2012; Chan *et al.*, 2019; Eastman *et al.*, 2011; McAdam, 2010; Rezgui *et al.*, 2011; Karakurt, 2019; Puolitaival and Forsythe, 2016; Arrotela *et al.*, 2021; Durdyev *et al.*, 2021; Saka & Chan, 2020; Succar, 2009; Singh *et al.*, 2011; Siebelink *et al.*, 2021; Babatunde *et al.*, 2020; Kekana *et al.*, 2014; WU *et al.*, 2021; Tan *et al.*, 2019; Nisbet and Dinesen, 2010; *Yongliang et al.*, 2020; Mendez, 2006; Ahmed, 2018; Azhar, 2011; Lesniak *et al.*, 2021; McAdam, 2010; Azhar *et al.*, 2012; Migilinskas *et*	41
2	Inefficient BIM education on collaboration among the professionals		
3	Habitual resistance to change from the traditional model of design and build		
4	Lack of the required competence on BIM application		
5	Poor awareness of BIM benefits		
6	An overall absence of practical skills, experience, and software knowledge that is essential to apply BIM tools properly		

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No.	Barriers Limiting BIM Application	Reference	Reference frequency sum
		al., 2013; Barak *et al.*, 2009; Hwang and Liu, 2010; McGraw-Hill, 2010; Bouhmoud and Loudyi, 2020; Arayici, 2015; Succar and Kassem 2015; Alsaeedi *et al.*, 2020).	
7	Misunderstanding of BIM concept	(Thomassen, 2011; Saka & Chan, 2020; Succar, 2009; Singh *et al.*, 2011; Siebelink *et al.*, 2021; Babatunde *et al.*, 2020; Chen *et al.*, 2015; Ilozor and Kelly, 2012; Ray and Firdaus, 2020; Olanrewaju *et al.*, 2020; Jin *et al.*, 2017; Azhar *et al.*, 2012; Al-Ashmori *et al.*, 2020; McAuley *et al.*, 2012; Chan *et al.*, 2019; Eastman *et al.*, 2011; McAdam, 2010; Rezgui *et al.*, 2011; Karakurt, 2019; Puolitaival and Forsythe, 2016; Arrotela *et al.*, 2021; Durdyev *et al.*, 2021; Kekana *et al.*, 2014; WU *et al.*, 2021; Tan *et al.*, 2019; Migilinskas *et al.*, 2013; Barak *et al.*, 2009; Hwang and Liu, 2010; McGraw-Hill, 2010; Bouhmoud and Loudyi, 2020; Arayici, 2015; Succar and Kassem 2015; Alsaeedi *et al.*, 2020; Nisbet and Dinesen, 2010; *Yongliang et al.*, 2020; Mendez, 2006; Ahmed, 2018; Azhar, 2011; Lesniak *et al.*, 2021; McAdam, 2010; Azhar *et al.*, 2012).	
8	Lack of support from senior leaders of the construction industry from the traditional method of contracting to embrace the use of BIM technology		41
9	Lack of cooperation from various built environment professionals		
10	Lack of well-develop practical strategies and standards		
11	Lack of support from owners and managers due to inadequate knowledge of BIM concepts		
12	Problems encounter in handling BIM tools security.		
13	Top leaders lack assurance about the long-term benefit of BIM use.		
14	Lack of cooperation among numerous contractors and subcontractors, not willing to reveal data regarding BIM experience.		
15	Project risks caused by BIM		
16	Lack of motivation to implement BIM in projects		
17	Lack of a Stable BIM tool Working environment		
18	Negative Attitude towards Working Collaborative		
19	Not fully formed Dispute Resolution Means for BIM Application		
20	lack of organizational goal set up in line with BIM technology usage.		
21	Nonexistence of BIM application protocols, long-term strategies within an organization		
22	Lack of proper administration of BIM incorporation all through the project lifespan		
23	Accessibility of BIM tools	(Hardin & McCool, 2015; Ahmed, 2018; Azhar, 2011; Lesniak *et al.*, 2021; McAdam, 2010; Azhar *et al.*, 2012; Migilinskas *et al.*, 2013; Barak *et al.*, 2009; Hwang and Liu, 2010; McGraw-Hill, 2010; Bouhmoud and Loudyi, 2020; Arayici, 2015; Succar and Kassem 2015; Alsaeedi *et al.*, 2020; Ozorhon and Karahan, 2016; Chen *et al.*, 2015; Ilozor	
24	Failures in technological support		
25	Absence of adequate quantifiable digital design information		
26	Absence of collaboration among built stakeholders		
27	Difficulties on required training time		
28	Inadequate information about the responsibility of each data		
29	The complex process of learning BIM technology		

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No.	Barriers Limiting BIM Application	Reference	Reference frequency sum
30	Data ownership and data privacy concerns	and Kelly, 2012; Ray and Firdaus, 2020; Olanrewaju *et al.*, 2020; Jin *et al.*, 2017; Azhar *et al.*, 2012; Al-Ashmori *et al.*, 2020; McAuley *et al.*, 2012; Durdyev *et al.*, 2021; Saka & Chan, 2020; Succar, 2009; Singh *et al.*; Siebelink *et al.*, 2021; Babatunde *et al.*, 2020; Kekana *et al.*, 2014; WU *et al.*, 2021; Tan *et al.*, 2019; Nisbet and Dinesen, 2010; *Yongliang et al.*, 2020; Mendez, 2006; Chan *et al.*, 2019; Eastman *et al.*, 2011; McAdam, 2010; Rezgui *et al.*, 2011; Karakurt, 2019; Puolitaival and Forsythe, 2016; Arrotela *et al.*, 2021)	41
31	Complexity in getting used to BIM Technology and procedure		
32	Inadequate of BIM data		
33	Lack of BIM experts		
34	BIM technology Incompatibility and interoperability challenges across the project life cycle		
35	Unsatisfactory government regulation	Puolitaival and Forsythe, 2016; Arrotela *et al.*, 2021; Babatunde *et al.*, 2020; Kekana *et al.*, 2014; Tan *et al.*, 2019; Arrotela *et al.*, 2021; Saka & Chan, 2020; Singh *et al.*, 2011; Siebelink *et al.*, 2021; Tan *et al.*, 2019; Thomassen, 2011; Al-Ashmori *et al.*, 2020; McAuley *et al.*, 2012; Eastman *et al.*, 2011; *Yongliang et al.*, 2020; Mendez, 2006; Migilinskas *et al.*, 2013; Barak *et al.*, 2009; Bouhmoud and Arayici, 2015; Succar and Kassem 2015; Alsaeedi *et al.*, 2020; Chen *et al.*, 2015; Ilozor and Kelly, 2012; Ray; Jin *et al.*, 2017).	24
36	Inadequate customer and market demand		
37	Firms that successfully implement BIM are reluctant to disseminate their experience		
38	Lack of organized BIM studying means		
39	BIM consulting market is confused		
40	Insufficient External Motivation		
41	High costs related to the BIM software, hardware and training	Puolitaival and Forsythe, 2016; Arrotela *et al.*, 2021; Durdyev *et al.*, 2021; Saka & Chan, 2020; Singh *et al.*, 2011; Siebelink *et al.*, 2021; Babatunde *et al.*, 2020; Kekana *et al.*, 2014; WU, *et al.*, 2021; Tan *et al.*, 2019 Puolitaival and Forsythe, 2016; Arrotela *et al.*, 2021; Durdyev *et al.*, 2021; Saka & Chan, 2020; Singh *et al.*, 2011; Siebelink *et al.*, 2021; Babatunde *et al.*, 2020; Kekana *et al.*, 2014; WU, *et al.*, 2021; Tan *et al.*, 2019; Thomassen, 2011; Al-Ashmori *et al.*, 2020; McAuley *et al.*, 2012; Eastman *et al.*, 2011; McAdam, 2010; Rezgui *et al.*, 2011; *Yongliang et al.*, 2020; Mendez,	35
42	Lengthy-time to get a return for structuring BIM expert squad		
43	Cost of BIM experts and time required for training		
44	Project planning cost increase		
45	Unclear Financial Profits		

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No.	Barriers Limiting BIM Application	Reference	Reference frequency sum
		2006; Ahmed, 2018; Azhar, 2011; McAdam, 2010; Azhar *et al.*, 2012; Migilinskas *et al.*, 2013; Barak *et al.*, 2009; Hwang and Liu, 2010; McGraw-Hill, 2010; Bouhmoud and Loudyi, 2020; Arayici, 2015; Succar and Kassem 2015; Alsaeedi *et al.*, 2020; Chen *et al.*, 2015; Ilozor and Kelly, 2012; Ray and Firdaus, 2020; Olanrewaju *et al.*, 2020; Jin *et al.*, 2017;)	
46	government not willing to support BIM use	(Al-Ashmori *et al.*, 2020; McAuley *et al.*, 2012; Eastman *et al.*, 2011; McAdam, 2010; Rezgui *et al.*, 2011; *Yongliang et al.*, 2020; Mendez, 2006; Ahmed, 2018; Azhar, 2011; Lesniak *et al.*, 2021; McAdam, 2010; Azhar *et al.*, 2012; Migilinskas *et al.*, 2013; Barak *et al.*, 2009; Hwang and Liu, 2010; McGraw-Hill, 2010; Bouhmoud and Loudyi, 2020; Arayici, 2015; Succar and Kassem 2015; Alsaeedi *et al.*, 2020; Ozorhon and Karahan, 2016; Chen *et al.*, 2015; Ilozor and Kelly, 2012; Ray and Firdaus, 2020; Olanrewaju *et al.*, 2020; Jin *et al.*, 2017; Karakurt, 2019; Puolitaival and Forsythe, 2016; Arrotela *et al.*, 2021; Durdyev *et al.*, 2021; Saka & Chan, 2020; Singh *et al.*, 2011; Siebelink *et al.*, 2021; Babatunde *et al.*, 2020; Kekana *et al.*, 2014; WU *et al.*, 2021; Tan *et al.*, 2019).	
47	Missing insurance framework for BIM application		37
48	Lack of clear definition of organizational arrangement and responsibilities		
49	Low knowledge about the harsh BIM application principles and guidelines for certain project professionals.		
50	Lack of clear Responsibility between stakeholders		
51	Lack of clear understanding between insurance structure and BIM application		
52	The unclear sole ownership right of BIM tool data		
53	Contractual BIM environment		
54	Lack of protocols in line with market demand		
55	Absence of insurance applicable to BIM application		
56	Lack of safety for intellectual assets Privileges		
57	Absence of support from policymakers		

Classification of barriers limiting BIM application

For ease of analysis, the 57 identified barriers limiting BIM Application in table I are classified into 6 categories: Professional Personnel Factors, Construction Management Factors, Technological factors, Environmental Influence, Financial Factor, and Legal Factors, as shown in Figure I.

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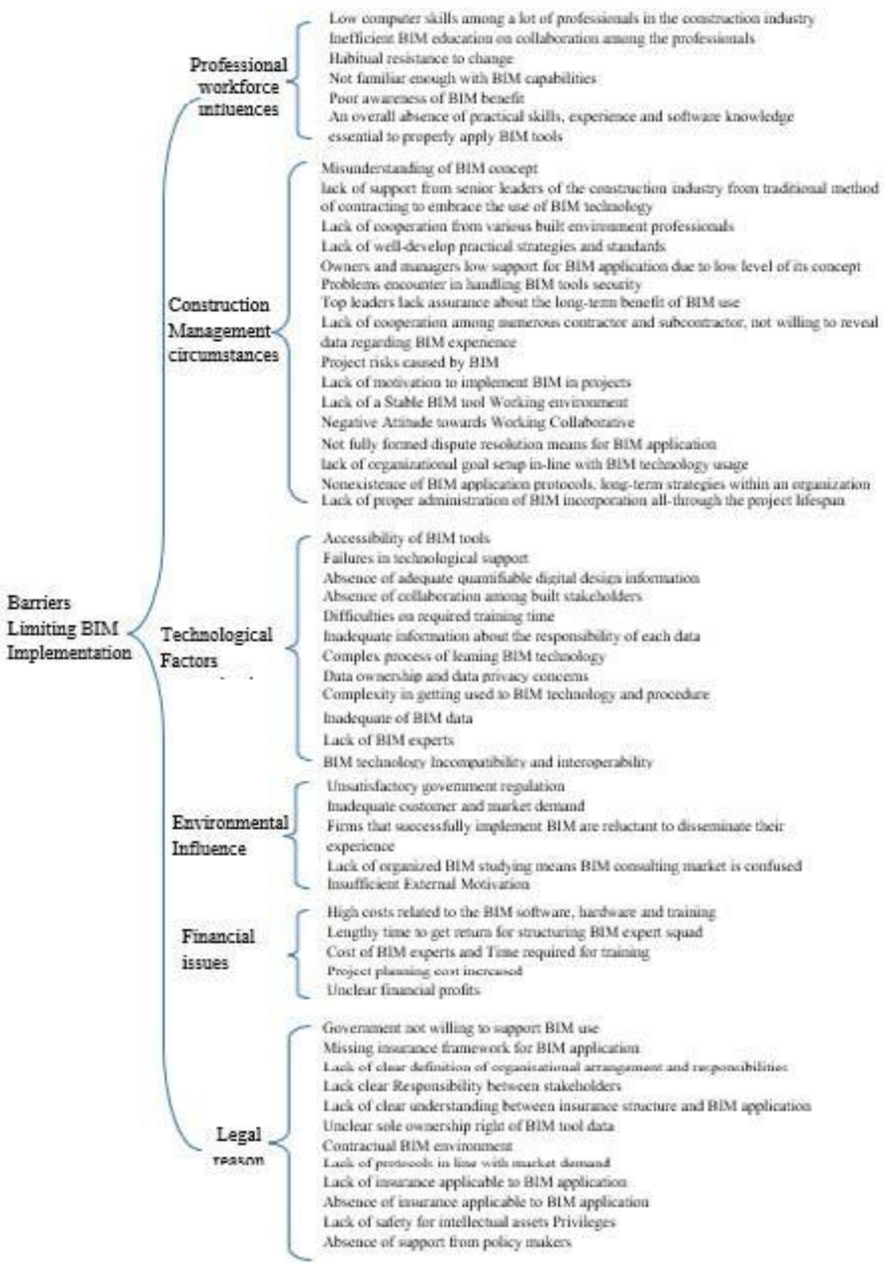

Figure I: Classification of barriers limiting BIM application

Table II. Classification of BIM Barriers encountered based on region yet to adopt BIM and the region that have fully adopted BIM

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S/N	Barriers classification	Region yet/ about to adopt BIM (Africa etc.)	Region incorporate/ fully adopted BIM (America, Europe, Asia etc.)
1.	Professional workforce influences	Low computer skills among a lot of professionals in the construction industry Habitual resistance to change Poor awareness of BIM benefit	Inefficient BIM education on collaboration among the professionals Not familiar enough with BIM capabilities An overall absence of practical skills, experience, and software knowledge is essential to apply BIM tools properly
2.	Construction Management circumstances	Misunderstanding of BIM concept lack of support from senior leaders of the construction industry from the traditional method of contracting to embrace the use of BIM technology Owners and managers have low support for BIM application due to the low level of its concept Lack of motivation to implement BIM in projects	Lack of cooperation from various built environment professionals Lack of well-develop practical strategies and standards Problems encounter in handling BIM tools security Top leaders lack assurance about the long-term benefit of BIM use Lack of cooperation among numerous contractors and subcontractors, not willing to reveal data regarding BIM experience Project risks caused by BIM Lack of a Stable BIM tool Working environment Negative Attitude towards Working Collaborative Not fully formed dispute resolution means for BIM application lack of organizational goal setup in line with BIM technology usage Nonexistence of BIM application protocols, long-term strategies within an organization Lack of proper administration of BIM incorporation all-through the project lifespan
3.	Technological Factors	Accessibility of BIM tools Absence of adequate quantifiable digital design information Difficulties on required training time The complex process of learning BIM technology Complexity in getting used to BIM technology and procedure Lack of BIM experts	Failures in technological support Absence of collaboration among built stakeholders Inadequate information about the responsibility of each data Data ownership and data privacy concerns Inadequate of BIM data BIM technology Incompatibility and interoperability challenges across the project life cycle
4.	Environmental Influence	Firms that successfully implement BIM are reluctant to disseminate their experience Lack of organized BIM studying means the BIM consulting market is confused	Unsatisfactory government regulation Inadequate customer and market demand Insufficient External Motivation

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S/N	Barriers classification	Region yet/ about to adopt BIM (Africa etc.)	Region incorporate/ fully adopted BIM (America, Europe, Asia etc.)
5.	Financial issues	High costs related to the BIM software, hardware and training Cost of BIM experts and Time required for training	Lengthy-time to get a return for structuring BIM expert squad Unclear financial profits Project planning costs increased
6.	Legal reason	Government is not willing to support BIM use Missing insurance framework for BIM application Absence of support from policymakers The unclear sole ownership right of BIM tool data Contractual BIM environment Absence of insurance applicable to BIM application	Lack of clear definition of organisational arrangement and responsibilities Lack of clear responsibility between stakeholders Lack of clear understanding between insurance structure and BIM application Lack of protocols in line with market demand Lack of insurance applicable to BIM application Lack of safety for intellectual assets Privileges

3. Discussion of BIM Barriers Classification

(1) Professional workforce influences

Professional workforce influence is the limiting factor associated with academically trained professionals. The lack of experienced professionals that are much conversant with the process of BIM technology application, who have adequate knowledge in managing BIM tools is an additional crucial restricting issue. Proper knowledge about BIM education and the teaching of professional stakeholders is necessary. This will enhance the comprehensive and perfect implementation of the BIM technology. It was reported by Zhang (2010) that most design companies (Architectural, structural, M&E) find it difficult to use BIM because of the low productivity understanding, customary struggle to change, and heavy work demands encountered during the preliminary period of setting up BIM tools. This sequentially makes it difficult to encourage the adoption of BIM easily.

(2) Construction Management circumstances

Construction management circumstances refer to the coordination and administration process associated with BIM barriers. These barriers are the professionals' attitudes toward BIM technology application, the unavailability of reports of projects where BIM application is fully and successfully integrated for references, the inappropriate mode of operation, and the absence of cooperation by various construction stakeholders. BIM technology disintegrates the traditional restrictions among various industry stakeholders and allows the

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sharing of project information in a single model in some collaborative environments (Yongliang *et al.*, 2020). This means that stakeholders will have to understand their basic role in the project team and transform the work process of their companies in line with the requirements of the BIM application. This will cause changes to the working process from design, file organisation, customer charge, and final results. Therefore, the construction firm will need adequate time to adapt to those changes (Sun *et al.*, 2017). The fragmented nature of the built environment firm is another barrier mitigating the efficiency and productivity of building developments. In this regard, numerous scholars have investigated the effects of fragmentation in the construction industry; possible required solutions were also proposed to overcome those barriers.

Notwithstanding, opinion varies as to which proposed solution will provide an adequate remedy to the identified barriers. Hwang and Liu (2010) have noted the need for computer incorporation. However, Sun *et al.* (2017) believed that construction professionals prefer to adopt BIM technology, which was basically due to the fragmented status of construction procedure, which makes each project sole unique and not reproducible.

(3) Technological Factors

The BIM technology-based software packages are also referred to as BIM tools. The technological factors refer to BIM tool-related factors limiting the application of BIM. These BIM tool-related barriers include lack of standards and protocols, imperfect/immature BIM software, among others. The confined capability of BIM software is the key issue preventing its application in the construction industry (Sun *et al.*, 2017). Furthermore, the main constraints are the absence of interoperability, scalability and assistance used for proper collaboration, and incompatibility to form cast-in-place (CIP) reinforced concrete constructions. Those are regarded as the major restrictions on the conventional implementation of BIM (Sun *et al.*, 2017). According to the IEEE (1990) glossary, Interoperability was defined as “the ability of two or more systems or components to exchange information and to use the information that has been exchanged”. Parallel disintegration between construction team members at a specified project phase (e.g., planning, building production, or operation) can be instigated by the range of software used. It can add to the hindrance of interoperability (Howard *et al.*, 1989). According to Nisbet and Dinesen (2010), the National Institute of Standards and Technology (NIST) estimates the general cost of insufficient interoperability to the tune of $15.8 billion yearly. This has been a great challenge facing the application of BIM. Young *et al.* (2008) were able to find out that BIM software managers are set to improve on interoperability. In addition, numerous

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global standards have been established to find a solution to the problems of interoperability. In a later year (Azhar *et al.*, 2011; Rezgui *et al.*, 2011; McAuley *et al.*, 2012) concluded that despite the increased awareness of BIM technology, there are still some inadequacies in BIM use. According to Rezgui *et al.* (2011), the affirm that statistical representation of a building and its environment are still crucial barriers to BIM technology application. The study of synchronization of data linking BIM technology and the progress of work done on-sit in day-to-day activities is another pressing challenge over the years. Chen *et al.* (2015 research indicate increased development in technologies, processes, and methods of synchronizing BIM technology, with updated daily site activities, such as laser scanning, camera, Global positioning system (GPS), geographic information system (GIS), augmented reality (AR), radio frequency identification (RFID), etc., the application of such technologies has made it possible to acquire and manage these difficult data for ‘bridging the constrain of BIM and construction work done on-site daily.

(4) Environmental Influence

Environmental influence refers to the limiting factors generated within the geographical area of the construction site. BIM implementation demands expert active interactivity all through the life cycle of the project. However, the present construction firm is generally identified for its lack of professional collaboration (Ozorhon and Karahan, 2016; *Jin et al.*, 2017; Tan *et al.*, 2019). This obstacle could hinder the application of BIM implementation in a construction project.

(5) Financial issues

Financial issues are the major cost incurred to implement BIM technology in a construction project, discussed in the literature review. This comprises the procurement of software and hardware basically for BIM use. Purchase of software, installation and tutoring costs, etc. Financial issues mean the monetary factors limiting the progress of BIM implementation. A research carried out in 2008, as reported by McGraw-Hill, shows that the major obstacle to a successful BIM application is related to costs and training problems. (Young *et al.*, 2008; Sun *et al.*, 2017), In addition, in 2004, a report published by the U.S National Institute for Standards and Technology (NIST) 2004 shows that construction firms waste close to $16 billion yearly due to poor interoperability in software.

(6) Legal issues

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Legal issues restrict factors initiated by lack of maturity of the regulatory/contractual environment. Barak *et al. (*2009) made it known that the result of Legal and insurance complications typically caused by defective software can result in a court case. There is numerous BIM software, and BIM models are regularly formed by numerous professionals with the software packages they are familiar with and used by different participants. Suppose a document relating to the design got lost along the line of sharing among the concerned professionals. In that case, due to improper usage or lack of proper understanding of the BIM models, tracing and confirmation may become very difficult due to the obscure responsibility. Furthermore, the following limitations highlighted by scholars must also be resolved; Méndez (2006) noted the control of entry and the safety of building information in BIM models; (McAdam 2010) also included ownership and protection of data, while, Yongliang *et al.* (2020) in their research highlighted lack of insurance, lack of standard form of contract, (Migilinskas *et al.*, 2013) also include lack of contractual protocols, etc.

Analysis of the reviewed published paper on barriers limiting BIM application

Table III shows the frequency at which the barriers were cited in the journals reviewed.

Table III: Statistics of factors limiting the application of BIM

Barriers Limiting BIM application/ Year of Publication	**Professional Personnel Factors**	**Construction Management Factors**	**Technological Factors**	**Environmental Influence**	**Financial Factors**	**Legal Factors**
1985-2005	0	0	0	0	0	0
2006-2010	7	6	7	2	5	5
2011-2019	21	22	21	15	17	19
2020	8	8	8	5	8	8
2021	5	5	5	2	5	5
Frequency Sum	41	41	41	24	35	37

Table III shows the time BIM barriers publications cited per year according to the selected reviewed literature. Sum of times scholars identifies BIM barriers yearly based on the selected published reviewed journals.

The implication of the *statistics is shown in Table III.*

(1) The most frequently identified factors, from most frequent to least frequent, are preprofessional factors (41/42 = 97.61%), construction management factors (41/42 =

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97.61%), technology factors (41/42 = 97.61%), Legal Factors (37/42=88.09%), Financial factors (35/42 = 83.33%) and Environmental influence factors (24/42 = 57.14%).

(2) The statistics imply two things: First, it indicates that published reviewed journals from the year 2006-2021 all identify one or two barriers relating to the following sub-division of BIM limiting barriers; professional personnel factors, construction management factors, and technological factors. This induces that those three sub-divisions are the key barriers hindering the successful application of BIM technology in any construction project, as identified in 42 reviewed published journals. This was also identified in (Chen *et al.*, 2015) research work; Utmost attention has to be mounted on those identified barriers under each sub-division of the limiting factors. Secondly, from 1985-2005 indicated that no publication on the barriers limiting the application of BIM technology. This may be as a result of limited knowledge, awareness, etc., of BIM technology application.

(3) Legal factors have received the fourth most attention. Among the sub-division of the barriers limiting the application of BIM technology with 88.09%, the sub-division "Financial Factor" which is the fifth with 83.33%, is next to legal factors, utmost consideration needs to be mounted to the two since they have over 80% range of frequency cited from 42 reviewed publications. Lastly, Environmental influence should not be left out, and scholars must critically check that area to affirm its possible implications.

(4) Among the 42 reviewed studies, 7 study in 2006-2010 (2006 – 1, 2007- 0, 2008 -1, 2009 – 2, 2010 – 3), 21 studies in 2011-2019 (2011 – 4, 2012 – 2, 2013 – 1, 2014 -2, 2015 – 4, 2016 – 3, 2017 – 2, 2018 – 1, 2019 – 2), 8 studies in 2020 and 5 studies in 2021. This indicates that Studies of the barriers limiting successful BIM application have become more common in the last years. This means that how these barriers have hindered the application of BIM is now more obvious. Therefore, an urgent need for effective solutions is required. This result indicates that more scholars and professionals are being drawn to the study of BIM technology applications.

4. Conclusions and Suggestions

BIM technology over the last decade has shown improved awareness and very quick development. Construction professionals have widely considered its application in many huge construction projects; the result derived from the application of BIM technology in construction projects has proven that great benefits can be achieved if BIM is successfully

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implemented in a construction project. However, numerous barriers which scholars identified as factors delaying the further improvement and adoption of BIM technology were highlighted and analysed in this study. The critical analysis of the selected literature reviewed has led to a general understanding of the barriers to successfully applying BIM technology. There are six categories of Barriers: (1) Professional Personnel Factors, (2) Construction Management Factors, (3) Technological Factors, (4) Environmental Influence, (5) Financial Factors, and (6) Legal Factors. The most commonly cited categories are Professional Personnel Factors, Construction Management Factors, and Technological Factors. Furthermore, construction professionals believe that the lack of expertise concerning BIM personnel, lack of data interoperability, and changes in the workflow are the key barriers to exploring the full benefit of BIM technology.

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South African Building Information Modelling and Organizational Size – A Quantity Surveyor's perspective

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Abstract

With so many factors influencing the adoption of Information Management (BIM), the study reviews BIM adoption and the size of organisations within the South African construction industry. It has been determined that there is a trend in the adoption of BIM between different organisational measures. This investigation highlights factors unique to the South African socio and economic influences on the Construction Build Environment (CBE). A quantitative approach with a placement theory analysis was used for the study. A survey grounded in secondary data was used to gather data, followed by a placement theory analysis of the qualitative and quantitative data. It was found that larger companies adopt BIM more readily than smaller enterprises due to increased incentives, including exposure to larger and more complex projects (clients), available funding, and a larger pool of expertise. This has led to the conclusion that the BIM adoption requires a more fit-for-purpose approach, rather than being approached with available opportunities than forced. The study was limited to professionals within the South African construction- built environment (CBE). Two survey sets were used; one focused on quantity surveying practices and the second on a broader spectrum of construction organisations to draw comparisons. Based on the findings, tertiary institutions should carefully consider incorporating BIM education in the already overflowing curricula. With the different available software packages constantly being enhanced, the technical aspects of BIM implementation should be weighed against critical thinking and BIM management aspects.

Keywords: Building Information Modelling (BIM), Organisational size

1 Introduction

The construction industry is mainly slow to adopt new technologies. It is not renowned for being innovative, even though the construction industry is one of the largest industries globally, contributing to one of its largest employment sectors (Abubakar *et al.*, 2014). Cao *et al.* (2017) state that, even though innovation such as BIM has been in the construction sector for more than a decade, it is still experiencing a low adoption rate. The World

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Economic Forum (WEF) also states that, although some new technologies have emerged in the industry's market, innovation and adoption in the sector are still very low (WEF, 2018). This statement is supported by the BIM Africa Report of 2020 (BIM.Africa, 2021), stating that slow adoption of BIM is evident.

As an innovation within the construction industry, BIM was developed to benefit all organisations and stakeholders, regardless of their size (Ding *et al.*, 2015). BIM is one of the most promising innovations in the construction industry that aims to address the issues of efficiency and performance that have long haunted the construction industry (Eastman *et al.*, 2011). Froese (2010) states that BIM aims to develop and improve the traditional paper-based construction process by moving the conventional approach to a digital working environment and allowing greater efficiency, communication, and collaboration in construction projects.

Despite the benefits of BIM targeting organisations of all sizes in the construction industry, there is an imbalance in adopting the innovation between organisations of different sizes (Ding *et al.*, 2015). Singh and Holmström (2015) suggest that the insufficient levels of BIM adoption may be due to the barriers organisations face when adopting innovations. Organisations face the following challenges when adopting BIM (Haynes, 2009; Zhou, Perera *et al.*, 2012): initial costs of adoption, inadequate skills and training, lack of demand, and lack of awareness of industry bodies.

The research asks: What is the correlation between the size of an organisation and BIM adoption in the South African Construction Build Environment (CBE), the advantages and disadvantages of BIM adoption, and the challenges faced when adopting BIM? The hypothesis states that in the South African construction industry, the size of an organisation has a positive correlation to the adoption of BIM, meaning larger organisations can adopt BIM more readily than smaller organisations, particularly quantity surveying companies. The study's objective is to investigate the factors that affect the adoption of BIM and how they affect organisations of different sizes in the South African CBE. This assists in identifying the relationship between an organisation's size and BIM adoption and identifying possible ways to address these challenges by learning from other countries.

2 Literature

Building Information Modelling

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Compared to other countries, the South African CBE is slow in adopting BIM, with many QS companies classified as small, two to three-person practices, with a diverse spectrum of clients and projects. The financial strength of clients and the following type of projects vary. This results in different project team compositions and thus technological requirements. The entire value chain of the Project Life Cycle (PLC) should show improvement to create a market for those producing usable data (Potgieter, 2017). In conjunction with the ASAQS, the BIM Institute has taken the initiative to compile an Elemental Classification System to assist model developers in producing such information for the Quantity Surveyor, who, in turn, can convey it to the contractors. The objective is to standardise how BIM information is classified within the model (ASAQS, 2018). This correlates with the suggestion of better collaboration between the supply chain and stakeholders (Odubiyi *et al.*, 2019). Waiting for the South African Government will not promote the adoption of BIM implementation (Potgieter, 2017), and other stakeholders will organically drive BIM adoption.

Even though the concept of Building Information Modelling (BIM) was adopted in building design software in the 1970s, it only started gaining traction in the industry in the early 2000s. This led to more researchers and research institutions investing in the concept to evaluate BIM's critical success and failure factors. Further studies have indicated that BIM adoption is observed to be at a greater rate in developed countries compared to developing countries. It is further stated that the developing countries showed a reduced inclination towards BIM adoption (Fazli *et al.*, 2014).

The purpose of BIM is to help consumers, contractors, technical teams and subcontractors to achieve harmonious project implementation processes throughout all phases of a project, namely the construction programme, initiation, procurement, implementation, and operation (Kocakaya *et al.*,2019). Allen *et al.* (2012) state that BIM offers potential benefits to architects in the design phase of a construction project by providing a platform that makes it easier to identify and avoid conflicts in project designs. They further indicate that projects would benefit from this system as the cost of rework due to design flaws and disputes will be drastically lower or non-existent. Uysal (Cited: Namli *et al.*, 2019) states that the on-site use of BIM in construction projects offers visual and appropriate information to contractors, which is obtained on-site at a reasonable time. This sees the likelihood of reducing the number of demands for Requests for Information (RFI), disputes, and conflicts frequently found on construction sites.

Abundant literature has been written on the many possible benefits of the acceptance and implementation that BIM will bring to projects within the construction industry. However,

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organisations face obstacles and barriers in implementing BIM within the sector (Ghaffarianhoseini *et al.*,2017). The following barriers towards BIM adoption in the construction industry have been identified (Froise and Shakantu, 2014; Ghaffarianhoseini *et al.*, 2017): lack of demand for BIM by clients, lack of skills, lack of help from corporate management, high cost of BIM training, the reluctance of the industry to adjust, and lack of awareness by bodies of industry.

The African BIM Report of 2020 acknowledges that the COVID-19 pandemic has accelerated the adoption of digital platforms on the continent. However, the adoption rate still falls short compared to other countries in the world (BIM.Africa, 2020). It is crucial to note that the quality of the "drawings" will also significantly impact the accuracy of the estimates. Role players have to understand how data is shared and used by other role players on the project and fulfil their obligation within the project team, e.g., having the correct decimal setting on the models (Exactal, 2018). The BIM Institute of South Africa and the Association of South African Quantity Surveyors (ASAQS), in conjunction with the South African Institute of Architecture (SAIA), have developed an elemental classification system to assist draftsmen in standardising the classification of elements to be used by Quantity Surveyors and other role players (ASAQS, 2018).

The evaluation of BIM adoption can be measured against the BIM maturity levels proposed by Mark Bew and Mervyn Richards (Cited: Sacks *et al.*,2018; BIM.Africa, 2020), as illustrated below.

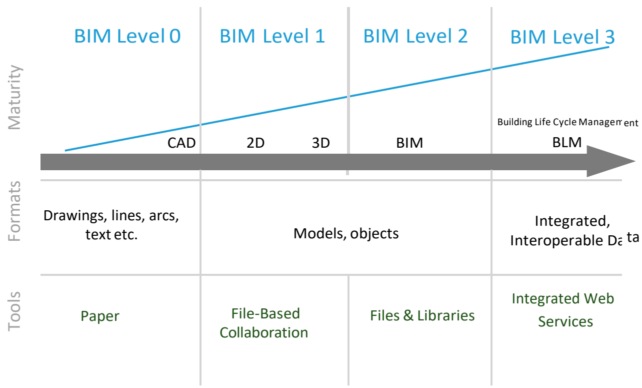

Figure 2.1: The BIM maturity model by Mark Bew and Mervyn Richards

(Modified & cited: Sacks *et al.*, 2018)

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Most highly ranked research articles on BIM adoption focus on the greater architecture, engineering and construction industry, not small and medium-sized enterprises (SMEs). It was also found that the United Kingdom (UK) is one of the leading countries when published articles on the subject are concerned. This might be attributed to the mandatory requirements by the UK government to operate at a BIM level 2, if the projects are publicly funded (Makabate *et al.*, 2020).

Although the African Architectural, Engineering and Construction (AEC) Industry reports 90% awareness, it reports an adoption rate on projects of only 45%. Of this, only 30% of companies does this in-house, while the majority of these respondents indicated only partial usage of BIM, e.g., engineering packages. Only 15% of respondents indicated that the model was used from start to finish (BIM.Africa, 2020). In contrast, the UK Government (the United Kingdom, 2011) took the initiative by propagating in May 2011 that any public sector construction project had to comply with BIM level 2 by April 2016. As indicated in Figure 2.1, BIM level 2 requires structured data for a built asset that provides collaboration throughout the supply chain. To a large extend, this led to BIM adoption increasing from 10% in 2011 to 70% in 2019 (Waterhouse, 2019a).

Innovation in organisations

Each organisation has a certain degree of creative capacity that plays a significant role in whether an organisation can implement innovative ideas or tactics. Business leaders have high levels of innovative capabilities who implement innovations rather than those with low innovative capabilities (Eurostat, 2019). These are the capabilities that distinguish organisations.

Internal and external variables play an essential role in an organisation's functioning and affect its capacity for innovation (Eurostat, 2019). The higher the innovation capacity of an organisation, the higher the efficiency of that organisation's creation. In their research, Lawson and Samson (2001) report that organisations that invested heavily in these "innovation potential factors" also have a higher likelihood of achieving a sustainable innovation outcome.

The seven factors of innovation capability that may influence an organisation's innovative potential, as prescribed by Lawson and Samson (2001), are vision and strategy, skill base use, organisational knowledge, management of imagination and ideas, organisational structure, culture and environment, and technology management.

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The UK National BIM Report of 2019 indicates the following results regarding BIM usage compared to practice size:

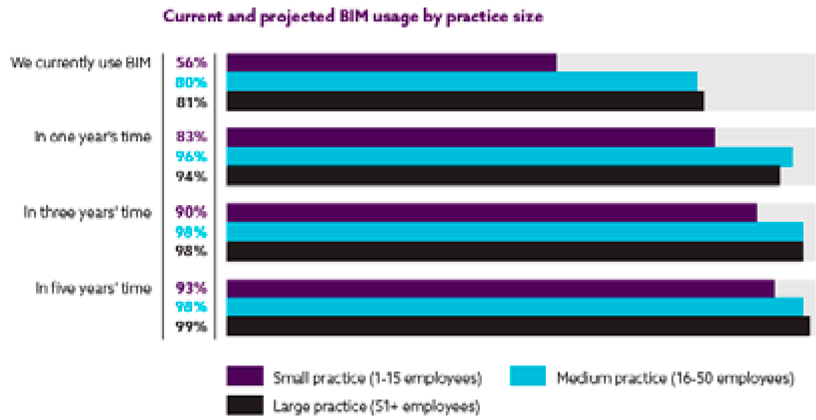

Figure 2.2: UK BIM usage by practice size 2019.

(Source: Waterhouse, 2019a)

A more moderate uptake of BIM within smaller practices rather than larger patterns in the UK built environment can be seen from the above figure. This translates into a lower confidence ratio towards BIM knowledge and skills within smaller companies or practices. The main reason provided for this phenomenon is a cost against incentive (Waterhouse, 2019a). Australia and New Zealand's BIM Report highlights the lack of in-house expertise (73%), lack of training (67%) and no client demand (67%) as being the most prevalent barriers to BIM adoption. Interestingly, organisational size is not used to measure BIM uptake as in the UK BIM report. However, the report suggests that in Australia and New Zealand, BIM adoption occurs more widely, irrespective of the organisational size (Waterhouse, 2019b). However, there is still a great need to improve research on SME's adoption of BIM to stay competitive with larger organisations (Makabate *et al.,* 2020).

SMEs are reluctant to adopt BIM and would rather pay for traditional 2D methods if deemed more adequate. SME's would require training, timing and proper costing to prove worthwhile to adopt and subsequently, reliability towards production remains a critical factor for SME's to adopt BIM (Li, Zheng, Siand Xu, 2019). China, the United States, the United Kingdom,

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Australia, and South Korea remain the top contributors to BIM adoption research, with Asia the leading contributing Continent (Makabate *et al.*, 2020).

From the African BIM Report of 2020, it is perceived that many respondents from the survey indicated that their particular government should better support BIM adoption. Some of the other 15 established barriers towards BIM adoption highlighted in the report are a lack of training, in-house expertise, legal framework, and cost involved in adopting BIM (BIM.Africa, 2020). This is supported by Saka *et al.* (2019), highlighting that clients are significant drivers of BIM adoption at the organisation/project level. Governments are one of the major advocators at the industry level.

3 Research methods

A Quantitative approach with a placement theory analysis was used for the study. A survey was used to obtain empirical data grounded in the secondary data obtained from a literature study (Naoum, 2007; Alavi *et al.*,(2018). Two data sets were used for the empirical data, limited to the South African CBE. The first tried to establish quantity surveying firms' barriers towards BIM adoption, while the second searched for the correlation between organisational size and the adoption of BIM:

1. Barriers towards BIM adoption in quantity surveying firms.
2. Organisation size and adoption of BIM.

With this being an explorative study, a non-probable convenient sampling method was used for the data collection. The survey was limited by the prevalent COVID-19 restrictions and was subsequently placed on the ASAQS's website and distributed via email to attract as many respondents as possible. The survey tool developed on "*Google Forms*" only sanctioned one respondent from an organisation to complete the survey. This method allowed for a non-equal chance for respondents to be selected. In comparison, it allowed for secondary data collection or interviews, if required (Trobia, 2008; Leedy and Ormond, 2010). A total of 61 respondents responded to the questionnaires circulated, with the target group being professionals within the South African CBE. Thirty-four professional Quantity Surveyors completed the first data set. At the same time, the second data set was completed by twenty-seven South African CBE companies. Ethical approval was obtained through the University of the Free State for the more extensive study of this explorative study. The two

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data sets' objective was to provide a comparable set of data, based on the literature that BIM maturity might differ across the CBE professions.

The first data set indicated that more research is necessary on the relationship between the company size and profession towards BIM adoption and the perspective towards overcoming challenges experienced when adopting BIM. Hence, the second set of questionnaires was distributed to understand better the different work environments and the relationship of BIM adoption. The respondents' distribution in South African provinces are illustrated in figure 3.1 below:

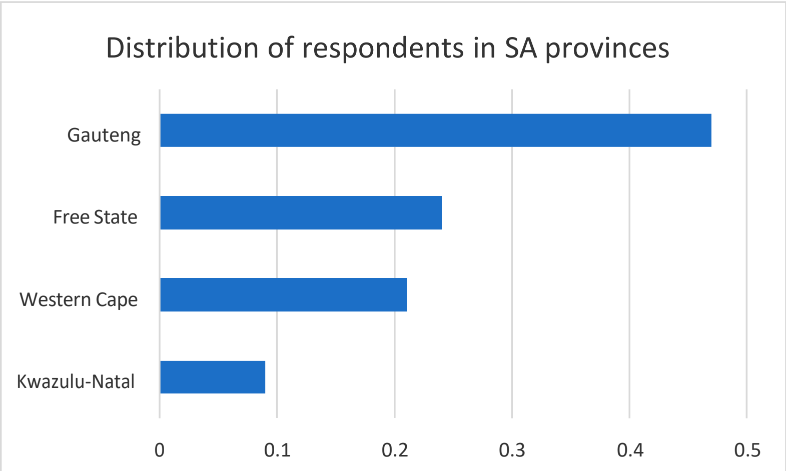

Figure 3.1: Distribution of respondents in SA provinces.

Likert scale questions were used for both data sets, and results were subsequently ranked and interpreted to allow for the placement theory discussions that followed.

4. Results

Barriers towards BIM adoption in quantity surveying firms.

With the research being an explorative study, a placement theory interpretation of the qualitative and quantitative data was used. Where applicable, qualitative data were grouped into a table to enable a more straightforward understanding. The questionnaire consisted of

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three sections. Section A focussed on creating the respondent's profile where a total of 9 closed-ended questions were asked. Section B and Section C then determined the respondent's perception of BIM, where a total of 11 closed-ended questions were asked in Section B and two open-ended questions in Section C. From the survey, the two most prominent role players on a project were identified as being the Architect and the client (35% and 29%, respectively).

The questionnaire identified specific barriers to BIM adoption as experienced by Quantity Surveyors. A majority of 85% of respondents agreed that there is not enough incentive to adopt BIM. The data further indicated a relatively even distribution towards the barriers of BIM adoption. This is interpreted as meaning that professionals' perceptions of BIM adoption may differ, depending on their working environment and experience. These barriers are highlighted in Table I below.

Table I: Barriers within the South African CBE towards BIM

Factors that are preventing South Africa from further progressing with the adoption of BIM throughout the construction industry?	
Factors	**Responses Percentage**
A lack in knowledge, understanding the benefits, the required skills and training (education)	29%
A lack in client demand and knowledge regarding the benefits of BIM	18%
Cost implication (too expensive)	16%
A lack in integration between professions to implement and adopt BIM	16%
A lack of Architect skills and knowledge to fully integrate BIM models that can be used by other professionals (especially Quantity Surveyors)	11%
A lack of government legislation (implementing mandates)	11%
Total	**100%**

The lack of client demand and knowledge towards BIM adoption ranked as the highest barriers (18% and 29%, respectively), suggesting that many Quantity Surveyors have limited exposure to actual BIM level 2 data, which requires further study.

Based on the literature, the survey searched for possible factors to overcome the identified barriers, as indicated in the second table.

Table II: Overcoming BIM barriers within the South African CBE

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In your opinion, how can the barriers (preventative factors) be overcome to improve the adoption rate in the construction industry?	
Factors	**Responses Percentage**
Incorporate BIM into the curriculum of educational facilities and increase training in-office.	33%
The Government must follow the example of leading countries and mandate BIM usage in specific government projects.	31%
Provide clients with more information regarding the benefits and capabilities of BIM.	22%
Provide professionals with the accessibility to BIM resources to become more familiar with the technology.	14%
Total	**100%**

Table II highlights that awareness is seen as a crucial factor to achieve BIM adoption. The top three factors highlighted are education, government incentives, and client awareness. From the survey, a strong emphasis was also placed on collaboration, standardisation, and best practices as proposed through the elemental classification system (mentioned in the literature). The majority of respondents (67%) further indicated that their 2D measuring tool is currently sufficient, of which 35% indicated that this would change in future.

Organisation size and adoption of BIM

The second survey endeavoured to highlight whether the barriers of BIM adoption were perceived differently based on the company size. The survey targeted companies throughout the South African CBE and categorised the respondents into micro-, small-, medium- and large enterprises. The barriers were furthermore expanded after the initial survey to better correlate with the secondary data. The results are illustrated in Table III by calculating the mean. The standard deviation of the mean was determined by allocating a factor of one (1) for disagreeing with the statement. A factor of two (2) for agreement and a factor of three (3) if the respondents agreed with the statements:

Table III: BIM barriers concerning the company size

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	MICRO: 0-10	SMALL: 11-50	MEDIUM: 51-250	LARGE: 250 and above
Additional costs	2.4	2.9	2.6	1.7
Risk and liability increase	2.6	2.4	1.7	1.4
Change in procurement methods	2.6	2.8	1.9	2.0
Implementation framework	2.4	3.0	2.4	1.7
Lack of skills and training	2.6	3.0	2.9	1.6
Organisation support	2.8	2.1	2.6	2.1
Client demand	2.6	2.6	2.6	2.0
BIM awareness	2.6	2.6	2.6	2.0

From Table III, it can be seen that additional cost and risk are more important for smaller enterprises than larger firms. It is further seen as less of a challenge to disrupt the larger companies' current operational framework. Finally, client demand and BIM awareness are experienced as more significant barriers for smaller companies than larger ones. This is shown in Figure 4.1.

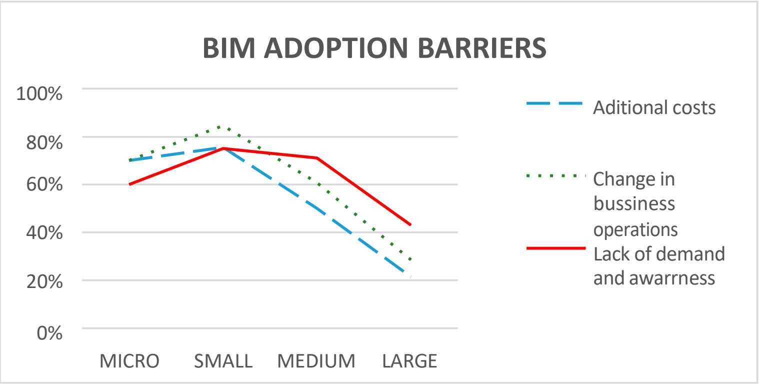

Figure 4.1: Summary of BIM adoption barriers compared to company size.

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Figure 4.1 illustrates a clear difference in the perception towards the barriers of BIM adoption in comparison to enterprise size. Of the small companies, 76% indicated that cost is a significant barrier towards BIM adoption, while only 22% of large companies agreed with this statement. A similar result was obtained for change in business operation, with 85% agreeing with this barrier and only 29% of large companies in agreement. However, the lack of demand and awareness had a closer correlation, with 75% of small companies agreeing with the statement, while 43% of large companies agreed.

5. Discussion of the results

The results strongly correlated with the BIM Africa Report of 2020, the UK National Building Specification's BIM Report of 2019 and Australia and New Zealand BIM Report 2019, discussed in the secondary data. The data shows that the South African CBE is following similar tendencies as other developed countries with BIM maturity following the incentives presented by the development of BIM technology. The second survey shows that designers have started using 3D modelling software and have clearly defined barriers that can be addressed. On the other hand, Quantity Surveyors indicated a lower adoption rate, as seen in their identified barriers. However, this does not mean that the Quantity Surveyors have not educated themselves on BIM collaboration's advantages.

Larger organisations showed a more significant tendency to be exposed to more international and technical projects than smaller companies. Larger firms perceived the three barriers highlighted in the study as less challenging. They were more inclined to have a more extensive array of in-house services, explaining more efficient collaboration between the design team.

Quantity Surveying firms showed they are dependant on the quality of BIM data provided in the designs. They are also less inclined in addressing this challenge without proper incentives, e.g. the project and client demand. Instead, these challenges are addressed most efficiently by reverting to 2D quantity take-off, although using available software. In contract larger firms, further inhouse collaboration promoted more integrated problem solving within the project team.

6. Conclusion

From the empirical and secondary data presented, very concise conclusions can be drawn. It was highlighted that the South African CBE is following similar patterns of BIM adoption as the United Kingdom's construction industry, albeit without a clear mandate from the South

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African Government. If this is considered, South Africa can be classified as ten years behind the UK construction industry. However, in saying that, it was highlighted that some initiatives had been implemented to promote BIM adoption and the advancement of good practices. The advantage of this position is that the South African CBE can learn how to best approach BIM maturity achievement from other countries.

Another vital factor to keep in mind is that the South African CBE, through globalisation, is not isolated in this regard. Many South African CBE companies are exposed to clients educated on BIM's potential benefit, and software developers improve collaborative capabilities. Many larger firms have started adopting BIM more readily than smaller businesses and are addressing real BIM implementation challenges. The emphasis fell on the education of clients and future role-players of the industry.

In conclusion, the study proved that larger firms tend to adopt BIM more readily than smaller companies, as they have more incentives and resources to do so. It is further concluded that the technical application of the software is instead a training aspect than an educational aspect. Subsequently, it is suggested that the incorporation of BIM education into the curriculum of educational facilities are enhanced, not necessarily on the technical application or use of the available software, but instead on BIM management and BIM implementation capabilities (potential). Technical application has to be carefully evaluated within the otherwise already overflowing curricula. This would carry more weight for future decision-makers to promulgate BIM maturity within the South African CBE.

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DII-2021-O45

Building Information Modelling in South Africa: Quantity Surveyors Perspective

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Abstract

The purpose of the study was to determine the extent that Building Information Modelling (BIM) is used by quantity surveyors in the South African construction industry and pinpoint the primary market drivers that amplify or hinder its adoption in the industry. The research entailed a literature review that was followed by a survey. The survey comprised a questionnaire distributed to 140 quantity surveyors throughout South Africa to examine how they used BIM and identify the factors the respondents believed to be the main drivers behind BIM adoption within the industry. The data received from the questionnaires were then analysed using descriptive statistics protocols and compared against the present literature. The findings indicated that only 21% of the respondents have engaged with BIM during the execution of their work. They, however, regarded the main benefit of BIM to be improved visualization of building elements for measurement and costing purposes. The high cost of investing in IT infrastructure and staff training was the significant barrier hindering its implementation. This research enhances the existing body of knowledge on BIM. By being aware of BIM's benefits and shortcomings for the profession, quantity surveyors can determine if its use is practical for them during the execution of their work. The paper highlights the value of BIM for the quantity surveying profession while pointing out the primary market drivers that should be focused on to increase its implementation in the future.
Keywords: BIM, South Africa, Quantity Surveying

1. Introduction

Building Information Modelling (BIM) is a system used to design and manage a physical asset employing a common information database containing all of the project information about the asset (Smith and Tardif, 2009: 29). The technology enables project teams to effectively coordinate and collaborate, which results in the digital depiction of an asset and the centralization of all the information regarding how it will be built and how it should perform. A BIM database thus allows information to flow between numerous parties across the entire life-cycle of an asset (Milyutina, 2018: 1; AECOM, 2020: 12).

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BIM has furthermore proved its capability to enhance the cost engineering and management of construction projects, which can deliver noteworthy savings on the construction and operation of an asset. Considering this, BIM has the potential to revolutionize the conventional methods of quantity surveying work (Aibinu and Venkatesh, 2012: 540). However, the current advancement of technology in the construction industry is seen by many quantity surveyors as a threat to the profession, which results in a lack of interest and a delay in the implementation thereof (Monyane and Ramabodu, 2014: 9; Haupt and Hefer, 2016: 3). This study, therefore, set out to explore the rate of BIM adoption by quantity surveyors in South Africa and identify the market drivers that influence its implementation in the quantity surveying profession.

2. Literature Review

The Role of the Quantity Surveyor

The initial role of the quantity surveyor originated in the early 1800s during the Napoleonic wars, which was to measure the building work of military facilities to make payments (Cartlidge, 2017: 7). However, this traditional role has evolved, with quantity surveyors now playing a critical part throughout the life cycle of construction projects (Gee, 2010: 33). Aibinu and Venkatesh (2012: 542) noted that the current role of the modern quantity surveyor is to add financial value to the pre-construction, construction, and post-construction stages of a project. Gee (2010: 34) similarly highlighted that the existing core services provided by quantity surveyors are: the compilation of cost estimates and feasibility studies, the compilation of bills of quantities, advising clients during tendering and procurement, contract administration, monthly cost control and reporting, and the compilation of final accounts.

However, since quantity surveyors derive their income from the construction industry, Frei (2010: 8) and Beukes (2014: 64) highlighted those changes directly influence the expansion of services offered by profession in the built environment. Considering this, Smith (2010: 4) noted that some professionals have recently extended their expertise to deliver non-traditional services such as tax advice, alternative dispute resolution, and facilities management. Hodgson et al. (2008) further summed it up well when they stated that the necessary skills of quantity surveyors had been extended due to the project-outcome emphasis of the construction industry shifting from ‘cost’ to ‘value’.

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The Benefits and Barriers of BIM Implementation for QS Services

Shen and Issa (2010: 255), Monteiro and Martins (2013: 239), and Abanda *et al.* (2017: 443) emphasized that two-dimensional designs frequently have discrepancies that result in the inaccurate measurement of building quantities, which subsequently results in the imprecise estimation of construction costs. They further collectively stated that software applications with three-dimensional visualization capabilities significantly improved the accuracy of cost estimates. Similarly, Choi *et al.* (2015) highlighted that accurate building information is critical for the precise taking-off of building quantities, particularly during the early phases of a construction project. Considering this, the implementation of BIM plays a vital role in producing accurate information throughout the life cycle of a construction project. It was clearly outlined by Bryde *et al.* (2013: 974) and Ismail *et al.* (2016: 3) that BIM enables improved measurement of building quantities due to 3-D visualization, a compilation of dependable cost estimates, accurate forecasting of how design changes and construction variations impact overall project cost, as well as reliable cost database management.

The Royal Institution of Chartered Surveyors (RICS) also published two relevant reports in 2011 and 2017. The 2011 RICS report, compiled by the Building Cost Information Service, detailed the overall use of BIM among chartered surveyors in the United Kingdom and United States (Building Cost Information Service, 2011). The report highlighted that the primary barriers hindering BIM implementation were the cost of training, a lack of standards, uncertainties over data ownership, and clients not requesting its use. The report further concluded that the primary future market driver of BIM would be clients demanding its use on projects, which Ghaffarianhoseini *et al.* (2017: 1050) reiterated in 2017.

The 2017 RICS report, compiled by the Society of Chartered Surveyors Ireland, highlighted BIM used by quantity surveyors in Ireland (Society of Chartered Surveyors Ireland, 2017). The benefits of BIM were specified to be the quicker measurement of quantities, more accurate bills of quantities, and enhanced cost management throughout a project. The barriers were mainly given as BIM unsuitable for traditional procurement processes and uncertainty of professional liability and legal implications when using it, supported by Ahmed's findings (2018: 111). The report again emphasized the old problems that stem from 2011, such as clients not requesting its use, the lack of standards and guidance notes, and the high cost of software and training for implementation, all still holding back BIM's use.

Mayouf *et al.* (2019: 545) interviewed 20 industry practitioners and academics in the United Kingdom to investigate the inclusion of quantity surveyors in the BIM process. The authors determined that the implementation challenges for professionals were a poor grasping of the BIM workflow, the friction between conventional work methods and the BIM approach, and

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the lack of a standard methodology when working with BIM. The respondents also highlighted that although 3-D visuals were helpful, they still had difficulty identifying missing information from models.

AECOM (2020: 12), however, reported positively again that BIM enhanced the practice of quantity surveying due to its capability of improving the visualization of building elements to measure and cost, which is brought about by the accurate taking-off of quantities, along with reduced calculation errors and less rework. The report further noted that BIM enhanced collaboration and communication amongst professional consultants, enhanced cost database management, and straightforward project handover between quantity surveyors.

Regarding South Africa, Kekana *et al.* (2014: 110) remarked that small firms and the reluctance by professionals to change the traditional methods of practice were the primary barriers to implementing BIM in the construction industry. Potgieter (2017: Online) similarly highlighted that most QS companies in South Africa are small practices whose clients do not desire the use of BIM, which aligns with the previously mentioned viewpoints of the 2011 RICS report and Ghaffarianhoseini *et al.* (2017). Lastly, Chimhundu (2015: 59) and Ndhlela (2018: 54) supported Kekana *et al.* (2014) and Potgieter (2017) by stating that the low uptake of BIM in the SA construction industry was attributable to the industry not yet being mature enough for its effective adoption, which is due to the country being a developing nation with a struggling construction sector that has mostly SMEs operating in it.

The Use of BIM by Quantity Surveyors

The previously mentioned 2011 RICS report received responses from 156 quantity surveyors, of which only 10% were consistently using BIM at the time, and a further 29% had limited engagement with it (Building Cost Information Service, 2011). Besides, only 10% of the respondents were then further considering adopting it for their practices. The respondents also conveyed that BIM was mostly used to extract quantities, construction scheduling, and facilities management.

The 2017 RICS report likewise had 121 quantity surveyors who responded to the survey (Society of Chartered Surveyors Ireland, 2017). Although all respondents indicated that they were aware of BIM, and 63% regarded their knowledge as good, only 25% stated that they were actively using it in their work. However, even though the active use of BIM was low, a further 38% of the respondents saw themselves being involved in a project that used BIM by 2020. It was reported that BIM was primarily used for 3-D visualization and automated quantity take-off, along with project cost planning and management.

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Adhikari and Keung (2018) researched the impact of BIM on the quantity surveying profession in Hong Kong. They sourced 27 responses from quantity surveyors working for construction firms in the region, whereby they concluded that BIM positively impacted the quantification of works, preparation of cash flows and tender documents, monitoring and control of project cost, preparation of payment certificates, variations and claims reporting of progress, and resolving of disputes. They concluded that BIM increased the overall value offered by professional practitioners.

Ismail *et al.* (2019) also studied the adoption of BIM by quantity surveyors in Malaysia. They surveyed members of the Royal Institution of Surveyors Malaysia (RISM), obtaining 202 responses. It was reported that the overall awareness of BIM among the respondents was reasonably high but uptake low, as 68% of them indicated that they were conscious of it but not using it at all. It was found that only 13% of the respondents were active users at the time. The general knowledge of BIM was also moderate among the respondents, with only 22% having worthy knowledge on the matter. Although 55% of the respondents indicated that they would consider adopting BIM in the future, just 16% regarded it as particularly important for their jobs. The authors consequently noted that this general view of the professionals could explain the low uptake of BIM in the region, which they deduced to originate from clients not requesting its use.

In South Africa, Monyane and Ramabodu (2014) surveyed 30 quantity surveyors in the Free State province to determine their use of BIM, whereby they reported that 53% of the respondents were not using it at all and 47% had some exposure to it. The respondents further regarded cohesive design management as the foremost benefit, whereby the authors concluded that architects and engineers are the key role-players in implementing BIM. This assertion was supported by Kekana *et al.* (2015), who also researched the use of BIM by surveying 65 professionals in the province of Gauteng, which consisted of quantity surveyors, architects, and project managers. The authors found that only 36% of the respondents had moderate exposure to BIM, while 78% reckoned that designers drive BIM implementation on construction projects. The authors, therefore, deduced that designers, such as architects and engineers, significantly control the exposure of other professionals to BIM.

The study aimed to determine the extent to which Building Information Modelling (BIM) is used by quantity surveyors in the South African construction industry and pinpoint the primary market drivers that amplify or hinder its adoption in the industry.

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3. Research Methodology

The aim of the study was attained by using a self-administered survey. The questionnaire intended to determine the extent to which quantity surveyors used BIM and if its use is practical and thus adds value to the profession.
A literature review identified the use of BIM and its main benefits and difficulties for quantity surveyors. This was followed by the creation of a questionnaire based on these identified factors. The questionnaire mostly consisted of closed-type questions, as they are simpler to answer due to respondents needing little skill and requiring less time to reply (Zikmund, 2002: 333). The questions regarding BIM were also mostly based on typical five-point Likert scales. Furthermore, the questionnaire was set up in Google Forms, a web-based survey administration application, for data collection.

Potential respondents were identified employing simple random sampling, which is a form of probability sampling. Their contact information was sourced from industry contacts and the websites of the South African Council for the Quantity Surveying Profession (SACQSP) and the Association of South African Quantity Surveyors (ASAQS). These organizations are the quantity surveying profession's regulatory body and association in the South African built environment. A participation invitation was sent to 140 quantity surveyors throughout South Africa employing an e-mail. The e-mail stated the research objectives, invited them to participate voluntarily, and provided the link to the survey. The main advantage of an e-mail survey is that it only requires an e-mail address for distribution, while a high response rate is likely as it requires little effort to answer.

The survey response rate was subsequently 41%, with 58 quantity surveyors responding to the survey. Considering this, the response rate was satisfactory. Lindemann (2019: Online) stated that the benchmarked response rate for e-mail surveys is 30%, mostly because spam filters are hard on 'survey' as a word. The data obtained from the questionnaires were examined using descriptive statistics protocols to calculate the mean scores and standard deviations, with the results subsequently being evaluated against the existing literature.

Characteristics of the Respondents

The operational sector of respondents

This question aimed to establish if the respondents are working for construction or consulting organizations. The respondents indicated that 65% worked for construction firms, while 35% worked for consulting firms.

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The size of the organizations for which the respondents work

This question aimed to establish the size of the firms for which the respondents worked. The respondents indicated that 15% worked for micro firms, 15% for small firms, 51% for medium firms, and 19% for large firms. The firms were categorized according to the national definition of small enterprise in South Africa (Department of Small Business Development, 2019).

4. Discussion of The Results

Use of BIM

The purpose of this question was to establish how many respondents have used or engaged with BIM on projects. The respondents indicated that only 21% have previously used or engaged with BIM, while 79% have never been exposed. These findings relate to Ismail *et al.* (2019), who similarly noted that 68% of quantity surveyors in Malaysia have never engaged with BIM. The 2017 RICS report also noted that 75% of chartered surveyors in the United Kingdom, specifically Ireland, were not using BIM in their practices at all. Gledson *et al.* (2012) and Makowski *et al.* (2019) also emphasized that SME's operating in the construction industry of the United Kingdom is aware of BIM but seldom use or engage with it. They respectively found that only 23% and 25% of the SME's had been exposed to BIM in some manner. Considering this, and that most of the respondents of this study worked for SME's, Carson (2018) remarked that organizations working on smaller projects are unwilling to implement BIM due to the traits of these projects, which includes limited budgets, shorter timelines and less risk.

Furthermore, this study's respondents' meagre use of BIM could explain why many potential respondents did not even bother to complete the survey, as they never work with BIM.

Benefits of BIM

The purpose of this question was to establish the respondent's experience and perceived benefits of BIM. The literature-identified causes were listed, and the scales were as follows: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. The causes were ranked according to their respective average weightings, with a mean score of 3 or more implying reasonable to strong support for a cause (i.e., factor) (Sullivan and Artino 2013: 542). Table I (below) subsequently indicates the major benefits of BIM according to the participants of this study.

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Table I: Benefits of BIM

Benefits of BIM		
Rank	Cause	Mean Score
1	Improved visualization of the elements for measurement and costing purposes	4.37
2	Enhanced communication and collaboration amongst the professional team	4.26
3	Reduced calculation mistakes and rework	4.16
4	Improved cost database management	3.95
5	Early project handover between quantity surveyors	3.84

These findings firstly relate to Monyane and Ramabodu (2014), Kekana *et al.* (2015), Ismail *et al.* (2016), the 2017 RICS report (Society of Chartered Surveyors Ireland, 2017), and the 2020 AECOM report, who similarly determined that 3-D BIM models enhanced the measurement and cost of building work, with the effect being reliable and accurate quantity take-off and cost estimation. The findings further closely correspond with the results of Hammad *et al.* (2012), Fan *et al.* (2014), and Allen and Shakantu (2016), who listed improved communication and stakeholder collaboration as their main benefit. Therefore, it is obvious that BIM eases quantity take-off and cost of works for quantity surveyors because of the visualized model while enhancing professional team communication and collaboration that brings about better project results.

Barriers of BIM

The purpose of this question was to establish the respondents experienced and perceived barriers to BIM. The literature-identified causes were again listed, and the scales were the same as with the benefits. Table II (below) subsequently indicates the major barriers of BIM according to the respondents of this study.

Table II: Barriers of BIM

Barriers of BIM		
Rank	Cause	Mean Score
1	High cost of investing in IT infrastructure and staff training	4.25
2	Incompatibility of project partners	4.04
3	Not compatible with conventional working and procurement methods	3.72
4	Clients not requesting its use	3.55
5	Uncertainties over data ownership and professional liability	3.10

These findings correspond with the findings of Liu *et al.* (2015a), Ghaffarianhoseini *et al.* (2017), and Ndhlela (2018), whose primary barriers were also high outlay cost and

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interoperability issues between project participants. Considering this, Halttula *et al.* (2015), Ahmed (2018), and Enshassi *et al.* (2019) further highlighted that senior management of organizations thought it would deliver a poor return on investment because of the capital required and time needed to upskill staff. The high ranking of incompatible project partners also indicates that the respondents are not aware of industry peers that use BIM with which they could collaborate on future projects, while they may be further cautious of the numerous available software packages of which many are not compatible, which is an issue that was raised by Johnson (2014) and Sacks *et al.*,(2018). Surprisingly, while numerous existing studies highly ranked the fact that most clients do not request BIM's use, the respondents of this study did not regard this as the foremost reason for not using it, even though most of them worked for SME's.

5. Conclusion and Recommendations

BIM technology has been available for over 30 years, yet its scale of adoption and maturity differs worldwide (Smith, 2014: 482). Countries like Australia, the USA, Korea, Finland, and the United Kingdom are market leaders. Their governments and subsidiary authorities play a critical role in promoting the methodology and its practice. However, these nations are developed countries with respectable governments and advanced construction industries, which differs from developing regions, such as South Africa, where many people and firms are still blissfully unaware of BIM's existence (Borrmann *et al.*,2018: 16). Considering this, Rokooei (2015: 94) and Sawhney *et al.* (2017: 11) regards construction project managers and quantity surveyors, along with governments, as the primary role-players to raise the overall awareness of BIM and its adoption in the built environment.

Nonetheless, this study determined that BIM mostly supports the measuring and cost of building work during the pre-construction stages while improving stakeholder communication and teamwork through a project. Besides, the most prominent reason for not using BIM was the amount of capital required for the necessary IT infrastructure and staff training. It, therefore, seems that the solution lies with the proposals of Alreshidi *et al.* (2014: 151) and Adhikari and Keung (2018: 358). They suggested that governments should provide incentive schemes to private clients that use BIM for their projects. At the same time, Babatunde *et al.* (2018: 757) and Adhikari and Keung (2018) further recommended that tertiary institutions include BIM in their curriculums and not just leave the education and training aspect for industry employers. Liu *et al.* (2015b: 163) supported these propositions by emphasizing that governments and the academic community should be more conscious of their role in driving the implementation of BIM. The authors suggested that public authorities promote the technology and stipulate standards and protocols for their respective

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construction industries. At the same time, academic institutions should educate students on the methodology and its application. Considering this, Mehran (2016) further recommended the establishment of public-private partnerships where private companies and vendors assist academics and governments in educating students and prospective users. This would help spread the high cost of implementation and not just leave it all for industry employers. Finally, SME’s may, however, still be wary of investing in BIM as they deem it unsuitable for their projects. At the same time, certain larger companies could be nervous about investing in the technology of which the return on investment is unknown. These are thus topics for potential research, whereby the efficiency of BIM could be investigated.

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DII-2021-OO4

Cost Efficiency: A Key factor for IT Outsourcing in Facilities Management

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Abstract

The recurrent fierce competition, increasing relevance of geopolitical economics, and the effect of production cost on market shares for companies in today's world have necessitated the need to look for ways of becoming even more efficient, especially in cost reduction. One of the ways of achieving cost efficiency is through outsourcing of information technology (IT). In recent years, organisations have increasingly used outsourcing to enhance their competitiveness in the public and private sectors, emphasising cost reduction. By reviewing available literature on recent outsourcing transactions, this paper established that cost reduction is still the main driving force in outsourcing regarding information technology (IT). Outsourcing information technology (IT) result in cost efficiency, thereby improving organisational performance

Keywords: Transactions, outsourcing, facilities management, information technology, organizational performance.

1. Introduction

Outsourcing can be defined as the 'contracting-out of services that were previously performed in-house. Outsourcing is a supply strategy often chosen to increase organizational efficiency and effectiveness (Steane and Walker, 2000). Barret (1995) described outsourcing as a process by which a user employs a separate company under contracts to perform functions previously carried out in-house and transfers to those supplier assets, including people and management responsibility. Also, outsourcing can be defined as replacing inputs or value-added previously created in-house by provisions by an external provider within a long-term contractual relationship. Only some expected mutual benefits and obligations are formally defined (Jumah and Wood, 1999).

During the 1980s, an organisation began a drastic downsizing transition, resulting in organisations contracting out more and more of their functions to external suppliers. Flexibility to meet changing market conditions became fundamental to business thinking (Barret, 1995). Cost is the main priority and a necessary prerequisite for any outsourcing requirement, which can be achieved from restructuring the workforce, implementation of

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best practice, continual innovation and the reduction of liability costs achieved through, for example, improved safety levels and a more productive split of preventative and emergency maintenance operations. The current thinking of outsourcing focuses on cost-saving brought about my organization’s ability to focus on non-core activities while allowing providers of outsourcing services to focus on development and advancement of technology.

A survey undertaken by Cloete (2002) shows that cost reduction was the main reason why managers decided to outsource their functions. A more recent survey by the British Institute of Facilities Management BIFM (2012) shows that 80% of the 130 respondents in the survey claimed that financial savings were the reason for outsourcing. Facilities Management outsourcing is a relatively recent phenomenon in the public sector, and little data are available on its effectiveness (Hui and Tsang, 2004).

What to and not to outsource will depend on a company’s needs and priorities. While some companies outsource their core activities on the value chain extensively, other companies, in contrast, are extensively outsourcing the secondary activities of their value chains such as information technology, accounting systems and distribution (Johnson and Schneider, 1995; Lacity and Willcocks, 1998). Also, the need to increase efficiency can directly conflict with the need to invest in customer care. As non-core internal functions, facilities management are continually put on the back burner, resulting in less efficient and less productive organisation operation. By outsourcing a non-core function within an organisation to a capable vendor, the organisation can reduce cost, resulting in performance maximisation. IT, catering, cleaning, waste management, recycling, security, and hospitality are the most frequently outsourced services. The services most frequently retained in-house are procurement, human resources, finance, estate management, and business strategy. Thus, the author concentrated on information technology (IT) outsourcing using the intuitive approach, considering that (IT) outsourcing is not limited to information systems or technology but includes the full spectrum of non-technology activities described above.

This paper argues that cost reduction benefit is still the main reason for information technology (IT) outsourcing which helps maximise organisational performance regarding facilities management. The conclusion is based on the literature review, which included published outsourcing transactions for private and public organisations.

2. Literature Review

Outsourcing has come a long way in shaping the way companies do business in today’s world. Due to very strong competition, changing trading conditions, high energy costs and

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other economic elements, most companies are forced to look at all means of reducing costs and maintaining a market edge (Jones and Jowett, 1998: 6). In these circumstances, facilities management has become established in all five continents, though it has traditionally been seen as a poor relation of the property and construction professions (Grimshaw, 2002: 3). Also, organizations have been increasingly turning to outsourcing to enhance their market competitiveness, increase profitability and refocus on their core business. According to Ancanani and Capaldo (2005), in recent years, both in the private and in public sectors, organizations have placed more attention on cost reduction and flexibility, focusing on core competencies and outsourcing non-core activities. But the relevance of these activities for the organization's performance requires an accurate analysis of what it is outsourced and how (Walker *et al.*, 2001; Kakabadse and Kakabadse, 2005).

While some short-term benefits for organizations can be achieved through outsourcing, there is a growing recognition that they may not fully assess longer-term costs (Bettis *et al.*,1992). Furthermore, outsourcing affects employment levels, patterns and conditions (Postner, 1990). Social issues may be affected regarding growth in earnings inequality since the contracts offered little scope to compete other than by worsening employees' terms and conditions of employment (Patterson and Pinch, 1995). Also, there are political effects at local and national levels. Still, one conclusion might be drawn from this trend: the public sector has effectively transferred low-paid jobs into the private sector (Cully *et al.*, 1999; Sachdev, 2001).

2.1 Outsourcing opportunities

No organisation can stay competitive in today's rapidly changing global economy by relying solely on its resources. Outsourcing is a necessary response to today's hyper-competitive environment (Corbett, 2004). Most literature on outsourcing often cites generating cost efficiencies and controlling the costs as the key reason for outsourcing. But in the modern scenery, outsourcing is highly complex, and outsourcing vendors provide services to achieve different objectives. Outside vendors are regarded as specialists who can provide a similar or better level of service at a lower cost than available in-house (Barthe´lemy and Dominique, 2004). However, one-off cost reduction is not the only driver. Through outsourcing, firms can generate various non-financial benefits. Firms can respond to environmental uncertainty in ways that do not increase costs associated with internal bureaucracy (D'Aveni and Ravenscraft, 1994). They can also focus on building their core competencies while outsourcing the non-core activities to specialist vendors for both one-off and continual improvements. This is because firms are reported to have limitations as to the depth of specialist knowledge possessed by the suppliers (Quinn, 2000). For example, it has been

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reported that many firms find it increasingly difficult to acquire, develop, and retain the people and technical know-how in-house necessary to maintain existing complex systems and develop and implement new technologies (DiRomualdo and Gurbaxani, 1998).

There is also hesitation about whether the firm will afford development risks for any desired innovation, compared to suppliers who have a vested interest in innovation and can spread risks across multiple present and future clients (Quinn, 2000). By outsourcing the entire activity that is not a core competence (Quinn, 2000) to specialist vendors, firms, thus, can speed innovation and accrue higher returns at lower costs. However, it should be pointed out that what is core and what is non-core is an academic debate (Kakabadse and Kakabadse, 2002). Firms can indeed benefit from the outsourcing of core competencies (Baden-Fuller *et al.*,2000); a nutshell description of outsourcing from the academic and practitioner literature is the continued emphasis that many critical capabilities reside outside the boundaries of the organisation and that outsourcing enables organisations to access these at lower costs.

2.2. Facilities Management Services

The International Facility Management Association (IFMA) defines facility management as a profession that encompasses multiple disciplines to ensure the functionality of the built environment by integrating people, place, process and technology (IFMA, 2017). Facility management was introduced in 1975 and grew in the United States throughout the 1980s and worldwide in 1990 (Maas and Pleunis, 2001). In Europe, the United Kingdom became the first country where facility management was established (Hassanien and Losekoot, 2002), building upon the lessons learned in the United States. Europe has a growing trend, especially the United Kingdom, to provide facilities management services through outsourcing. A recent survey by the FM Business Confidence Monitor, a survey of professionals from the facilities management sector in the UK, found that 70 per cent of these professionals described the facilities management business environment as ‘positive’ or ‘very positive and over half (54 per cent) expect it to improve over the next 12 months, while only 4 per cent still believe it will deteriorate (BIFM, 2015). The facilities management sector employed roughly 10 per cent of the UK working population and was estimated to be worth £111 billion a year to the UK economy; this makes it an important bellwether for business performance as a whole (BIFM, 2015).

Ancanani and Capaldo (2005) described a British Institute of FM (BIFM, 2004) in the UK, where facility managers claimed that reducing the cost base and affordability are the most important issues for the public sector client organizations, often at the expense of best value.

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That good management practice is still lacking. The majority of the respondents (55.1%) to the survey reported the use of the solely in-house provision (by direct employees of the organization), 36.7% had a mixed provision (partly in-house, partly outsourced), and only 8.2% had fully outsourced provision. The survey also showed that this situation could change over the next 5–10 years with mixed provision growing in importance and overtaking in-house provision and expected growth in fully outsourced provision (BIFM, 2004; International Facilities Management Association (IFMA, 2004)).

Germany and France are also relevant markets. In particular, the German market is rapidly changing both on the supply and demand sides. A demand increase of about 10–15% is expected in the next few years. French suppliers have internationalized their market in Italy (Economical and Social Research Centre for the Construction Market (CRESME, 2002)). About 90% of contracts are still for a single service, but in some sectors (health, universities), integrated contracts are increasing (Building Services Research and Information Association (BSRIA, 2003)). In Spain, after some delay, FM is becoming relevant, above all in the banking, telecommunications, and energy sectors (CRESME, 2002). In France, some organizations, mainly health services (Shohet and Lavy, 2004), have already outsourced relevant auxiliary and support services to private providers (CRESME, 2002). However, in the USA, innovative approaches are being applied through partnerships with private partners and partnerships with public employees incentivising to produce cost-saving and quality services (Lawther and Martin, 2005).

2.3. Outsourcing and Facilities Management

Outsourcing simply means services rendered for an organisation by personnel from another organization. Barret (1995), when analysing the scope for outsourcing, said, “Facilities management concept of co-ordinating many previously disparate support functions tendered to solve one problem but create another. The internal bundling of services associated with facilities management spawned empire-building. An organisation’s internal empires are not known for their flexibility, tendering to solve problems by recruiting more staff. To maximise the benefits of facilities management, some organisations discovered that the external procurement of services could overcome the downside of inflexibility and empire building. Furthermore, intensifying competition, together with a global recession, placed increasing pressure on organisations to reduce total operating costs and concentrate on core business functions. Contracting-out offered the solution to these demands, facilitating both efficiency gains and cost-effectiveness.”

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"There has been an increase in the use of out-sourcing undertaken over the years. Data from the computer services corporation index survey (1998) of European information systems showed that 71% of these executives planned to contract out some information technology operations by 1995, compared with 36% in 1990/91. This boosts the value of contracted-out information technology from the US $1.6bn in 1990 to approximately US $10bn by 1996. Also, the scope of outsourcing was increased by 70% of facilities managers in the UK according to the P & O commissioned report between 1988 and 1990" (Barrett and Baldry, 2003)

3. Research Methodology

Outsourcing is a form of innovation regarded as a frontier in strategic management that affects how the information technology (IT) industry, such as computers, software etc., is managed (Quinn, 2000). Thus, this paper concentrated on information technology (IT) outsourcing using the case study approach, considering the limitations that outsourcing is used in information technology (IT) and non-technology activities like cleaning, services, etc., that form part of the functions performed in the facility management.

The case study approach is found useful for this study as it is mostly exploratory. According to Benbasat *et al.* (1987), by using case study research, one can study the topic in a natural setting and generate theories from practices and at the same time answer 'how' and 'why' questions, that is, to understand the nature and complexity of the process taking place. Supporting further the use of case study, Yin (2009) deemed the case study method appropriate when the research does not require central over the behavioural event and when the focus of the research is on the existing events. The case study was selected based on purposeful sampling, which is useful for understanding issues related to the research theory (Patton, 2002).

This study focused on seven case studies of information technology (IT) outsourcing transactions between 1995 and 2017 for the public and private sector involving big companies to show the cost reduction benefit of improving performance through IT outsourcing.

IT Outsourcing Transactions

Transaction 1: IKEA and Wincor Nixdorf

IKEA is a Swedish-founded multinational group that designs and sells ready-to-assemble furniture, kitchen appliances and home accessories. In 2013, IKEA groups announced a joint

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offshore outsourcing project with Wincor Nixdorf to set the IT solutions to all the cash settlement units in their branches. During 2014-2015, Wincor Nixdorf set 12 thousand POS systems in 300 IKEA stores in 25 countries. A 6-year deal between them includes installation and exploitation of POS systems. The deal includes the point of use and further improvement of Wincor Nixdorf software – TP.net, which is in charge of all the transactions in cash units and collects the data from all over the commercial network. Having a single software provider offshore, IKEA not only lowered the work to run the stores, but it also has a significant cost reduction in implementation and exploitation (Existec, 2017)

Transaction 2: Thomas Cook Group Plc and American Express.

Thomas Cook Group Plc is one of the world's leading leisure travel groups with over € 8.5 billion sales and more than 22 million customers in the year ended 30 September 2014. A workforce strength of 9,720 and an annual turnover of € 7834 million. Thomas Cook UK and Ireland have over a 6.2million passengers, 847 retail outlets and 31 aircraft.
The company decided to outsource its services to Accenture to be operated from its Peterborough headquarters. This led to the transfer of nearly 250 Thomas Cook employees to Accenture. A single integrated SAP was also developed for the entire business. This resulted in cost reduction and profitability within a few months (Backofficepro, 2018)

Transaction 3: Unilever Outsourced ERP System

Unilever is a British-Dutch transnational consumer goods company co-headquartered in London, United Kingdom and Rotterdam, Netherlands. Its products include food and beverages, cleaning agents and personal care products. While growing, Unilever Europe started to face dramatic operational problems. Unilever Europe, over the years, had expanded by country and division. As a result, different business groups and geographies operating across 24 countries used multiple ERP systems. In 2005 its leadership team decided to integrate its multiple business units into a single and create one ERP system across Europe. Not being a specialist in IT solutions, the company outsourced the development of the ERP system to the external party. As a result, these improvements have directly contributed to the € 700 million annual savings on operational activities (Muzychko, 2015).

Transaction 4: General Electric / General Electric International Services/India

GE used to be a pioneer in many business branches, including offshore outsourcing. They were the first to transfer its operational department, data maintaining department, and call centre into India's country of low expenses, creating a special GECIS (General Electric International Service) department. GECIS provided finance and bookkeeping, customer verification, e-learning and business analytics, IT outsourcing and software development support, securing thousands of business

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processes in 11 GE branches. By the end of 2004, over 12 thousand people were working in GECIS, and you can imagine how much General Electric saved on people's salaries only because they were working in India, not in the US.

However, this is not the end of this story. GE decided GECIS can bring more income if they evolve from a subsidiary company to a standalone unit, and it will provide analogical services to other companies. Intended – done.

All these operations were maintained within a framework of unified policy, founded by General Electric CEO Jack Welch, called "70:70:70". That number combination means 70% of their work in GE must be outsourced, 70% of that is given to dedicated offshore centres, and 70% will be in India (Existec, 2017).

Transaction 5: IBM Canada and American Express.

IBM made a 10-year contract with the National Bank of Canada for $700 million with its Canadian subsidiary company. IBM Canada heads over the bank informational structure maintenance, including its websites and call centres. Besides, the partners will join for future development projects in the IT-sphere.

But a much bigger contract with $4 billion was obtained by IBM In February 2002. Following a 7-year outsourcing contract, IBM, alongside American Express, will manage the "americanexpress.com" website, administrate the computer network AmEx, process around 1 billion credit card operations daily, maintain the database, and keep technical support to the company employees. Most of the American Express IT staff (around 2000 specialists) formally are transferred to IBM. And American Express leaves new services, product development, and customer relationship to itself (Existec, 2017).

Transaction 6: EDS/Government of South Australia - Entire IT Infrastructure Outsourcing

In October 1995, the government of South Australia executed an agreement making EDS its preferred strategic partner in a nine-year, $600 million outsourcing deal. Significantly, the agreement marked the first time a government had contracted out its entire IT infrastructure (PR news wire, 1995). An integral component of the deal was EDS's commitment to establishing its regional headquarters in Adelaide's Technology Park with a new Information Management Centre-one of only three worldwide. EDS also established a new Information Processing Centre-one of 16 EDS processing centres worldwide (Myerson, 1996). South Australia expects to save $100 million over the contract's life by consolidating multiple data centres and standardising networks for over 140 government agencies. Further, the government expects over 900 jobs in South Australia due to the agreement (Campbell, 1995).

Transaction 7: EDS/Inland Revenue - Largest Public-Sector Outsourcing Agreement

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In November 1993, Inland Revenue, the British equivalent of the United States Internal Revenue Service, selected General Motor’s subsidiary EDS (Myerson, 1996) as its vendor in an l0-year outsourcing transaction valued at more than $1.5 billion. At the time, it was the largest outsourcing agreement ever signed in Europe (Business wire, 1993). It remains one of the largest public-sector outsourcing transactions in the world (Caldwell, 1995). This IT agreement, which was part of an overall British government privatization effort, transferred to EDS the responsibility for computer and telecommunications systems and other Inland Revenue businesses. EDS was to purchase $105 million of information technology from Inland Revenue, and approximately 2,000 Inland Revenue employees were expected to transfer to EDS as part of the transaction.

4. Findings and Discussion

All the companies studied had initiated an outsourcing policy to reduce costs, with the desired cost-saving being between 10 and 20%. In the case of Thomas Cook, the company was able to reduce its cost base by € 140 million and, within 16 months of outsourcing, returned to profitability (Backofficepro, 2018). Cost savings are sought in two stages: initial cost savings derived from restructuring the workforce, restructuring processes, and introducing new systems and ongoing cost savings derived from the implementation of best practice, continual innovation and the reduction of liability costs achieved through, for example, improved safety levels and a more productive split of preventative and emergency maintenance operations. Also, in terms of payroll, an architect earns $3,000 a month in the U.S. but $250 a month in the Philippines. A Java programmer earns $60,000 a year in the U.S. and makes $5,000 annually in India. U.S. aerospace engineers earn $6,000 a month; the same workers in Russia take home $650. Net savings on operations are generally somewhere in the 20% to 40% range (Corbett, 2004).

The result from IBM/American Express made other financial institutions outsource the development and implementation of new software, information processing, websites, and call centres. According to experts, this trend will only grow. Overall, the outsourcing evolution follows the tight cooperation between financial and informational technologies. They evolve from separate contracts to a wide, mutually beneficial partnership that enriches both sides (Existec, 2017).

All the transactions discussed above show a consistent benefit of cost-saving of outsourcing as far back as in the 1990s. This means that business leaders should no longer view outsourcing as a mere business tactic but an essential tool to remain competitive on the world

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stage. According to Corbett (2004), outsourcing is no longer just about cost-saving. It is a strategic tool that may power the twenty-first-century global economy.

5. Conclusions

Based on the literature review from various publications on (IT) outsourcing in private and public companies, this paper showed that outsourcing information technology would reduce cost, which is the main factor driving facilities management.

The area of concentration is on information technology, and it is my view that further research should be on health care and the built environment. On the vendor selection, the method to be used will depend on whether it is a public or private sector transaction. In both cases, the fundamental factors for consideration should ensure that the best practice and maximum performance from cost reduction through information technology outsourcing can be achieved.

The selection of a vendor should be based on the nature, scope and complexity of the work that must be outsourced. Other factors to be considered include experience in the same or related area of the organization business processes, location of the vendor, reputation, capability, financial stability, size, available personnel, and having the required skills and knowledge to do the job, quality of reference the current workload. Finally, when choosing an outsourcing provider, managers need to evaluate the vendor's ability to provide excellence in facility management and meet the required performance.

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DII-2021-010

Impact of Value Engineering in Road Construction on Cost, Quality, and Time Management

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Abstract

The construction industry has been one of the significant contributors to Zambia's economic growth and National Development, estimated at 21.1% of GDP. The Government of Zambia has embarked on road construction to improve social-economic development. Despite such efforts,results indicate that most roads constructed do not meet desired outcomes and cost more than the budget due to claims. This entails implementing sustainable construction protocols that address issues of cost, quality, and duration. Integrating Value Engineering (VE) in road projects is recommended. This study is aimed at establishing the impact of VE on road construction projects in Zambia. The study utilized survey research through questionnaires, interview guides, and observations at National Council for Construction (NCC), sampled contractors, and consultants to understand the impact of value engineering on cost, quality, and rate of production. A total of 40 questionnaires were distributed, but only 32 were responded to, bringing the response rate to 80%. Results showed that NCC offers training in road construction meant to impact on quality, rate of performance, and cost. 87.5% of the respondents confirmed that VE impacts quality, cost, and rate of production. Results also showed that 84.4% of respondents identified that applying VE at the conception stage yields more positive results than any other stage. Value Engineering needs to be incorporated in the road construction project to help scrutinize the project well and consider all possible alternatives to increase performance rates and improve quality at optimising cost.
Keywords: Construction Industry, National Council for Construction, Project, Road Construction, Road Development Agency, Value Engineering.

1. Main Body of the Paper

Contractors, consultants and clients are the three major prayers in road construction projects in Zambia whose roles and responsibilities are important to meeting the technical specification of the completed road project. The industry has been characterized by failure by consultants and clients to critically analyze road requirements through its project cycle,

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resulting in claims and variations, thereby increasing project cost, compromising quality, and prolonging duration. Road construction projects are complex tasks that require the management of different professionals, skilled and non-skilled human resources, and plant and machinery integration. The responsibilities of each human resource are intertwined or pre-requirement; hence need to consider every task effectively. Failure to address any human and non-human resource challenge may affect the project's quality, cost, and duration (Mwanaumo and Chisumbe, 2015). This calls for the road construction industry to establish an adequate and efficient system that reduces shortages and promotes efficiency and effectiveness to increase productivity, improve quality and reduce costs (Ltd, 2012). This system should encourage professionals to have site experience, innovative and communicate effectively with team members to design and implement sustainable road projects.

To improve and enhance efficiency in the transportation infrastructure in Zambia, the sector has experienced a period of exceptional activity and large expenditure in road construction and rehabilitation (Mwiya *et al.*, 2014). Despite the Road Development Agency (RDA) using the Highway Management System in road construction, the construction process has experienced regular work stoppages due to failure by consultants and clients to establish projects requirements at the planning and design stage. A developing country like Zambia requires implementing sustainable road construction techniques such as Value Engineering to minimise cost, quality, and duration. Sustainable techniques such as VE will encourage professionals based on on-site know-how, innovativeness, consultation and effective communication to deduce all requirements needed for successful road projects without attracting claims due to unforeseen circumstances. This study, therefore, aims to establish the influence of VE on cost, quality and duration. Many authors have defined value engineering in different ways, but the following relates to the study. Atabay and Galipogullari (2013) and supported by (DBIA, 2015) have defined Value Engineering (VE) as a systemic analysis of project components performed by qualified professionals to address cost, quality and duration. VE has further been defined as a technical process to select the best alternatives on project implementation to reduce cost, improve quality and work within a duration

Furthermore, VE has been defined as a systemic process to improve efficiency and sustainability in the project cycle by removing unnecessary costs while maintaining quality and safety standards (Amirkhani, 2015).

The definitions above identify three major components of Value Engineering: improved production rate to return value for investments, quality of the product, which covers improving performance, reliability, safety, and reduced cost. Apurva (2013) has simplified VE to a ratio of function to cost. In simpler terms, Value Engineering can be achieved by either improving the function or reducing the cost. The function can be achieved by considering acceptable substitutes, while cost can be managed by removing unnecessary

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expenses. All costs that do not contribute or are unrelated to the project objectives are unnecessary expenses (Mansour and Abuesef, 2015). These costs are attributed to failure to establish project requirements at the planning, design and documentation phase (Potts, 2008). In the VE relationship, the function may also be replaced with “Performance” requirements by the client, while cost covers resources such as materials, labour, price, and time (John and Paul, 2007). VE can be applied at any point in a construction project. However, the earlier it is applied, the higher the return on the time and effort invested. The Patrick Macleamey curve in Figure 1 demonstrates that the greatest benefit and resource savings are typically achieved early in development during the conceptual stages. The curve depicts that the ability to impact performance is greatest from conception through design development when the cost of design changes is lower, as shown by the blue (2) and red (3) line, respectively, while vice versa from construction post-construction. Traditionally, the ability to impact performance has occurred from contract documentation to construction as depicted by the black (4) line, which has resulted in valuations and has affected the cost and duration of projects. The proposed VE system requires that the ability to impact performance is greatest at the conception and design development phase as depicted by the green (4) line and are minimal from construct documentation to the post-construction phase. This will maintain or reduce the project time frame with the required effort and cost.

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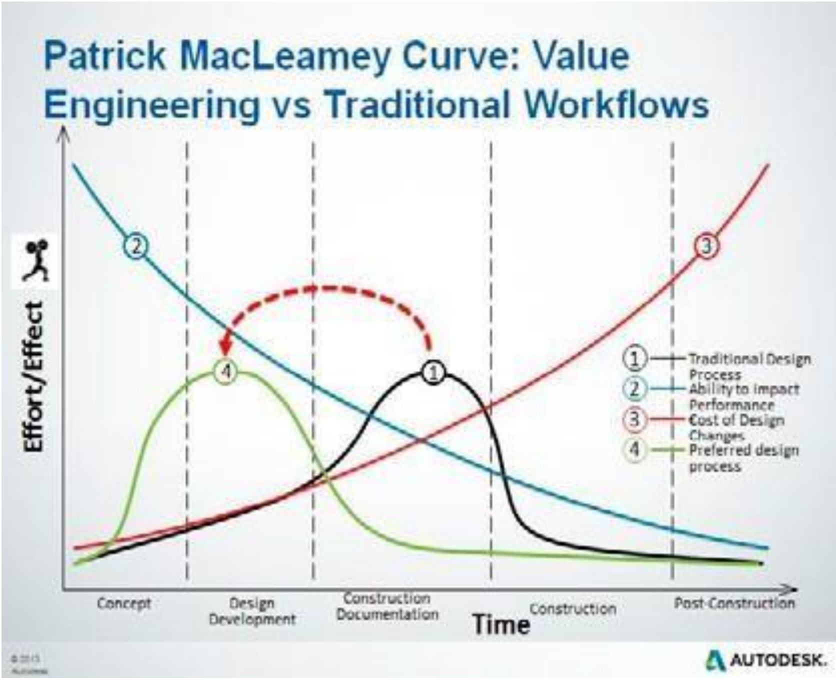

Figure 1: Proposed VE system –

Source: Autodesk.com

What have value engineering systems been adopted globally to enhance quality project delivery? The Society of American Value Engineers (SAVE) has adopted the International 6 phases system shown below (Mansour and Abuesef, 2015).

1. **The Information Phase:**
   This phase involves establishing the scope of operations. Also identifying, collecting, and disseminating information to VE participants. Participants examine and analyse the components and costs, identify criteria and limits affecting the activity, rank or assign values and divide them into manageable chunks.
2. **The Function Analysis phase:**
   This is where innovation begins once a framework is determined. Four creativity techniques are used, which includes: focused brainstorming, innovation, improvement, and avoidance. The detailed function of each component of a project is developed and understood, including its objectives. At these stages, construction approaches and their requirements should be established.

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3. **The Creative Phase:**

   This stage involves evaluating all possible approaches to attaining the project objectives efficiently and sustainably. It involves: collects, solidifying, and ranks the ideas generated in the creativity phase. The criteria used are: "criteria weighting matrix and evaluation analysis ranking" and "performance of the function determination and study team consensus ranking".

4. **The Evaluation Phase**:

   The process involves generating alternative models that can be tested from the ideas, solutions and approaches developed at the creation phase.

5. **The Development Phase**:

   This is where they develop the ideas into the high-value return product that typifies the results we discuss and show in our results and clients sections. They are scored against benefits, risks and disadvantages, and the highest potential solution or approach further. The process ensures that it produces the most product for the least cost to develop viable, efficient, and cost-effective alternative proposals. At this stage, the most sustainable approach is adopted, accompanied by technical specifications and designs.

6. **The Presentation Phase:**

   It involves presenting the best result through the development phase to the client for approval and implementation.

7. **Implementation Phase**

   This is the decision to implement the recommendations of the presentation phase. This calls to implement measures that document and monitor implementation of the added value features and establish the final value of recommendations.

8. **Verification Phase**

   Having established the final status of the recommendations and the estimates for their added value. Monitoring and feedback will allow generating Value statistics for future projects to ensure effectiveness in the application and identify potential process improvements.

Further, according to John and Paul (2007), a three-stage value engineering process diagram comprising of; Pre-Study, VE Workshop, and Post-Study as demonstrated in figure 2, has also been established.

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Figure 2: Value engineering flow process diagram - Source: (John and Paul 2007)

Furthermore, Abdulaziz (2013) outlines another value engineering systematic process depicted in figure 3:

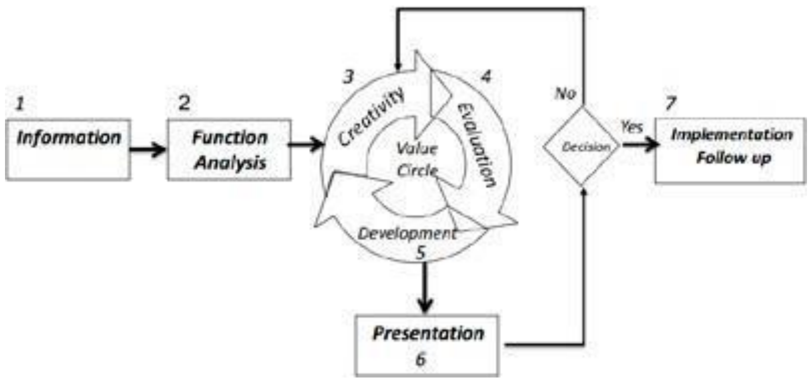

Figure 3: Value Engineering Job Plan - Source (Abdulaziz, 2013)

Depending on the application, another scholar (Apurva, 2013) confirmed that VE is a universal disciplined process consisting of four, five, six or more stages, including Preparation, Information, Analysis, Creation Evaluation, Development, Presentation and Follow-Up. This is also supported by (DBIA, 2015).

To carry out a good VE process, the following conditions should be met: establish an organized Job Plan that includes, at a minimum, the six phases identified in this standard. As defined in this document, Function Analysis is performed on the project. A multidisciplinary group of experienced professionals, project stakeholders, and VE Team Leader trained in VE techniques is qualified to lead a team using the Job Plan.

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Implementing VE is an important element of sustainable construction that should identify and develop a road construction project to minimize environmental impacts and optimize social-economic development. Principles of VE shift a person or team from a general understanding to a specific and precise understanding and consequently improve the product's value (Ali and Price, 2014). VE should be a company- value wide activity to produce a change in attitudes and provide an effective way of handling problems. It should encourage people to think and use their creative abilities and effectively communicate with each other to improve their overall effectiveness and the profitability of the road construction project.

The current construction system used by RDA is not different from VE, except it requires professional discipline.

The National Council for Construction act gives the National Council for Construction (NCC) authority to regulate and manage construction activities in Zambia. The institution is also responsible for the training of different technicians in various fields of the road construction sector. These technical skills are paramount in implementing a successful Value Engineering system that addresses cost, quality and duration.

2. Research Methodology

The study adopted qualitative and quantitative methods known as the Mixed Method (MM) because of its ability to alleviate the weaknesses and provide richness and details otherwise unavailable if each method were pursued separately. NCC and 40 participants from road engineering consultants and contractors were conveniently and purposely sampled for this study to establish the effect of value engineering on cost, quality and duration.

The Mixed design approach was adopted in the study to obtain answers from NCC, contractors and consultants on the impact of value engineering systems used in road construction on cost, quality and duration. Guided interviews, observation and questionnaires were used during data collection, respectively.

2.1 Research Approach

The research was achieved by targeting the NCC, contractors and consultants. NCC monitor’s and regulate all construction activities in the country. NCC was purposely chosen to perform a benchmark study regarding the training of technicians in road projects who can affect quality, reduce cost and improve performance. Questionnaires were also used to obtain information from contractors and consultants. The main objective of collecting information

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from contractors/consultants was to conclude if value engineering affects quality, cost, and duration.

2.1.1 Objective 1

Information on the training courses offered by NCC was obtained through an interview with the NCC principal officer, who outlined different courses offered by the institution with institutional support brochures and their relevance to contributing to a successful value engineering system. The interview was done by first explaining to the participants what the research intended to achieve at the end of the study and how information received from participants would be treated to safeguard the interest of all participants/respondents. The next segment of the interview involved asking questions based on the objective.

2.1.2 Objective 2

Forty participants educated professions from contractors and consultants company were purpose and conveniently sampled and questionnaires distributed among them. Ten masters responded to Thirty-two, 14 bachelor's degrees, one advanced diploma and seven diploma certificates. The questionnaires were then analyzed using SPSS to deduce useful information about achieving the second objective of concluding if value engineering impacts cost, quality, and duration.

3. Results and Discussion

3.1 Impact of Construction Courses Offered by National Council for Construction on Value Engineering

The National Council for construction offers eight courses essential in the input of the value engineering processing. Courses such as contract management, basic land survey, construction material testing, road conditional survey and management of civil engineering construction processes are essential in the information, function analysis, creation, evaluation and design development phases of value engineering. Knowledge in these courses will enable one to collect information, establish project requirements and sources, select sustainable alternatives, estimate cost, and develop designs for presentation to the client's approval and implementation.

These knowledge skills are also essential in the implementation phases as they cover the management of human and non-human resources throughout the construction process. Understanding these courses will enable one to manage cost, quality, safety, and work within

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the duration. Knowledge of culvert and drainage structure construction and earth moving equipment are other essential skills under the implementation phase.

The course offered at NCC aims to enable these skilled technicians working together with professionals to contribute valuable input in the construction process to have a smooth construction process from inception to post-construction stage without any variation that may affect the cost, quality and duration. This is in line with the Value Engineering system, whose objective is to maintain cost, enhance quality and work within budget through a professional, disciplined process of planning, evaluating and monitoring.

3.2 Responses from Questionnaires

A total of 40 questionnaires were administered with a response rate of 80%. The respondents were 57.5% from Consulting Engineers (23 responded) and 22.5% from Contractors (9 responded). The primary data obtained from questionnaires were analyzed using Statistical Package for Social Science (SPSS) and Excel to deduce impacts of value engineering on the rate of performance, quality and cost of the projects. Table I shows the summary of the numbers of participants in the study areas.

Table I: Participant's Information

Qualification				**Category**		**Contractors Grade**			
Masters	Degree	Advanced Diploma	Diploma	Contractor	Consulting Engineers	1	2	5	NA
10	14	1	7	9	23	5	2	2	23
32				**32**		**32**			

Results in Table I show that professional participants in the study had an adequate understanding of value engineering and other related fields of road construction following their satisfactory level of academic qualification.

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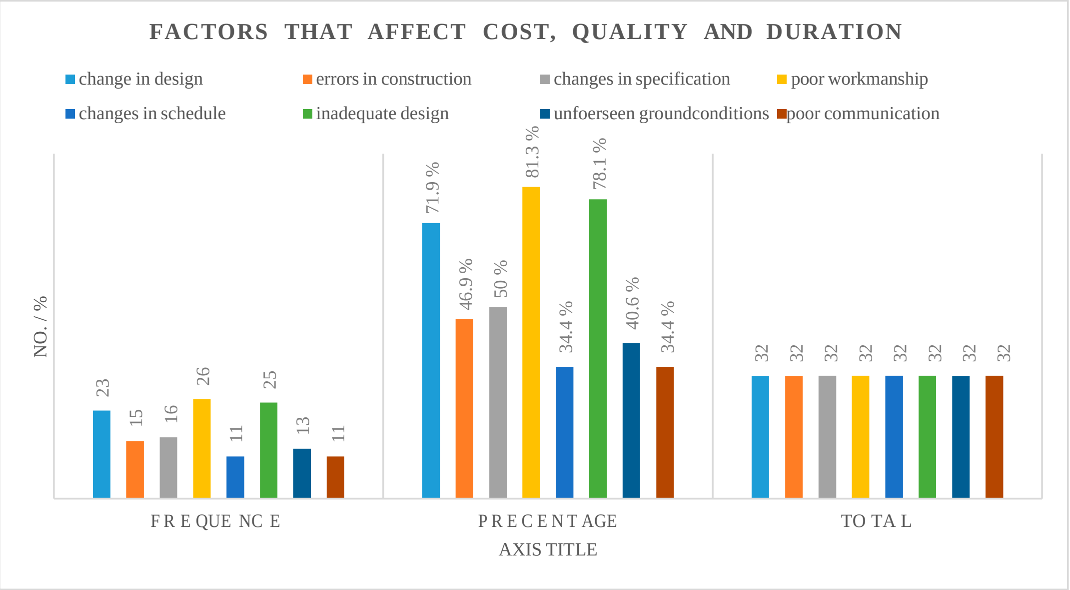

Figure 4: Factors that affect the rate of performance, quality and cost of road construction projects

Figure 4 outlines several factors in road construction projects that affect quality, cost and rate of performance. Results indicate that poor workmanship at 81.3%, preliminary design at 78.1%, and changes in design at 71.9% are the major factors that adversely affect the road projects' performance, quality, and cost. The respondents also confirmed the following factors to impact quality, cost, and performance rate: changes in the specification at 50%, errors in construction at 46.9%, unforeseen ground conditions at 40.6%, change in work schedule, and poor communication, both at 34.4%.

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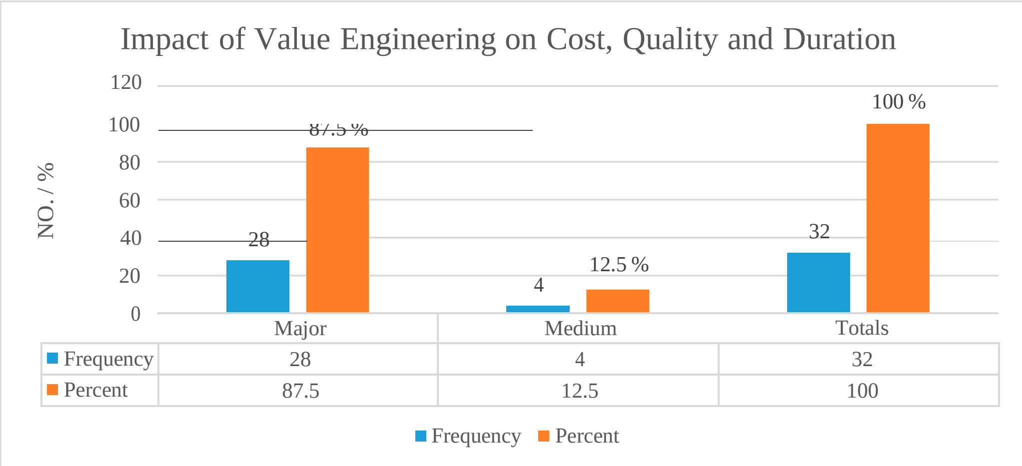

Figure 5: Positive Impact of Value Engineering on Cost, Quality and duration

Results in figure 5 indicate that value engineering positively impacts quality, cost, and duration, as indicated by 87.5% transcending to a frequency of 28 respondents. VE provides a systemic analysis of project components to minimize environmental impacts and optimise social and economic development to improve performance, reliability, quality, safety, and life cycle costs.

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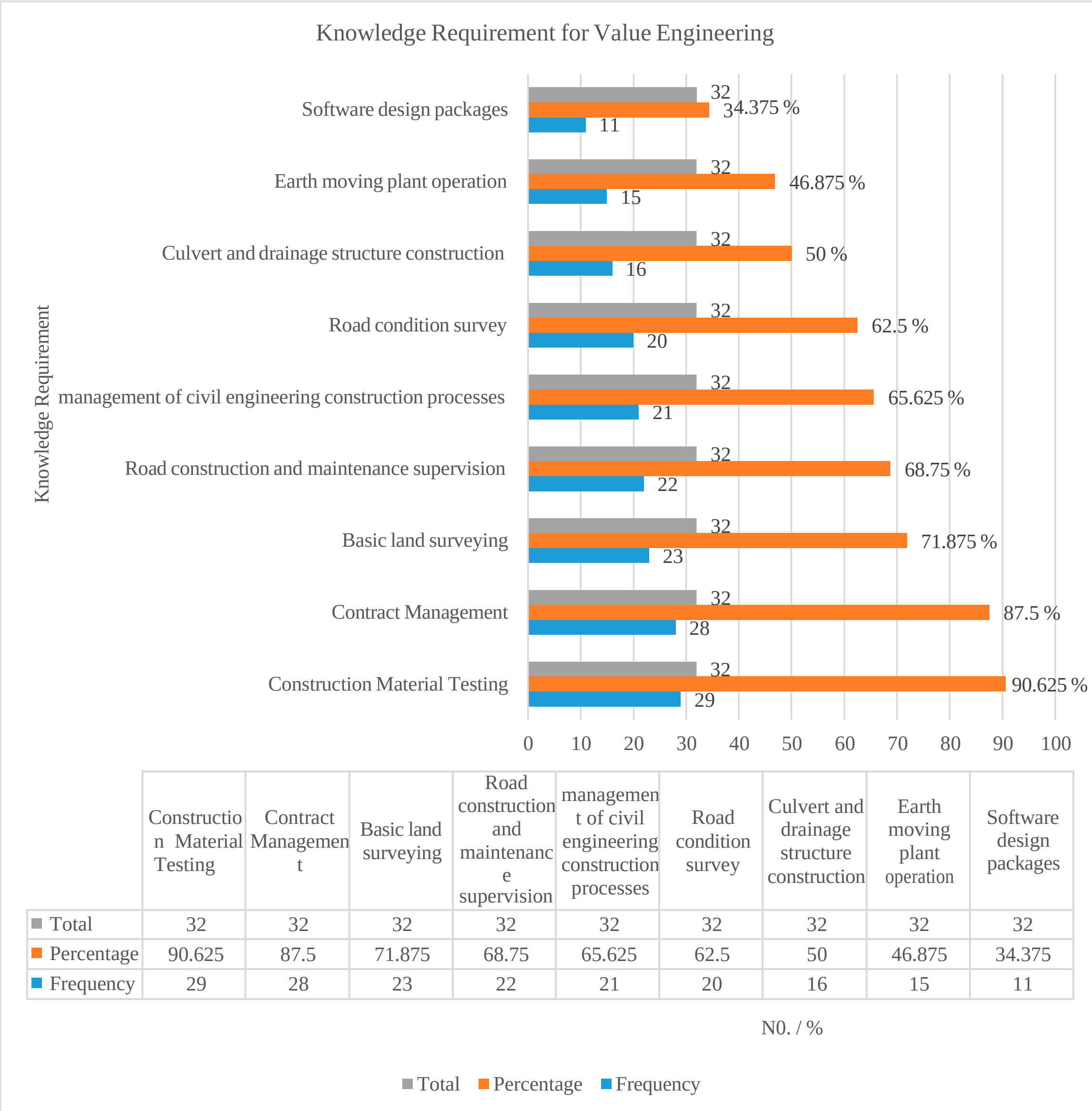

	Construction Material Testing	Contract Management	Basic land surveying	Road construction and maintenance supervision	management of civil engineering construction processes	Road condition survey	Culvert and drainage structure construction	Earth moving plant operation	Software design packages
Total	32	32	32	32	32	32	32	32	32
Percentage	90.625	87.5	71.875	68.75	65.625	62.5	50	46.875	34.375
Frequency	29	28	23	22	21	20	16	15	11

Figure 6: NCC Construction training skills impact on Value Engineering

Contractors and consultants confirmed results obtained in section 3.1 on the knowledge skills required to facilitate value engineering on road projects. These knowledge skills, with the highest being construction material testing at 90.6% and least being software design packages at 34.4%, are essential in planning, evaluation and monitoring of road projects from inception

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to the post-construction stage. In the information phase, conditional road survey at 62.5%, basic land survey at 71.9% and construction material testing will be essential for collecting information. Contract management at 87.5% and civil engineering construction process management at 65.6% will be useful in function analysis where a sustainable approach is selected from the list of alternative construction processes. On client's approval, software design will be useful in design. At the implantation phase, road construction and maintenance supervision at 68.8%, culvert and drainage construction at 50%, and earthmoving and plant operation at 46.9% will be additional skills for a successful road construction project.

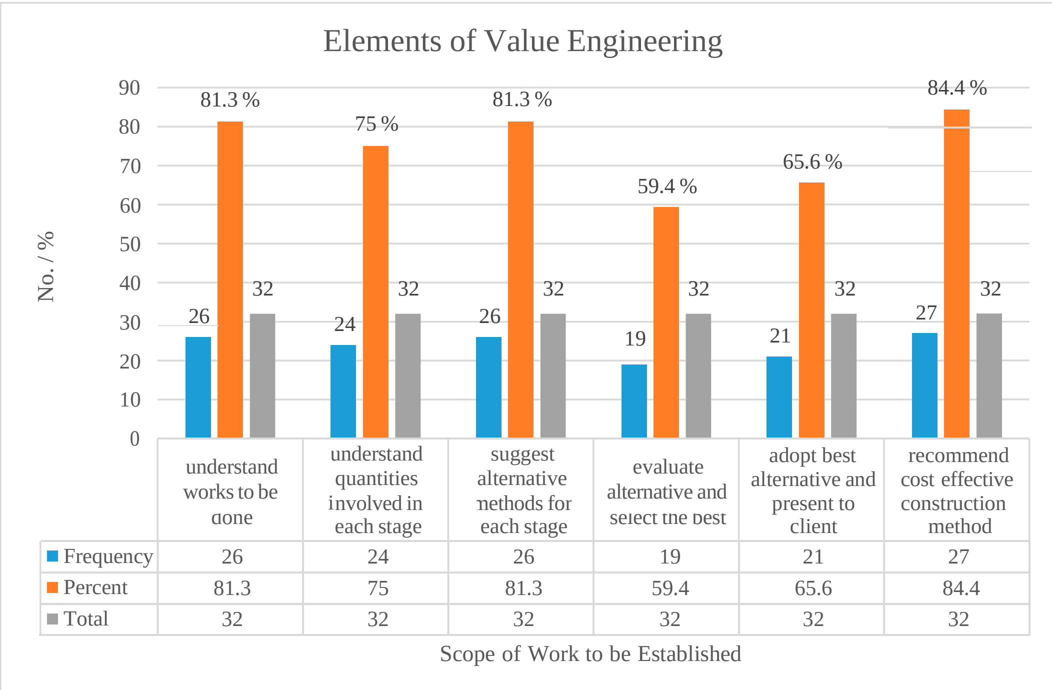

Figure 7: Elements of Value Engineering

Results in figure 7 show elements of value engineering that can help impact positively on cost, quality and rate of performance. A cost-effective construction method was recommended at 84.4%, which should be assisted by understanding works to be done or establishing the scope of works suggests alternative methods for each construction phase at 81.3%. This can help contractors/consultants to plan with less unforeseen conditions effectively. 75% of respondents added that understanding quantities involved in each work

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stage help contractors and consultants to facilitate proper cost estimates of each construction works and avoid future claims. Alternatives will then be analyzed and evaluated. The best alternative selected, which stood at 59.4% and 65.6%, respectively, can be applied in each construction stage to adopt the less costly, quality output, and high performance. These elements are key in developing a cost-effective, sustainable construction approach that retains quality and maintains planned duration.

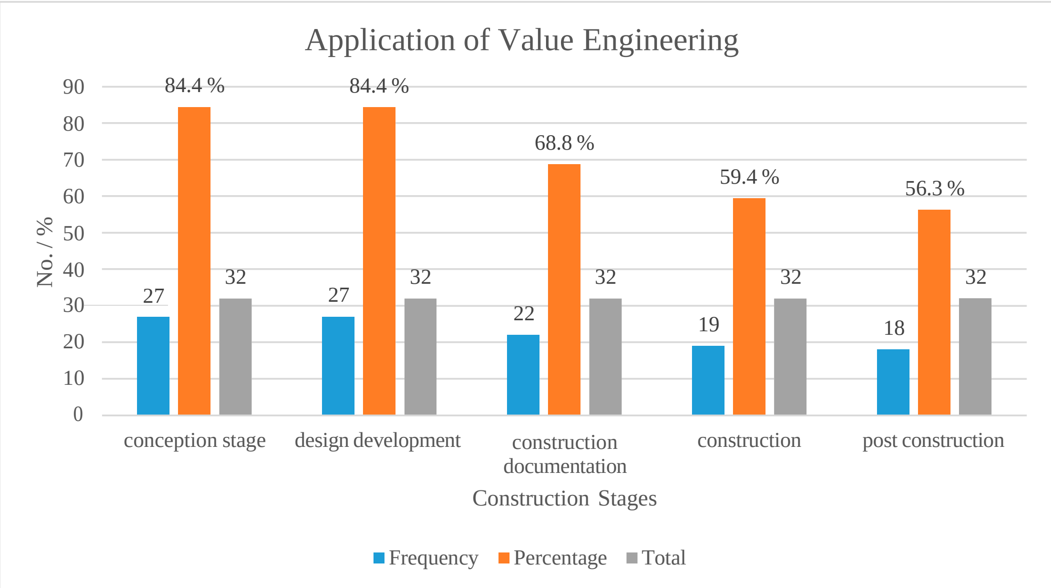

Figure 8: Favorable point for application of Value Engineering

Results obtained in figure 8 resonated with information in figure 1 on the Patrick Macleay Curve, where value engineering has the greatest impact when applied at conception and design development stages. The ability to impact performance is higher, and costs are lower. This is indicated by 84.4% of respondents, as shown above. Figure 8 also shows that value engineering should be applied throughout the construction circle as depicted by 68.8% at construction documentation, 59.4% at the construction phase, and 56.3% at the post-construction stage. Application of value engineering throughout the construction circle has a positive impact on cost, quality and duration. It creates a surveillance system over a road project which enable the management team to identify any threats and put mitigation measures.

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4. Conclusion

Developing systems in road construction processes such as value engineering that promote sustainable construction processes and address cost, quality, and duration is essential for a developing country like Zambia. It will be a mechanism to identify and develop road projects with minimal negative impacts on the environment, optimal whole life cost and satisfying client quality requirements. It shifts a person or team from a general understanding to a specific understanding and improves the product's value. VE should be a company-value-wide activity that should help produce attitudes and provide a way of handling significant problems effectively. It should encourage people to think and use their creative abilities and effectively communicate to improve their overall effectiveness and profitability. The value engineering process is not different from the existing road construction process; it is a more professional discipline process that should be applied throughout the construction circle to yield positive results. Therefore, this study has established that the application of Value Engineering should be led by skilled, qualified personnel who effectively understand the road construction process to deal with complex components of road projects. Results have shown that the value engineering system can considerably reduce project costs and improve quality and performance by implementing effective evaluation and adopting sustainable road construction processes. The ability to impact change or performance is high at the conception stage and design development. The cost of design changes is lower than the construction documentation, construction, and post-construction stage, where that ability to impact performance is lower. Still, the cost of design changes is high. The possible challenge of value engineering would measure the disciplinary capability of the participants and key stakeholders to follow this systematic approach to improve performance, reliability, quality, safety and life cycle costs.

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DII-2021-022

Exploring The Impact of Asymmetric Lock-In on Cost Overruns in Megaprojects: The South African Energy Sector Projects

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Abstract

The post immediate 1994 period was characterized by democratizing access to the world's cheapest electricity while inadvertently neglecting the power supply parity with induced demand. It was only in 2008, when the infrastructure struggled that megaprojects were seen as the viable way out. The ensuing scramble exposed management shortcomings, political interference, a weak economic climate, and pressure to deliver all obfuscated transparent contractual processes. Thus, asymmetric lock-in could have found a fertile ground to flourish from the getgo. Interviews were conducted alongside questionnaires sent to professionals and component/ equipment suppliers building the coal power stations of Kusile and Medupi. The uniqueness of these projects could have encouraged excellent investment because of unique components produced by a limited group of international players. The availed contract documents were analysed thematically whilst the interviews were dealt with thematically. What became manifest was that a speedy implementation and a fuzzy allocation of roles opportunistically gifted the private parties an opportunity to enrich unfairly. The bespoke cutting-edge technologies gave the manufacturers carte blanche on prices without fear of being uncompetitive. The study established the need for minimum time thresholds in planning, considering contextual exigencies below which the go-ahead for the project should not be granted as it has been seen that cost control becomes unwieldy in the absence of upfront strictures.

Keywords: information asymmetry, lock-in, megaprojects, niche players, special investment.

1. Introduction

Megaprojects are generally identified by their behemothic size, complexity, and the large catchment area of impact, which might mean the country's economy in its entirety (Locateli, 2017). According to Flyvbjerg and Cantarelli (2010), the major challenge is inefficiencies with information dissemination, which impacts the project's rollout. If the limited information leads to wrong decisions, especially over-optimism regarding costing, then the shortfall must be met through other programmes' virement. The resultant domino effect in the fiscus hampers other programmes in the pipeline. Suppose there is a lob-sidedness regarding access to information from opposite sides one party will be unfairly favoured (Ajuwon and Gbahbo, 2017). Lock-in applies when the parties have gone too far with an ill-

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advised course of action (Cantarelli *et al.*, 2010). When the aggrieved party realises that replacing the partner they are not happy with would be costly, there is an asymmetric lock-in (Zhang and Fenn, 2019). Due to megaprojects complexity and high riskiness, their implementation is often buffeted by many challenges worldwide, and South Africa should be no exception. The country's energy experience is interesting because it had in the 1980s excess electricity that was the most affordable worldwide.

Nonetheless, these former heydays were spoilt by over-infatuation with the democratising of access to energy due to the disintegration of Apartheid social stratification that led to the unleashing of unprecedented demand (Saylor *et al.*, 2011). The resultant load-shedding was hitherto unknown, and the thus rattled utility company Eskom hastily implemented the power stations construction projects (Burkhardt and Cohen, 2019). Unfortunately, this could have turned out as a hotbed for asymmetric lock-in. Most studies in this area have not investigated this phenomenon in this context.

Studies forward of this one (Schieg, 2008) have indicated the helpfulness of identifying potential information disparities and planning for exchanging the same. Similarly, this research concurs that lock-in seems to affect fair project execution. A recommended approach is to improve the reporting protocols with the project to ameliorate this challenge. Xiang *et al.* (2012) acknowledge that asymmetric information reduction mitigates project risk; this is critical because asymmetric information is one of the chief causes of project risk. However, the genericity of this particular study notwithstanding as it is not focusing on megaproject, it is still relevant. Cantarelli and Flyvbjerg (2013) confirm that there is a strong relation between lock-in impacting cost. The study also advocates for the understanding of lock-in as there is an undeniable link with cost overflows. The study is in line with other studies conducted by the researcher concentrating on the energy sector. The utilization of bespoke equipment manufactured by niche producers could have encouraged opportunistic behaviour manifesting as asymmetric lock-in. According to Zaid *et al.* (2015), to reduce the lock-in effect, the policies in the country should champion the adoption of new technological advances. This will counter carbon-based technologies that are steamrollered by leading economies and multinationals, although their deleterious externalities on the environment are well known. The vested interests ignore the cost-effective and cost-neutral alternatives (ibid.). This work is needful as there are issues of legitimacy as large corporations and central government dominate the discourse, thus compromising general public governance (Witz *et al.*, 2021). The main question was, to what extent does asymmetric lock-in influence cause cost overruns in energy megaprojects in South Africa? This research utilized the following objectives: to Investigate the reasons behind cost overruns in megaprojects. Investigate whether special investments resulted in asymmetric lock-in in Medupe and Kusile and assess how unique project designs create opportunities for exploitation. This study is important because, according to Hetemi *et al.* (2017), large projects are bedevilled with an ever-present danger of lock-in. However, there is no adequate empirical appreciation of this problem

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(ibid.). The criticality of abiding by the fundamental principles and not giving way to outside influences when implementing critical megaprojects in a country is alluded to by Witz *et al.* (2021). In the same vein, this particular study provides a South African elucidation. It takes the debate further by looking at asymmetric information and asymmetry where there is a special investment that unavoidably leads to asymmetric lock-in. It is proposed that this is harmful to the economy if it occurs when dealing with critical projects.

2. Context

Flyvbjerg and Cantarelli (2010) posit that megaprojects could collapse for three fundamental reasons:

- Technical Issues: impediments are resulting in schedule slippage include ill-informed forecasts, poor estimating techniques, and inadequate information, resulting in disadvantageous decisions that are magnified when the staff is inexperienced. On top of that, it is important also to remember that generally, mortals are not good at forecasting things that are still yet to happen.

- Optimism Bias: over-excitement about the project could trigger unreasonable optimism about budget and schedule practicality. It is worth noting that Optimism Bias features a cause of cost overruns predominantly and schedule slippage vis-à-vis technical challenges. The external political vested interests and a desire to beat the competition could also lead to the downplaying of the actual cost by project promoters to ensure a green light from the public leaders.

- Strategic Deception and Misrepresentation Issues: deliberate and dishonest twisting of facts by the sponsors directly affects the project's cost. This could be directly related to withholding facts regarding the true costs and benefits to secure the bid and start the operations on site.

Around the world, late or overly expensive megaprojects abound. The main challenge with these projects is that there is a lot of uncertainty, necessitating at least an ‘open’ terms of reference (Leijten *et al.*, 2010). This is important where it is very difficult to predict the outcome of the processes and the trade-offs between different decisions. Deloitte (2007) points out that around twenty per cent of African megaprojects ever go past financial closure to reach the implementation stage. According to Hetemi *et al.* (2017), the decision-making and project implementation stages are critical. Adugna (2015) claims that all the different stages of project execution could be affected by cost and schedule overruns. Some studies demonstrate that the most susceptible time is during the construction stage. There are a lot of contingent factors that could affect the cost at this stage (ibid.). All the project team members contribute to cost escalation, whether the client, contractor, consultant, or other external players. The invariable client in the South African projects is the parastatal energy Eskom.

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Consistent cost and schedule overruns of megaprojects imply the suboptimal use of the taxpayers' money (Shrestha *et al.*, 2013). In a study conducted by Olatunji (2010), it was found that the South African construction industry's peculiarities were poor management quality, poor design evaluation, insufficient planning, late payments to contractors and poor monitoring systems during construction and design stages (Shrestha *et al.*, 2013). The study by Hwang *et al. (2018) shows that the efficacy of cost control is generally* limited in the megaproject. This study acknowledges these strides made by others and looks at the megaprojects in particular, within the context of a developing country; that is, considering megaprojects as an effective intervention in preventing a looming disaster in a critical sector such as energy generation. The failure of such projects affects the entire economy, and its handling must meet specially tailor-made strictures.

The Energy Megaprojects

The rising population worldwide has driven humanity's insatiable hunger for energy to previously unknown levels. Fossil fuels are providing more than 50% of the world's energy needs. From the 1850s, when commercial oil extraction began, about 135 billion tonnes of oil have been pumped from the earth's belly, assisting to power motor vehicles, enabling energy generation installations to be viable and have been proliferated in domestic use as well (Gray, 2017). About US$4.46 trillion is going to be invested in power generation for the main classes of coal, wind, nuclear and biomass. The world's regions involved in this boom are Africa and the Middle East at US$960 billion, led by the Asia-Pacific region at US$1.99 trillion. The developed regions of Europe are standing at US$739.5 billion and the Americas at US$852.3 billion. This growth in demand is going to increase global capacity by 2,450GW (Globe Newswire, 2019).

The Middle East and Africa, together with the countries of the Asia-Pacific, are hungry for energy because of the booming economies and unprecedented urbanization. The BP Statistical review has shown that in 2017 the world consumption of energy was 13,511 million tonnes of oil equivalent (Mtoe). The contributors to this were the Middle East and Africa at 1,347 Mtoe, Eurasia and Europe at 2,948 Mtoe, the Americas at 3,473 Mtoe and Asia-Pacific at 5,744 Mtoe (Globe Newswire, 2019). The preceding discourse elaborates on the criticality of power generation in advancing development, making it pertinent to appreciate sectoral peculiarities to lessen mishaps that could slow growth in a developing economy like South Africa.

The Energy Megaprojects in South Africa

The global energy crisis had not bypassed South Africa, as, before energy power shortages, the growth of the local economy was generally steady up until 2007. Then without warning, the system collapsed under the demanded strain. The erstwhile president Thabo Mbeki

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admitted that the early ominous signs the system would soon give in were ignored through prevarications. The subsequent screening, largely characterized by injudicious contracting to make for the lost time, was costly. The hurried implementation could have had adverse results for the country ever since (Burkhardt and Cohen, 2019). The delays in completing Medupi and Kusile planned for 2012 and 2014 in that order are costly to the country when considering that they are the third and fourth-largest power stations globally. The country is facing stagnant economic growth because of constant power cuts since the current infrastructure cannot cope with the demand load at times. The main reasons for the delays are endemic corruption at Eskom and the new phenomenon of state capture (Gosling, 2019).

Since the critical infrastructure was affected, it should have been instructive enough as a take-home lesson for future endeavours. Critical infrastructure could be regarded as installations and facilities that the disruptions of their operation could adversely impact the economy, national security and public health of a country (Department of Homeland Security, 2019). Any interference with the critical infrastructure could affect the scheduled delivery of services and goods in an economy, thus affecting tax collection by the state and general wealth generation. The disruption could either be regional or national. Any disaster that could impact the critical infrastructure could affect several sectors in the economy like employment, trade, the actual production of goods and other aspects of the society’s well-being (Critical5, 2015). The panic around the poor performance of the critical energy sector induced panic buying, thus compromising the acceptable procurement strictures. The obsession with seeing tangible progress with the projects diluted the state's bargaining power and tilted the power asymmetry favouring private partners.

Lock-in means the contractual clauses impede a party to a contract from walking away, although it turns out to be injurious to their interests (Liebowits and Margolis, 1995). The Locked-in party has to find coping mechanisms as there is no turning back. The disadvantaged party often hobbles along a path they find immensely painful (Cantarelli and Flyvbjerg, 2013). This could partly explain why hastily implemented projects are always bedevilled with major cost overruns as the normal processes for accurate cost projections are largely overlooked. (Ajuwon and Gbahbo, 2017). Giezen *et al.* (2015) argue that the surging use of megaprojects globally calls for a careful approach given their unpredictability and sophistication. The KISS (‘keep it simple stupid’) adage where expected outputs are arranged into a priori categories should be implemented such that there is a piecemeal approach to, for instance, engineering problems, where they can be managed incrementally in isolation. There has to be strict budget management and schedule progress by a select core group of accountable players. Evidence abounds that the projects were not adequately planned, thus compromising the public representatives' bargaining power around the negotiation table. The uneven playing field could only comprise value for money for the general populace.

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3. Research Methods

To gain insight into how asymmetric lock-in affects cost overflow, a mixed-method was adopted. The experts were interviewed with professionals employed at Medupi and Kusile power projects, and some sent questionnaires. This split the problem into manageable parts that could speak to many different relevant individuals (Sneider and Larner, 2009). A questionnaire advantages are that data is gathered in a standard format making analysis manageable. Thus even the sequence of the questions can be maintained (Brace, 2013). According to Zeiger (2017), questionnaires are indispensable when the audience is large, and the face-to-face arrangement could make respondents uncomfortable. Qualitative methods, in this case, interviews, are normally used to delve into other people's experiences, viewpoints and relations through their lived experiences (Pathak *et al.*, 2013). Interviews were adopted using open-ended questions to appreciate the problem in-depth (Frey and Oishi, 1995). Interviewers in Open-ended interviews can probe further, thus enriching the quality of responses (Wimmer and Dominick, 1997). Nine (9) people in all were interviewed (five executives and the senior officials), and they comprised Eskom professionals that comprised quantity surveyors, construction managers, project managers, civil engineers and others. The selection of a sample was deliberate as the respondents had to satisfy the goals of the objectives (Saunders and Thornhill, 2016). Questionnaires were sent to 50 people (mostly middle management officials) involved in procuring components from the private companies and ESKOM; 39 responded, which was good. The analysis was thematic for interviews and statistical. Common themes were elicited from the interviewees' responses which were after that coded. After grouping the themes, commonalities were identified to elicit any meaning from the identified patterns (Trochim, 1989). Official documents that were perused were analysed using content analysis. In using content analysis, a proper understanding of the language was regarded as important as it is critical to understand the contextual meaning of the text in the documents (Jordan *et al.*, 2005).

The Two Projects [Medupi and Kusile]

Medupi Powerstation can easily be considered the biggest investment for Eskom in its history of 96 years (Bekker and Eberhard, 2008). Once fully operational, the Medupi power station will deliver 4800MW with six units each capacitated to produce 800MW. Because of the water shortage in the area, the units are dry-cooled by utilizing a new supercritical boiler and turbine technology to operate at specifically high pressures and temperatures (ESKOM, 2011). Upon completion, it will have the title of being one of the biggest power stations that do not use water, and 12 % of the country's energy needs will be catered for (Shuster, 2015).

This installation is designed to operate for 50 years, and it is the biggest energy investment by Eskom in 20 years. It will be the third power station in Eskom's fleet that is dry cooled. In the world, it ranks as the third biggest coal-fired station (ESKOM, 2011). The projects utilized various designs delivered through a diverse procurement packaging, all driven by a

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variegated crew of construction and engineering experts (ibid). Vital information was unfortunately unavailable during the design stage, which meant details around the size of some equipment, loading and location of some components could not be agreed upon, thanks to the rush towards implementation (Shuster, 2015).

The other power station of Kusile is stationed in Mpumalanga, very close to another station called Kendal that has been operational for a while. The technology at Kusile is equally innovative. Besides dry cooling technology, it also uses flue-gas desulphurisation to mitigate sulphur dioxide emission during power generation. These technological interventions place Kusile at number two in the most advanced power stations in the country (ESKOM, 2011). This study's twin projects dealt with vital equipment like generators and the skills requisite for their deployment. However, since the machinery was tailor-made, this special investment meant Eskom would invariably be locked-in asymmetrically. Thus the impact of this lob sided arrangement needs more scrutiny. It is also notable that the two are each above $1 billion; thus, they qualify to be accoladed with the title of the megaproject.

4. Findings

Respondents were spread, as shown in figure 1 below. As can be seen, most of the respondents were from the management side of things at 56%, meaning they were the people who had an overall picture of the projects. 22 % were from cost consultancy, and they could have advised on the most economical methods and at least flagged very unpredictable elements. According to Hetemi *et al.* (2017), the decision-making stages are very important. When there are many unknowns, the price is likely to increase, hence the call for flexible terms of reference, including withdrawal when the cost is unmanageable.

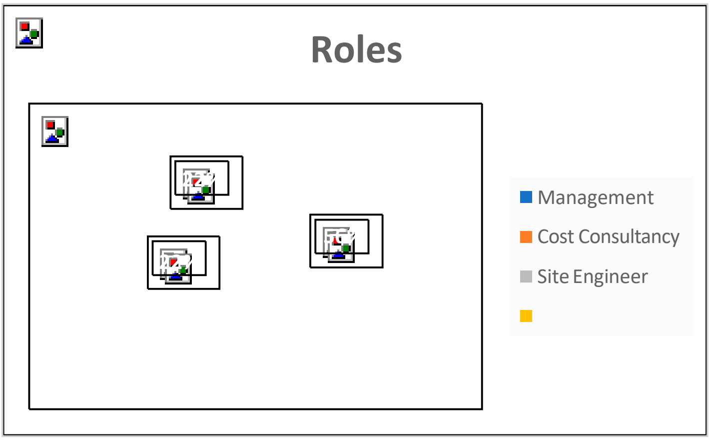

Figure 1: Respondents' spread

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Instead of appointing a main contractor and a project manager, Eskom assumed the roles even though they did not fully understand their expectations. Most respondents said there was no defined scope of works and planned work sequence when the project started. Some of the participants relayed how the tender drawings were only portions of previously built power stations. These could have been some of the reasons why there was cost spillage.

When looking at the particular investment, all the respondents claim the design of the Medupi project was a failure. The consultant's design is not operating as expected. Respondents mentioned that the problem was that Eskom did not understand the scope of the work and the designer's role. This gave the designers the freedom to design in whichever they see best. The power station was designed for high-quality coal, inefficient for Eskom since low-quality coal is being used. Due to the above problem, there is a need for a new design, further adding to the burgeoning costs. The appointed designer/s had been given full power on how to design the power station. This has shifted the design knowledge distribution to the designer since the client is, unfortunately, not equipped with the latest knowledge.

5. Main Discussion

Excepting South Africa, all the SADAC region countries utilize foreign companies and expertise to construct 70% of the work. Due to the highly specialized nature of the two projects analysed here, Eskom solicited the assistance of Hitachi Power and Alstom since there was no local capacity. Hitachi Power Europe did all the design, erection and acquiring of all the equipment. Eskom wanted to leverage Hitachi’s reputation as the market leader in steam generator production, particularly its ecological friendliness and competitive pricing know-how. Hitachi appeared to have amassed a wealth of knowledge doing similar work elsewhere, before Medupi and Kusile. They might likely have had the upper hand in knowledge vis-à-vis their Eskom counterparts as Eskom had never built a new power station in twenty years, thus weakening their position in attaining parity with their partners. This disadvantage could have led to upping of the prices beyond the market rates by Hitachi as Eskom was not au fait with the latest developments. Leijten *et al.* (2010) are clear that open terms of reference should have been had to prevent opportunism, something Eskom never did.

The probable cause of cost overrun affirms Shrestha *et al.*, (2013) study, which decried poor planning as a cause for cost overruns. In knowledge-intensive megaprojects, the study showed that starting the project without minimum time allowable for planning is a guaranteed route to failure. The normal megaprojects take four years to plan, and these took only a year to get started on site. That means a lot was overlooked, and the contractor/suppliers were always capitalising on that. This appears to agree with the work of Hetemi *et al.* (2017) that strongly suggests that lock-in is highly possible in large projects. The nation was very much in tenterhooks due to power shortages, and the private partners had the sole monopoly on the available technological innovations. This poor stranglehold of cost control resulted in runaway costs, as posited by Witz *et al.* (2021).

The pressure to get started, along with poor prior planning, was so heightened to the extent that all the major sub-contractors were made to start at the same time. Resultantly, rational sequencing was so compromised that the shallow and deep civil engineering work could not consistently lead the follow-on steel structures. Inevitably these mishaps necessitated accelerations which came at a cost as rates had to be renegotiated. These incidents appear to agree with Ajuwon and Gbahbo (2017) work that shows that if the relationship is asymmetric, the contractor is likely to behave opportunistically. Any revisiting of the rates ex-post is always a sure-fire invitation to ask for higher rates by the contractor. It is also noteworthy that the political pressure meant any delays by Eskom could elicit wrath from the administration, thus further weakening their bargaining power. The work done by Giezen *et al.* (2015) suggests that because of the unpredictability in megaprojects, the engineering work should be compartmentalised and approached piecemeal. This will isolate each problematic area, and it could be dealt with separately to avoid being overwhelmed with the complexity of putting everything together, thus promoting opportunism.

The overreliance on the designer gives them information supremacy and the opportunity to make exorbitant claims. Unfortunately, Eskom would not pull out since there is esoteric knowledge about the design only possessed by the service provider. Moreover, the cost incurred in withdrawing would end up stalling the Medupi project as the designs with new partners would have to be redone. The afore-described scenario is a classic asymmetric lock-in favouring the private company designing the vital equipment for the project. If there are no policies to champion the new cheaper and cleaner technologies, Zaid *et al.* (2015) argue that multinationals will always push for carbon-based technology that is more expensive.

Moreover, there is a clear indication from this study that the bulk of the monetary erosion takes place during the construction phase. Adugna (2015) study alluded to earlier is helpful, although it came short of clarifying to what extent lock-in could influence price escalation. The overreliance by Eskom on a powerful sole supplier who almost monopolises the entire supply chain in this sector was a breeding ground for opportunistic behaviour. This could have been diluted or mitigated somehow, reducing the client's vulnerability to the supplier/contractor.

The problems highlighted above means the special investments in equipment produced by a few powerful players gave them carte blanche to dictate the prices as they wished, much to the detriment of public interests.

6. Conclusions

The study demonstrated that hurried implementation of huge complex projects will always result in difficulties. There must be a demonstration of patience in giving enough time to the

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planning stage. The critical part of planning should include proper staffing to avoid any deleterious power asymmetry favouring the private sector. The study showed that neglecting this critical intervention means no control over the opportunistic private players. The project duration and the planning thereof should allow for delays without the ill-advised reliance on unrestrained optimism. If the private sector detects any panic, they will bloat the cost unreasonably to exploit the situation to their advantage. Poor planning in knowledge-intensive contracts with monopolistic players easily results in asymmetric lock-in, especially where there is a special investment.

It is recommended that the contract be designed so that the government can pull out if there are grounds to believe that the supplier is opportunistic. Proper planning will allow the simplification and separation of different aspects of the project for better manageability. The components should be designed to accommodate other manufacturers' components if there is a change.

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DII-2021-023

Handling financial implementation challenges of Public-Private Partnerships (PPPs) in Zambia

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Abstract

Governments in developing countries face considerable challenges in single-handedly delivering development to their people. Modality of involving the private sector in closing the development gap has been a significant vision for governing authorities. In a bid to reverse Zambia's stifled growth, the country enacted the public-private partnership (PPP) Act No. 14 of 2009. An array of critical success factors (CSFs) underlies decisions by countries for adopting the PPP model of development. The establishment of PPPs as the 'new normal' for development has revealed insufficient knowledge among building industry technocrats regarding the operability of such schemes. Further, implementation challenges have mainly affected financial, technical entities of valuation decisions over the main stages of the project, namely the proposal submission, negotiation, construction, and operation phases. This paper aims to highlight two knowledge gaps relating to the governance of PPPs. Firstly, there is a need to know the extent of built environment professionals' knowledge of the 'PPP new normal' for development. And secondly, there is a need to verify the scope of its transforming effects on Zambia's growth trajectory because of CSFs used for its introduction. To ascertain these objectives, a mixed research approach was used consisting of interviews, the administration of a questionnaire, and two case studies. Findings from this research revealed that this mode of development remains misunderstood by professionals owing to PPP complexities. Principal Component Analysis in SPSS showed that PPPs have had little transformative effect regarding CSFs used to establish them. Transformative prospects lie in industry professionals' acquaintance with potential risk factors affecting prudent fiscal management of projects.

Keywords: Financial risks, Implementation, Public,-private partnership, Transformative

1. Introduction

PPPs are new public management (NPM) that improve contractual practices efficiency and accountability for open competitive tendering. Multilateral lending agencies responsible for foreign direct investment (FDI) insist on methods that foster such culpability. Governments around the world have changed their philosophies regarding the purchasing of infrastructure services. The earlier position included financing, designing, and operating the country's

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material portfolio with huge associated risks. As an off-the-budget benefit to governments, PPP developments are the reason they are preferred over the traditional form of procurement. The combined advantage of competitive tendering (in the case of a solicited bid) and flexible negotiation guarantee that risk is transferred away from the public. Project risk complexities introduced before and during the development reveal the kind of financial structuring and hedging options that ensure satisfaction for both client and investor. Lessons, therefore, are in abundance from successes and failures of implemented PPP projects across the African continent.

2. Literature review

PPPs work on the premise of combining public and private sector entities in the execution of projects. This combination is aimed at mobilising funds as well as expertise. Akintoye (2009) cited three factors that have enabled the stage to be set for PPPs in Africa:

- The influence of global economic affairs that affected the social-political environment;
- Introduction of stringent procedures for regulating public sector borrowing; and
- The recognition of infrastructure in the growth of economies and alleviation of poverty disturbed by scarce income levels in the public sector.

African economies have therefore recorded a rise in projects secured under the PPP mode of development.

2.1 PPP challenges

Ndandiko (2006) and Zulu and Muleya (2009) have expressed contrary views regarding Sub-Saharan Africa. They argued that PPP procurement is fraught with difficulties of deficient regulatory frameworks and bankrupt public and private sectors rated as important conditionalities for the success of PPPs (Li, 2005; Zhang, 2005). Challenges (or risks) in PPP projects occur across a range of issues which include (Solino and Vassallo, 2009):

- The project's relationship period (or concession);
- The funding method; and
- The spread of risks between the project partners from the private and public sectors.

The quantification of risks requires measures to mitigate them as they pose challenges to the project. Wang *et al.* (2000) suggested the following mitigation measures in **Table I** below.

Table II: Mitigation measures

Risk type	Possible mitigation measures

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Currency risk	(a) Weighing the position of foreign reserves (b) acquisition of authority to transfer of convertible currency (c) obtaining support from the government for privileged access
Expropriation risk	(a) Forging relations with other international funding agencies (b) Obtaining offshore insurance for loans and equity investments
Change in law risk	(a) Obtaining government guarantees for export and import restrictions (b) Sharing of risks for loan borrowers and output purchasers
Political violence risk	Obtaining political insurance with multilateral and bilateral political insurers
Government approval risk	Obtaining all government approvals and guarantees
Loan security risk	Foreclosure and insolvency, security measures

The hallmark of PPP projects is the allocation of risk (Rwelamila *et al.*,2003). The nomenclature of the pattern of risks, particularly for developing countries embarking on using this mode for development, has insufficient information and remains a challenge (Ndandiko, 2006). During the evaluation process, the developer's due diligence needs to be investigated for actions against various risks that can affect the project. Surmounting project risks instils confidence in achieving the intended business goal (Warnes and Warnes, 2014). And as risks are evaluated, this guarantees the success of the PPP project (Mukalula and Muya, 2014). Contract conditions target threats that arise as a combination of the political, legal, economic and social environment prevailing in the country (Joslin and Konchitchki, 2018). Merna and Lamb (2002) listed eight time-related risks that affect loan repayments before and after the commissioning of a project. These were:

(a) currency risk.
(b) interest rate risk.
(c) equity risk.
(d) commercial risk.
(e) liquidity risk.
(f) counterparty risk.
(g) country or political risk; and
(h) accounting and economic risk.

There should be measures instituted to curb risks spiralling out of control once the project commences. Financial accounting and risk mitigatory instruments are the two subjects that must occupy the project team during the execution stage. The developer must use various hedging instruments to avert the financial failure of the project. Aggarwal *et al. (2011) found*

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that Chinese Corporations with risk exposure of between 20 - 40% are extremely high. Financial instruments need to have longer maturity tenures to counter the interest rate risk arising from extended periods of implementing the project. Raising construction equity for large PPP projects is a challenge in developing countries banking sectors (Zulu and Muleya, 2009). Distorted economic information can cause projects to be financially pressured, resulting in one of these equities. Risk-sharing by the public, therefore, becomes a safer choice (Kartashova, 2018). Speedy project execution reduces exposure to commercial risk. On the other hand, the developer's susceptibility to solvency must be dealt with through liquidity risk. Credit risk of this nature can be mitigated by enacting laws that would enhance sharing of information through banks (Kusi *et al.*, 2017). Saunders and Cornett (2008) suggested the use of forwards, futures, swaps and options in curbing the lack of national liquidity

Project lenders assess counterparty risk in getting assurance over the developer's financial standing of the developer. To do so, debt serviceability is associated with a country's political risk. The effect created by such a risk is considered as harmful as the equity cost for investors (Warnes and Warnes, 2014). Expropriation or, worse off, project cancellation may be remedial modalities but would impede progress. Accounting risk is a retrospective assessment of a company's risk structure, while economic risk focuses on their wider repercussions to project operations (Toumi *et al.*,2018). All these risks relate to the proprietors' project cost on interest rates for loans procured from multinational companies during the development process. The upturn for investors' execution of PPP projects comes when interest rates are low and slows down when they escalate. Walsh (2003) pointed out five methods that give an overview of cost and time in the context of risks. These are:

(a) A sensitivity analysis that gauges the effects of suppositions on project net present values and total costs;

(b) Scenario planning involves evaluating the project in different situations;

(c) Monte Carlo analysis examines the chances of obtaining the reality of the project in light of postulations made in cost projections;

(d) Decision rules/trees analyse options against set measures; and

(e) Discount rate accounts for the envisaged risk for the recovery of invested funds in the project.

The CSF's study by Chan *et al.* (2010) also singled out appropriate risk allocation, concluding that there was the need to understand better individual factors affecting project success. Pongsiri (2002) argued that while many governments in developing countries are eager to sign their first demonstration PPP contracts, most have inept legal and regulatory

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frameworks to monitor private contractors' performance and ensure contractual compliance. Performance monitoring achieves better and informed decision-making which is a need in emerging economies that have adopted the PPP mode of procuring construction projects (Pongsiri, 2002; Zhang, 2005b).

3. Research methodology

Mixed method research was the design adopted for the investigation. A two stage-structured focus group study provided the initial non-probability sampling for the research. The primary methods used were interviews and questionnaires management under this technique (Kothari, 2011). Interviews and questionnaires were conducted on a selected team of professionals conversant with the establishment of PPPs in Zambia. This list was provided by the National Council for Construction (NCC) and consisted of cross-section individuals from the industry. Interviews conducted lasted between 30 and 40 minutes. All those selected had worked experience with implemented as well as upcoming projects. Documentary (or archival) evidence was used for the two case study projects as secondary data. Eventually, data triangulation was the end process used to compare the results from the three data collection methods. The philosophical approach adopted was both ontological well as epistemological (Creswell, 2003).

4. Findings and Discussion

The focus of the interviews and questionnaires was fourfold in firstly identifying financial risks. After that, methods to evaluate risks and how pursued CSF impacted the PPP projects were also investigated. All collected qualitative data was analysed descriptively (Silverman, 2010). The accuracy of the financial methods used was assessed using Spearman's Rho. Results from Principal Component Analysis (in the Statistical Package for Social Sciences - SPSS) were used to show what CSFs were transformative because of risks in implementing PPPs. CSFs from the questionnaire were then compared to those Principal Component analyses.

4.1 Background information on focus panel respondents

Respondents demonstrated that they held management positions and with ample experience on the subject of PPPs. Ten of the participants had an average age of 45 years. The results in **Table II** below show the composition of the interviewees holding high or middle-level positions in their organisations. The level of experience for the interviewees varied from 2 to 14 years.

Table II: Composition of the focus panel

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Organisation	Positions held	Number interviewed
Private Sector consultants	Managing Partners	5
Public institution	Senior managers	4
Private sector	Chief Executive Officer	1

To identify vital common features, results from the interviews, questionnaire survey and Rotated Component matrix were evaluated together.

4.2 Project Critical Success Factors

PPP implementation in Zambia was critical, and Interviewees were asked if the PPP law had been instrumental to the process. **Table III** below shows a summary of the results CSFs.

Table III: PPP critical success factors

Interview	Survey	Rotated Component Matrix
(a) Good working structure (60%)*; (b) Delegate work to the private sector (20%); (c) **Clarity of policy** (15%); (d) Publicity or sensitisation of PPPs (5%).	*(a) Saving time in project delivery* (9.82%) *(b)* **The benefit to local economic development** (9.78%) *(c)Transparent procurement process* (6.21%)*(second last on list)	*(a) Strong and good private consortium* (0.504)* *(b) Transparent procurement process* (0.593)*

The results show a varied matrix of what CSF was considered to ensure the success of PPPs in Zambia. Italicised factors have been listed by writers such as Akintoye (2009) and Li (2003) as vital components throughout the entire PPP negotiation process to implement the project. Rwelamila *et al.* (2003) had shown the necessity of such factors if PPPs are to succeed on the African continent. Frequently, protracted negotiation processes are a common feature and, in many instances, had derailed implementation (Zulu and Muleya, 2009).

4.3 Risk identification in achieving PPP project success

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Respondents were asked to indicate risk identification methods to be used in achieving PPP project success. **Table IV** below shows the results.

Table IV: PPP risk identification factors

Interview	**Survey**	**Rotated Component Matrix**
Experience (85%) Feasibility study (15%)	*Experience* (11.00%) Site visit (10.77%)	*Experience* (0.752) Data bases (0.752)

49% of the survey respondents stated not having any PPP experience despite their many years in the construction industry. Only 42% of the survey respondents had a bare experience of PPPs. This suggested that the subject of PPPs is largely unknown. PPPs are a highly complex type of contract that must transcend basic construction pacts (Yescombe, 2007). As much as PPPs can drive development through private finances, construction professionals must know how they work. The handling of 'risk' is the centrepiece of PPPs and must not be done where there is an 'absence of a risk management culture' (Zulu and Muleya, 2009). Frequently, the financial structure for PPP incorporates debt profiles, cover ratios and equity return (Toumi *et al.*, 2018).

4.4. **Financial decision-making tools critical for the success of PPP projects**

Interviewees were asked to indicate which financial decision-making tools had been used on implemented PPP projects. A total number of 6 tools were identified as:

(a) Financial appraisals (40%);
(b) Cash flow analysis (20%);
(c) Profit and loss analysis (10%);
(d) Development concept (10%);
(e) Cost-benefit analysis (10%); and
(f) Life cycle costing (10%).

Respondents preferred 'financial appraisals' for assessing PPPs, which received a response of 40%. Although cash flow analysis (with 20% response) followed, it was observed that PPP consultants preferred a combination of assessment tools upon further inquiry. It was further observed that the tools were fairly basic in examining the financial worthiness of PPP projects. However, the tools assessment accuracy for projects was of grave concern (Yescombe, 2007).

4.5 Spearman's Rho for accuracy of methods

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In seeking to assess the accuracy of the financial tools, Spearman's rho was used as it gives the comparative intensity of a connection. There is no resulting straight evaluation between 0 + 1. A proportional reduction in error (PRE) is calculated when the rho value is squared. Using the following equation (Healey, 2009):

$$r_s = 1 - \frac{6\sum DD^2}{NN(NN^2-1)}$$

Table V: Spearman's rho calculation for financial decision-making tools

Financial tools	Mean	Field means ranking	Focus group rating	Focus group ranking	D	D^2
Payback period of project	4.30	1	5	1.5	-0.5	0.25
Internal rate of return	3.98	2.5	4	3	-0.5	0.25
Life cycle costing	3.98	2.5	3	4.5	-2	4
Discounted cash flow	3.74	4	3	4.5	-0.5	0.25
Net present value	3.62	5	5	1.5	3.5	12.25
					$\sum DD^2 = 0$	$\sum DD^2 = 17$

Spearman's rho value=0.15

Using the focus group's means and accompanying field mean ranking, a Spearman's rho value of 0.15 was obtained. A predicted reduction in error of 2% is obtained when 0.0225 is squared for using financing tools as they would guarantee 98% accuracy of PPP estimates done (Walsh, 2003).

4.6 Project success through PPPs

Respondents were asked why PPPs would be necessary for projects to succeed. Results are as seen in **Table VI.**

Table VI: PPP project success

Interview	Survey	Rotated Component Matrix
As budgeted (70%)	Employment creation (8.58%)	*Satisfy stakeholders* (0.523)

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Development addition (30%)	Quality buildings (8.53%) *Technology transfer* (8.49%	Value for money (0.660) Development addition (0.711)

Again, what constitutes PPP success is a matter of debate. Stakeholder satisfaction must ensure that the project is (Akintoye, 2009, Mukalula and Muya, 2014):

(a) viable;
(b) affordable; and
(c) bankable.

These are the features that financing institutions look for in surveying the financial perspectives of projects. Profitability and risk are positively correlated and assure lenders of a return on capital invested (Smith *et al.*,2014).

5. Conclusion

This paper demonstrates the complexities of PPP projects due to risks affecting projects and the needed transformative CSFs for success. The change must affect the financial knowledge base of construction professionals. Right at the onset f the project, financial risks must be carefully considered by the concessionaire. Lack of disclosure of accurate information about the project is a risk that those wishing to use the PPP development model must contend with. ***Projects will only register a healthy net present value and payback period if would-be investors provide true information***. Only then would it be guaranteed for taxpayers not to be over-burdened with unjustifiable lengthy concession periods, in as much as extended concessions would maximise profits to the investor but are potentially detrimental to 'beneficiaries' of PPP projects.

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DII-2021-026

The Effect of Real Estate Obsolescence on Economic Suitability

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Abstract

This paper aims to briefly review literature over a 20years period that identified problems towards economic sustainability such as real estate obsolescence, which involves inadequacy in the fulfilment of planning, spatial development, and the future. The paper uses narrative literature research methodology to critically review existing literature and advice compiled from different scholars' studies. The general conclusions are that some of the issues of real estate obsolescence in real estate may lead to economic unsustainability. The literature reviewed noted that obsolescence is the negative key factor of property depreciation and has a significant and immediate impact upon the investment value of property in the real estate sector. Although there is no precise definition of the term obsolescence given its wide-ranging scope, this study has distinguished the various forms of obsolescence that affect the economic sustainability of the real estate sector. It is hoped that the progress being made in methodology will be incorporated in directed guidance towards real estate economic sustainability. The paper offers an applied examination of an issue that impacts many aspects of the contemporary real estate industry. This paper aims to review literature about challenges of real estate obsolescence, which hinder the economic sustainability of real estate in South African cities.

Keywords: Obsolescence, Real Estate, Property, Sustainability, Economic Sustainability & Planning.

1. Introduction

Pourebrahimi *et al.* (2020) and Franz (2020) argue that the word obsolete distinguishes between discarding unpleasant subjects and outdated structural or management problems for the real estate or property industry. While defining obsolescence, looking at its degree of difference from depreciation will address how these two terms differ and how they relate. In accountancy, both terms can be used interchangeably to measure how wear, use or any reduction in a secure asset's valuable economic existence is measured by depreciation due to technical or market conditions (Zheng and Chen, 2017). Butt *et al.* (2010) is in line with Ji *et al.* (2017) in stating that the word obsolescence is derived from Latin 'obsolesce', which refers to the growing old of something further speaks of the process of becoming obsolete. This is not deviating much from the above definition, which states that a building structure

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can be strictly described as 'obsolete' as it becomes utterly useless for all imaginable uses which it was called upon to help (Butt *et al.*, 2010; Ji *et al.*, 2017). Essentially, obsolescence is due to the depreciation of value, impaired suitability and usefulness caused by new technologies, popular model innovations, improved production methods or outer aspects, making an Unfitting framework for constant use (Ning and Sun,2016). According to Thomsen and Van Der Flier (2011), the performance of how usable property is, how satisfied occupants are, and how life cycle costs of built facilities of a property are, are highly implicated in the dilapidation of a structure over time. Not surprising then that the major factor inherited from the word 'obsolete' is time, which is impeccably reflected by age in the real estate industry.

Moreover, Zheng and Chen (2017) state that the relationship between depreciation and obsolescence is that depreciation is forfeiture in the current usage value, which occurs due to a building becoming obsolete. The implication is that obsolescence causes the building, and the result of obsolescence is depreciation. Grover *et al.* (2021) explain that it is rather not important whether obsolescence is functional, aesthetic or in value; internal obsolescence affects real estate. Thus, the objective of this review paper is to unearth the issues in real estate obsolescence the may negatively affect sustainability, with the hope that there is more exposure to elements that further hinder the real estate industry.

2. Research methodology

This literature review in this study was carried out to identify publications related to 'obsolescence and economic sustainability in the real estate industry over 20 years. The main keywords used were: Obsolescence, Real Estate, Property, Sustainability, Economical Sustainability and Planning. Several scholarly databases were explored, including Google Scholar, EBSCO, Science Direct and Emerald. The search came back with 65 papers, of which, after refining with the titles and abstracts, only 54 papers could be explored. All the papers retrieved were manually explored and analysed to ensure that the titles and abstracts were suitable for this survey. This investigation concluded that research on the 'obsolescence and economic sustainability' topic in the last 20 years has an increasing trend, as shown in Fig. 6 below. This graph is based on the 54 papers explored and retrieved following the procedure explained above and limited to the period between 2000 and 2020, considering that the number of publications on this topic before 2000 can be regarded as insignificant.

The most relevant papers were read and analysed further. This allowed the identification of trends and key areas that were covered by many papers, namely: 'functional and financial obsolescence', 'aesthetic obsolescence', 'environmental obsolescence', 'physical obsolescence', 'mitigation and resolution approach such as BIM and renovation', which represented the research scope within the 'obsolescence' topic. The papers were classified according to the years, as illustrated in Table II. This classification shows that most of the research on obsolescence was done in 2020, followed by 2013 and 2005. This is an indication

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that obsolescence is a serious problem and need immediate intervention. The years of classification in which no literature was not recorded does not mean no literature was published in those years. However, it could indicate that the literature collected in this study could be limited.

Nevertheless, another fact that can be appreciated from this classification is that papers are exploring obsolescence resolution and mitigation approaches. Still, in this study, we highlighted the “renovation for obsolescence” as a key mitigation strategy. Therefore, we recommend a classification study that shows a clear trend towards a particular area within the obsolescence topic in recent years.

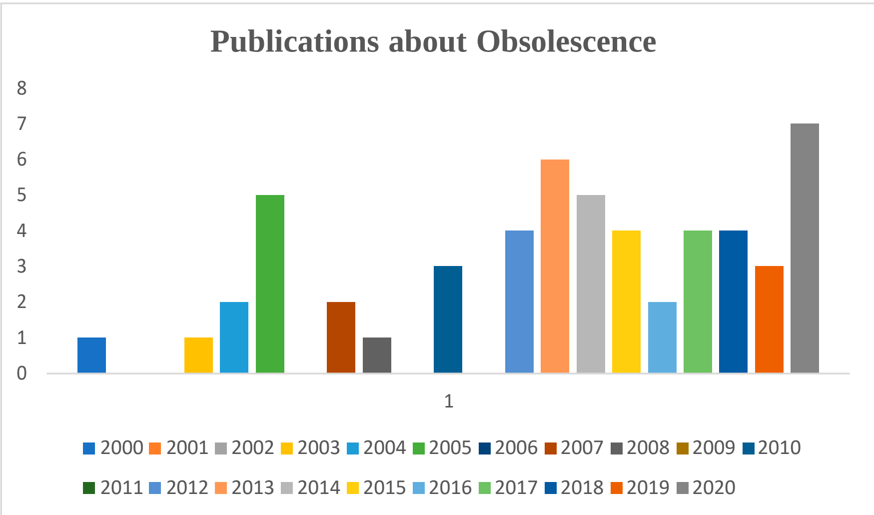

Figure 1: Yearly publications on obsolescence within the real estate industry. Please note that no articles were reviewed for 2001, 2002, 2006, 2009 and 2011, respectively.

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Table I: Classification of key papers in relation to 'obsolescence and sustainability'

Authors	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2000
Oloke, Simon & Adesulu; Cisse *et al.*, ; Alterman Abili, Onwuzuluigbo and Kara; Ibiyemi & Tella; Kazmierczak and Handley								6												
Grover & Grover; Johnson; Bokhari & Geltner; Famuyiwa & Babawale; Volk *et al.*, .							5													
Reilly; Bartels; Ermel, Sandborn & Pecht;Owusu-Ansah									4											
Bokhari & Geltner;Natsvaladze and Beraia;UKEssay; Chen			4																	
Ndlebe; Zheng & Chen; Ji, Chai and Wang; Nwanekezie and Nwanguma				3																
Ning & Sun; Butt, Jones, Savic, Gorse, Hudson, & Paul					2															
Thomsen and Van Der Flier; Butt, Giddings, Cooper, Umeadi, and Jones										2										
Reed & Warren-Myers; Reed & Wu, 2010; Butt, Umeadi and Jones											3									
Yau & Chan													1							
Kauko; Whitten & Bentley														2						
Cooper																		1		
Orviku Jaagus, Kont, Ratas and Rivis																			1	
Yusof																				1
Pourebrahimi, Eghbali, Roders; Franz	2																			
Moniz; Hutt *et al.*, Sarker-2019		3																		

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3. Causes of obsolescence of building stocks

Zheng and Chen (2017) inform us that several reasons lead to obsolescence within the built environment or the real estate industry for different property types. Age alone in-built structures is not a dangerous issue. Three fundamental causes of depreciation are factors that contributed to obsolescence: physical obsolescence due to ageing, environments, and the degree of probable future maintenance costs; and functional and aesthetic obsolescence due to structural designs which have survived and used the life or are no longer adequate (Grover and Grover, 2014). According to Ning and Sun (2016), as much as physical decay is the easiest to point out, environmental factors are the most crucial factors and are currently the most acknowledged cause of the processes of real estate obsolescence. Therefore, opting out of relevant life cycle management may lead to proper prevention, diagnosis, and cure of any obsolescence, to ensure economic sustainability in the real estate industry (Thomsen and Van Der Flier, 2011). Grover and Grover (2014) agree with Cooper (2004) and note that the RICS Red Book also uses physical, functional, and economic to categorise obsolescence. They further note that physical obsolescence is when the cost of repairing, servicing or renovating real estate remains usable.

Additionally, Ji *et al.* (2017) mentioned that universally, there is a massive necessity to assess, elude and cure obsolescence. Ning and Sun (2016) share common information likewise and state that the real estate industry at large recognizes the enhanced need to evade obsolescence to constrain unsustainability. Pourebrahimi *et al.* (2020) state that functional and structural obsolescence is driving most demolitions of buildings that have undergone obsolescence.

Regarding the pre-war stock, oversupply, and economic drives, about 87% of the demolitions are caused by obsolescence types mentioned already in the study. Nevertheless, what certainly causes obsolescence is quite complex, and to remedy it, the know-how of the relevant techniques and instruments must be considered (Ning and Sun, 2016). Since the causes of obsolescence are difficult to detect, it is extremely important to recognize building obsolescence and its diverse types because it can prevent the real estate industry (Vandewater, 2015). Due to the radical and pressing obsolescence, buildings' traditional lives steadily decrease (Reed and Wu, 2010). Various types of construction/property obsolescence are present. Zheng and Chen (2017) mentioned how their indifferences make the literature more complicated because they seem very related and coincide with vast common causes.

Prevention of obsolescence entails well thought and planned systematic analytic periods that may hinder the performance of buildings (Ji *et al.*, 2017). Furthermore, factors affecting

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decay and obsolescence in real estate stock are design, construction, use, and management says (Reed and Wu, 2010).

This study will emphasise future developments/sustainability, flexibility in design, and structure to accommodate the potential change. Prevention should therefore be launched at the earliest stage to anticipate changes and continue throughout the life of the property (Butt *et al.*,2015).

4. Types of obsolescence

The clarity in the misperception and fallacy surrounding depreciation and obsolescence is that the former occurs when a structure becomes obsolete (Reilly, 2012). Therefore, depreciation results from technological development, which is considered the basis of depreciation (UKEssay, 2018). The effect of obsolescence is divided into two factors: fixable and incurable aspects Reilly (, 2012), where incurable obsolescence is less controllable and more vital than curable obsolescence (Reed and Warren-Myers, 2010). Incurable obsolescence is mostly a threat. It can immediately truncate a structure's physical life, but identifying accurately or measuring all forms and types of obsolescence can be rather daunting as they tend to overlap (Reed and Wu, 2010). In the real estate industry, three main forms of obsolescence - the physical, functional and economic - historically exist, according to Reed and Warren-Myers (2010). Also, Butt *et al.* (2010) mention that some types of obsolescence are used as a systematic classification needed to illustrate various features and impacts of obsolescence. In the figure below, the main difference between each type is emphasized. Numerous physical, functional, and economic considerations might not necessarily influence the real estate value of a particular enhancement which the market might consider desirable on the date of value. Still, they will likely have a profound effect at a future time (Cooper, 2004).

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Below is a diagram showing types of obsolescence:

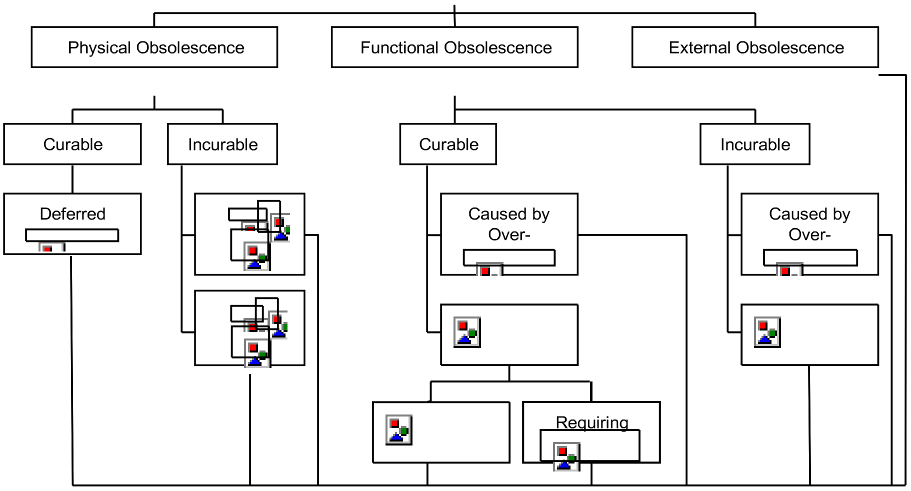

Figure 1: Types of obsolescence Source: (Reed and Warren-Myers, 2010)

4.1. Functional and financial obsolescence

More than anything, entrepreneurs ought to be very vigilant about Financial obsolescence. This type of obsolescence transpires when investment and frequent expenses are not balanced by earnings and subsidies (Bokhari and Geltner, 2014). Thus, financial obsolescence is the balance between costs and benefits (Cooper, 2004). Moreover, according to Butt et al. (2010), financial obsolescence signifies a 'loss in value' and is labelled as social or economic obsolescence (subject to the driving cause behind it). Economic obsolescence can also lead to social and aesthetic obsolescence (Ibiyemi and Tella, 2013). However, business, financial and economic obsolescence features are categorized in one group of building obsolescence, emphasising costs and incomes.

According to Ibiyemi and Tella (2013), functional obsolescence is when the design or specification does not satisfy the function that the property was built to meet. In the real estate industry, this happens when technology advances or when there are legislative changes. For example, climate, health, and safety laws or access to disabilities may lead to changes. (Grover & Grover, 2014). According to Orviku *et al.* (2003), technological obsolescence is often curable. On the other hand, functional obsolescence is incurable. A

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building structure can be functionally obsolete because of a defective layout or inability to adapt to the current technology (Ibiyemi and Tella, 2013).
Nevertheless, Grover and Grover (2014) point out that functional obsolescence refers to the overall building impact, while technical obsolescence refers to uneconomically non-mechanical and electrical parts. Also, a decline in the need to use a distinct property or goods is connected with market obsolescence, which occurs when the market shifts (Kauko, 2007). We can extrapolate from the literature that the types of obsolescence have common characteristics which tend to overlap.

4.2. Aesthetic obsolescence

Aesthetic obsolescence refers to when either fashion in architectural style changes or the building looks old and fails to satisfy an inspiration associated with up-to-date products (Bokhari and Geltner, 2018). In recent years, aesthetics have expressed stakeholder values. To achieve this value, the decline in the revenue of old buildings enforces stockholders to refurbish the buildings to ensure attractiveness and competitive gain. (Butt *et al.*, 2015). According to Bokhari and Geltner (2018). Functional components are related to building obsolescence as well as aesthetic obsolescence. The effect of aesthetic obsolescence is greater in commercial buildings because new architectural styles can fetch higher rental values (Franz, 2020).

4.3. Physical obsolescence

Pourebrahimi *et al.* (2020) and UKEssay (2018) expressed that the degradation of the physical structure is causing physical obsolescence only. However, this is not true since only the degradation of the physical structure of buildings is regarded as a cause of physical obsolescence, making it look as though it cannot be caused by other factors (Famuyiwa and Babawale, 2014). According to UKEssay (2018), building components may be regarded as one of the construction's physical features, meaning that if a building part deteriorates, it is also physically obsolete. Orviku *et al.* (2003) also note that lack of efficacy because of the stage of development and use of an asset or its components is physical obsolescence.

Therefore, environmental factors such as water (for example, rain, condensation, snow, and ice), solar and thermal radiation, air pollution, biological factors (for instance, micro-organisms, bacteria), stress factors (for example, physical wind effect, hail), and non-environmental factors, for example, pressures generally enforced by people, are determined

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by physical obsolescence because of various activities (Famuyiwa and Babawale, 2014). This means that there are possible external causes, such as natural disasters, that physical obsolescence may occur, linked to user behaviour, or too weak maintenance policies (Oloke *et al.*,2013). Pourebrahimi *et al.* (2020) must remember that they are largely a combination of time and purpose to distinguish between physical degradation and physical obsolescence. Physical deterioration could easily be controlled by using appropriate materials and components from early as the design stage, suitable construction methods, and decent maintenance throughout the building operations (Oloke *et al.*,2013). Nonetheless, similar apprehensions are appropriate for physical obsolescence and more difficult to control since they include unforeseen, alternating, and singular events (Orviku *et al.*,2003). Apart from irregular and unpredictable physical obsolescence, physical degradation is an ongoing process used to identify physical outdatedness, making it insignificant to separate physical decay from physical obsolescence (Oloke *et al.*,2013). Based on Ji *et al.* (2017), designers managed the deterioration rate by choosing the correct material, construction methods and acceptable maintenance standards. This can be achieved by providing a versatile and adaptable design approach, facilitating later modifications and renovations (Ji *et al.*,2017). Below is a list of some of the attributes which cause rapid deterioration of buildings and their components (UKEssay 2018):

- Focus on initial construction costs without looking at the effects of use costs.
- Unsuitable buildings and their components design and detail.
- Use if there are insufficient data on the durability of materials and parts.
- On-site construction activities are poorly regulated, monitored, and inspected.
- Different causes of degradation lack comprehension.
- Inadequate attention was paid to building stock repairs.
- Owners' and occupies unauthorized use.

4.4. Environmental obsolescence

According to Abili *et al.* (2013), in a case where the character of an area no longer makes a building suitable for the originally planned use, that shift in change is termed environmental obsolescence, which normally could be of greater relevance to the depreciation of land rather than to the depreciation of buildings. Therefore, the building appears to be environmentally redundant when there is a need for changes of an area's infrastructure, for example, when more space, pedestrian areas, efficient public transport, and roads are needed; which makes it more difficult to predict this form of obsolescence because it does not apply directly to the

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building design. Environmental obsolescence may be overt or indirect (Butt *et al.*, 2010). According to Chen (2018), environmental changes, for example, high pollution, road blocking, and urban decline, trigger environmental obsolescence (e.g. an office building which unexpectedly become redundant when the adjacent site is used for industrial use or when factory engine disruptions and air pollution suddenly affect tenants, causing a decline in building income). Other causes include degradation, inconvenience and other environmental aspects, which are the same factors that can contribute to obsolescence in location and climate (Yusof, 2000). Because of common terms, local, environmental and locations obsolescence are grouped into one construction obsolescence category Nwanekezie and Nwanguma (2017), regardless of their differences in size.

5. Function of planning regulations, developmental controls, and its effects on real estate obsolescence

Planning policies, planning rules, and development assessments impact the physical landscape, defining land use and construction features (Van den Dool *et al.*, 2015). Legal considerations include statutory and administrative restrictions or modifications under Kazmierczak and Handley (2013). Strategic land use plans and land use controls are the two common planning instruments for land use management and development (Sarker *et al.*, 2019). In terms of market forces, laws appear to be a leading planning basis in advanced economic countries. However, socio-cultural and political norms in developed countries still appear crucial in some cases (Volk *et al.*,2014). Planning laws in the whole world consist of technical and practical elements that influence the concept of justice (Alterman, 2013).

The planning act is referred to as the legal factors or laws according to Volk *et al.* (2014), and they regulate South Africa's land use and growth, which give landlords freedom to decide how to use the land, but there are restrictions on this liberty. In technical terms, planning legislation establishes the mechanisms for public communication, information access, and legal powers conferred on stakeholders. This makes laws a tool for government policy planning (Alterman, 2013). It should be noted that, while legislation can exist on paper in developed countries, numerous urban areas probably do not have planning legislation. These developing cities do indeed require planning laws and development controls to allow for the increasing value that may affect the livelihood of the residents, the superior inevitability towards businesses, and more importantly, towards sustainable environmental resources (Cisse *et al.*, 2013).

Therefore, the sustainability of the inner city requires all the necessary stakeholders to partake in the city's wellbeing. Some of the major elements that require a thorough

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assessment for real estate obsolescence concerning urban planning are zoning regulations (the concentration of progress in risk disposed of areas), humans inhabiting hazard zones, the subdivision requirements that take into account danger and weakness, the control over illegal expansion, the level of flexibility, land, and property hazard scrutiny, the formation of hazard maps, situation-grounded planning, the concentrated planning of land and property and practical planning acquisition (Whitten and Bentley, 2007). The policies on hand for town planners in South African Municipal offices include the involvement of major urban planning requirements found in the SPLUMA bylaw that came into effect in 2013. These laws should be implemented, and it is required that it be clear how these laws assist in resolving problem-building issues and the encouragement of successful economic sustainability in the world.

Planning laws can be used to apply for appropriate zoning, allow for the allotment of space for agricultural production, and follow prevailing and new areas of the cities (Sarker *et al.*,2019). On the other hand, legal changes can provide opportunities (Johnson *et al.*,2014). For example, an area that was previously zoned residential would mostly be appreciated by commercial developers in a case where the area is rezoned for business. The legal issues of specific concern may be as follows, according to Natsvaladze and Beraia (2018).

- Facilitations;
- Rules on access;
- Mineral rights and waters;
- limits on zoning and other use;
- Title registration and transmission.

State and local rules, which have primary authority over land and property growth in general, are important for stockholders or private owners to be familiar with (Natsvaladze and Beraia, 2018). And to furthermore acknowledge certain tools that could be of benefit to the industry as well (Bartels *et al.*,2012):

Table II: Typical example of tools necessary for urban development in the Built ***Environment***

Types of Tools	**Tools examples Accessible BRE Checklist for Sustainability**	**Sustainability**	**User**
		Measurements	**Country**
Macro Level -		3	UK
Urban Planning	Public Sustainability	3	International
Tool	Assessment		
	SEEDA	3	UK
Building Level -	Ecotect	1	Australia

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Design Tools	Design Consultant for Building	1	USA
Building	BREEAM	1	UK
Environmental	EcoHome / CSH	1	UK
Frameworks and	LEED	3	USA
Rating Systems	SPeAR	3	UK
LCA Tools	ENVEST	2	UK
	TEAM	1	International
Infrastructure Tools	CEEQUAL	2	UK

6. Reconstruction of vs building rehabilitation/renovation

Reconstruction in the real estate industry faces many challenges and great potential opportunities along the way, especially to eradicate inferior buildings, disputed land use, and conservation problems (Owusu-Ansah, 2012). Owners of an obsolete building may be well paid for demolition (or expect greater profits if they demolish their building to build a bigger or better one) (Yau and Chan, 2008). Choosing to redevelop the land sites could be professionally planned by being realigned or rearranged to completely take advantage of the development prospects of a particular plot (Vandewater, 2015). Entrepreneurs tend to focus too much on new development, as many are looking for vacant sites to build on and are not too concerned about land reform (Ndlebe, 2017).

Most people prefer traditional rather than modern construction. Nevertheless, traditional houses are rarely demolished prematurely to build a modern house; they are sold and produce continuous services to their new owner (Gregory, 1947). Obsolescence can lead gradually, normally with demolition, to the end of life without sufficient care. Some owners plan to refurbish their homes, while others choose to destroy them and leave them free. The organized situation is seen in significant decision-making or the design of the constructed system (Owusu-Ansah, 2012). Except for monuments and other historical buildings that are not allowed to be demolished, empty, valueless service buildings in a vacant land that no one will demolish (Yau and Chan, 2008). Obsolescence, however, is not a required prerequisite for demolition, and alleged obsolescence does not always constitute a necessary real cause for demolition (Franz, 2020). While obsolescence is a precondition justifying demolition, other options, such as restoration, reuse, and transformation, exist to prolong the building's service life (Butt *et al.*,2016).

The challenge of inclusive growth in the modern era will be overcome or lost in urban areas where policymakers believe that improving existing infrastructure will bring stability to the built environment Moniz *et al.*,(2019), sustainable financial improvements at concurrent

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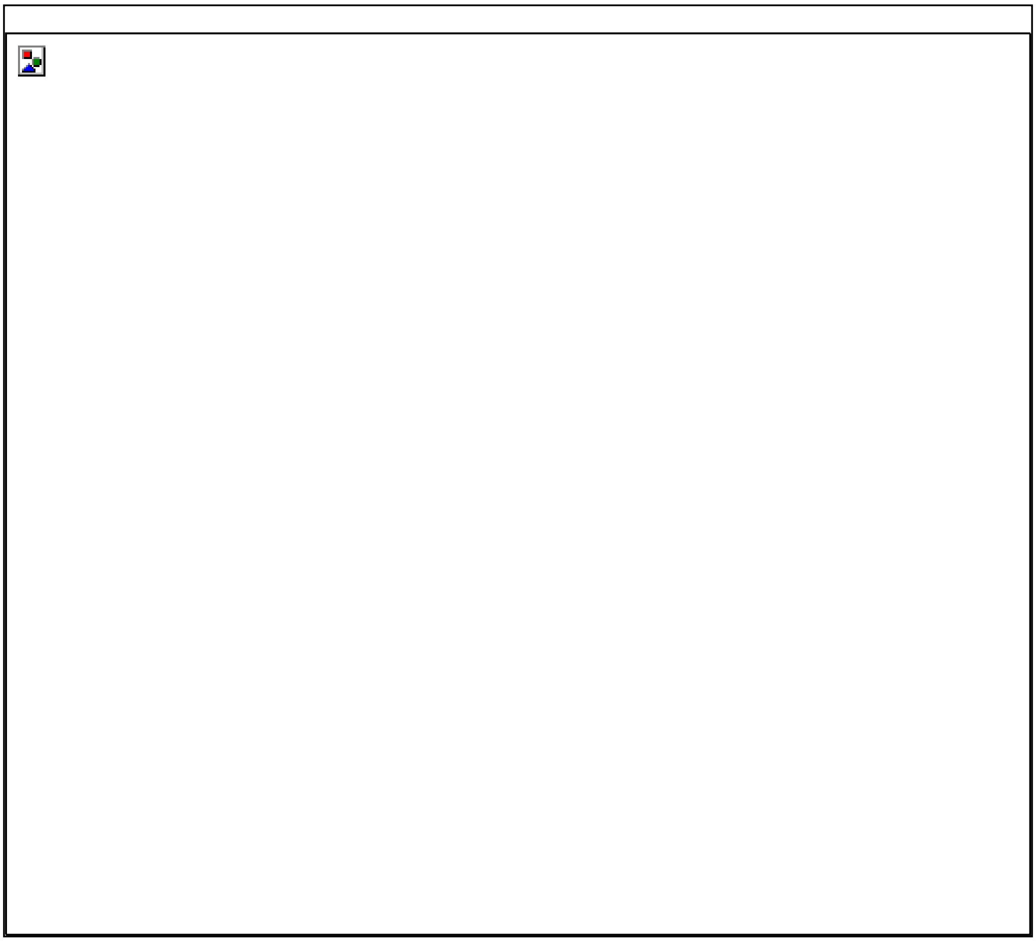
costs will rehabilitate the building's life, improve performance and make it easier to use the building (Ndlebe, 2017). Below is a figure for sustainable city development:



Source: Sarker *et al.*, (2019)

Figure 2: Sustainable city development framework

7. The pattern of urban growth

Urban growth also means that local consumer growth patterns and direction dictate demand (Abrey, 2015). In any sector, a community's growth trend dictates the business path in that environment (Mkhwe, 2019). Therefore, applying various land use theories in a specific area helps determine the demand for property production (Butt *et al.*,2011). Urban or city

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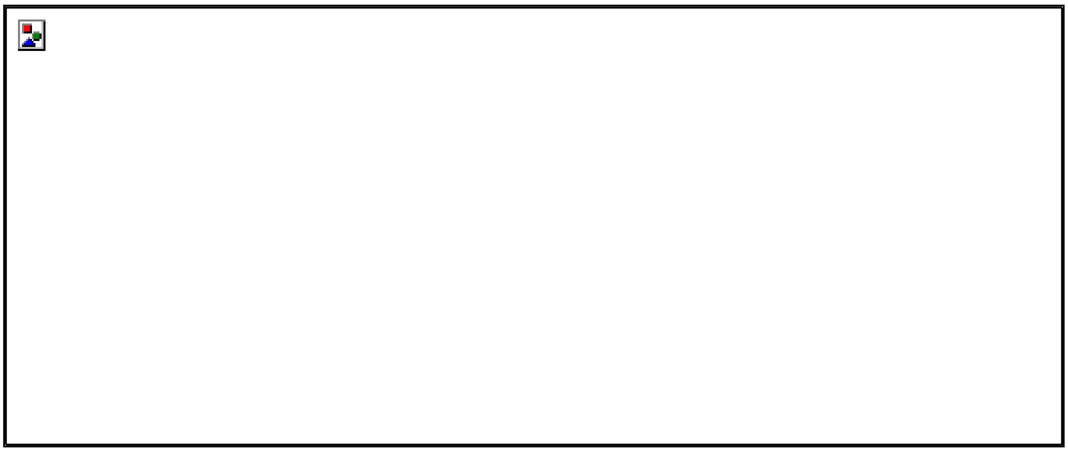
planners work with governments, civic associations, and the community to anticipate future growth and land use (Butt *et al.*,2010).

Traditionally, there are four hypotheses of land-use planning patterns that are of use, and all are examples of theories (Mkhwe, 2019):

- Hoyt's multiple core theory
- Babcock's axial theory
- Hoyt's sector theory
- Burgess' concentric circle theory

Quite evidently, the application of the theories as mentioned above in an area could assist in the establishment of a market demand trend (Mkhwe, 2019). Below is a figure showing the pattern of urban growth:



Source: Mkhwe, 2019:75

Figure 3: The pattern of urban growth

8. Conclusions and Recommendations

From the literature, we can conclude that obsolescence is the negative key factor of property depreciation and has a significant and immediate impact on property investment value in the real estate sector. Although there is no precise definition of the term obsolescence given its wide-ranging scope, this study has distinguished the various forms of obsolescence that affect the economic sustainability of the real estate sector. Moreover, the literature reviewed for this paper indicates that obsolescence is a discrete and complex term containing an

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overlapping set of relationships. Thus such relationships may vary from building to building, depending on the usage and time. Therefore, property managers should manage the relationship with project stakeholders from the planning stages of the building until the end. This is because all property projects have people expecting their delivery. The feasibility studies should be communicated should there be a need for project discontinuity due to non-compliance with legal requirements and environmental standards.

Thus, before constructing any building/property, its use should be well researched and clearly defined. The municipal or government regulation should be explored and highlighted. For example, when municipal zoning does not allow improvement or alterations of buildings because they are heritage sites, such regulations should be revisited as the community's growth trend dictates the business path. We, therefore, recommend that property stakeholders should be included in policymaking.

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DII-2021-015

Measuring Procurement Performance Using Sigma Level Metric

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Abstract

This research highlights the possibility of measuring the performance of procurement processes by applying sigma level metrics. This advocates a new way of procurement performance measurement by applying quality principles to foster sustainable forecasting of procurement performance. A literature review on performance measurement, Six Sigma in service operations, and performance measurement of procurement processes was conducted. This led to the development of a theoretical proposition on sigma level computation and procurement performance. A multiple case study of three public entities in Ghana was used to test the theoretical proposition. Procurement process performance can be measured by applying sigma level computation. This provides an alternative way of measuring procurement performance and harmonises all performance indicators into a single metric to promote consistency, accuracy, clarity and enhance uniformity in understanding irrespective of one's professional background. The study remains confined to procurement processes in line with ISO 10845-1 standard. The performance level derived from the Sigma level computation is limited to 2013 to 2015. An alternative way of measuring the performance of public sector procurement processes is proposed. The findings are not limited to Ghana but are generalizable to entities that follow the procurement processes outlined in ISO 10845-1.

Keywords: Competitive tendering process, Performance measurement, Procurement process, Sigma Level.

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1. Introduction

Public Procurement accounts for a large percentage of spending in the world's economy. According to the European Commission (2017), the EU spends over EUR 1.9 trillion on public procurement each year, representing about 14% of its GDP. Public procurement as a percentage of GDP between 2017 and 2018 ranged between 12%-38%, 3%-10%, 13%-56%, and 19–24% in the Netherlands, Italy, the United Kingdom and the United States, respectively (Hafsa *et al.*, 2021). Public procurement can account for a minimum of 50% of total government expenditure in developing economies (Knack *et al.*, 2017). For instance, in Ghana, Ameyaw *et al.* (2012) report that approximately 50-70% of the nation's budget (after personal emoluments) is spent on procurement. Thus, it is clear that public procurement quality level can have significant effects on economic growth. Hence, the need for procurement excellence to enhance delivering efficient operations, especially in the public sector. However, establishing excellence requires accurate procurement processes to determine whether public entities adhere to best practices.

Procurement processes have been measured in diverse ways, mostly integrating financial and non-financial measures or qualitative and quantitative measures. This is because the criteria for measuring procurement performance for every entity is unique as it is usually aligned with the mission and vision of the entity. This has led to several approaches to measuring procurement processes' performance, including Contract Management Maturity Model (Rendon, 2008); Capability Maturity Model; and Balanced Score Card (Rotchanakitumnuai, 2013), with the latter being notoriously used. In recent times, the trend has been for researchers to propose newer approaches to measure procurement process performance, all in the quest to enhance the accuracy and clarity of the measure. Examples are, Consolidated Framework for Government E-Procurement (e-GP) (Chomchaiya and Esichaikul, 2016); the use of six indicators to categorise processes as above average, average and below-average (Flynn, 2018); and Data Visualization Tool to Benchmark procurement processes (Agrahari and Srivastava, 2019).

All these approaches have been useful in providing a holistic perspective of performance measurement. However, a common weakness with these approaches to procurement measurement has been the inconsistencies in the measurement metric (Little, 2009), leading to varied understanding and interpretation of performance levels by stakeholders with different professional backgrounds. This view is supported by Chomchaiya and Esichaikul

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(2016) as they conclude that various stakeholders attached a different degree of importance to various measures used to ascertain procurement performance. For instance, they found that finance officers viewed financial measures as most important, whereas service support staff viewed contract management as most important. These varied view leads to inconsistencies in understanding, measuring and ascertaining performance level of the procurement process.

Therefore, there is the need to identify a metric that can harmonise all performance indicators to promote consistency, accuracy, clarity, and enhance uniformity in understanding irrespective of one's professional background. The sigma level metric can convert all qualitative data into quantitative data and apply statistical principles to establish the performance level of any process. Adopting statistical principles allows all stakeholders to understand and interpret the performance level more consistently and uniformly. Hence, the sigma level metric can improve the measurement consistency and uniformity to enhance accuracy and clarity of establishing the performance level of procurement processes.

In this paper, the use of sigma level metric to measure the performance level of procurement processes is explored. A theoretical tone is set for the study by discussing sigma level metric and performance measurement. Then the need to identify all performance indicators and their measurement criteria to provide a basis for ascertaining the performance level of procurement processes is established. Next, the possibility to apply sigma level computation is discussed, after which a theoretical proposition is developed. Further, to authenticate the theoretical proposition, a multiple case study of three Ghanaian public entities is used to measure the performance of their construction procurement process.

2. The Concept of Six Sigma

The Six Sigma concept can trace its roots to the standard normal distribution curve (Setijono, 2010). The curve denotes the total population with infinite series of segments in both directions. Each segment is a deviation from the mean and is called the Sigma (σ) in statistics. Hence, as the curve contracts, the cumulative population is around the mean and within the specification limits representing excellent performance.

The sigma symbol (σ) represents a standard deviation in statistics and measures the defects in a product or process. The quantity of variation within normally distributed data and the limits of the mean or average. The Six Sigma level means that, for a particular process or

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product with a million opportunities, there is a defect rate of 3.4, whiles 99.999% of the process or product are defect-free (yield). Another way of saying this is 3.4 defects in a million opportunities. However, it is necessary to note that the 3.4 DPMO leading to the Six Sigma level is based on 1.5 shift of process average (Antony, 2006; Bothe, 2007; Setijono, 2010). This provides a robust advantage in improving quality in processes because it allows for designs that are comparatively resistant to natural or inevitable sources of variation (Bothe, 2007). Table I illustrates the defect rate per million opportunities in different sigma levels.

Table I: Relationship between Sigma Level and Defects Per Million Opportunities (DPMO)

Sigma (σ) Level	DPMO
1	690,000
2	308,000
3	66,800
4	6,210
5	320
6	3.4

Source: Extracted from Tehrani (2010)

2.1 Sigma Level Metric and Performance Measurement

Establishing success is contingent on the ability to measure the performance level (Collins, 2015) accurately. This requires the establishment of a benchmark as a basis for comparison. However, there is a multi-dimensional concept relating to the performance of a process. According to Lamine (2019), some define performance as the art of doing the 'right things right, where others view it as ensuring the achievement of set goals by using resources effectively and efficiently. This denotes outputs observed differently depending on the objective of a process and the expectation of the one measuring. Thus, to enhance measurement consistency and clarity, there is a need to apply a metric that will streamline measures, whether qualitative or quantitative, financial or non-financial and in a way that will enhance understanding irrespective of the background of those who will use the information.

To understand the capability of a process, the sigma level metric provides a high-level baseline. This baseline is calculated by using the metric DPMO. Measuring the

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performance of the procurement process must be based on all the required performance indicators of the process. The reason is to establish the performance of the process instead of limiting it to a specific performance indicator. This requires the identification of the key performance indicators of the process and the application of a metric that can combine all the performance indicators in a single computation. The sigma level metric becomes handy. However, there is a need to establish the performance indicators of the process to apply the sigma level metric.

Public Procurement Performance Indicators

Raymond (2008) identifies the core principle of procurement according to the 2005 Commonwealth Procurement Guidelines as value for money. The underpinning principles supporting this are accountability, transparency, competition; efficiency and effectiveness; ethics; and industry development. Others identified seven (7) procurement principles as integrity, openness, transparency, economy, competition, fairness, and accountability (Lynch, 2013). Dough *et al.* (2014) identified a total of thirteen (13) measurable indicators. These 13 indicators are categorised under established procurement requirements: fairness and equity, competitiveness, transparency, time effectiveness, cost-effectiveness, compliance, and ethics. The indicators identified by Dough *et al.* (2014) are, however, more specific than those identified by Raymond (2008) and Lynch (2013) as the economy can be further broken down into cost and time effectiveness. Chomchaiya and Esichaikul (2016) concluded on 21 significantly distinct performance metrics identified from stakeholders' perspective to measure procurement performance. Agrahari and Srivastava (2019) adopted 14 performance indicators to measure the performance of the procurement process. Kumar and Ganguly (2020) established that the important indicators of the impact of e-procurement adoption on production cost are efficiency, effectiveness, transparency, and coordination.

The above shows that the performance criteria and measurement metrics for procurement processes are not the same. This is why D'Haene *et al.* (2015) concluded that there is no single approach to measuring the performance of procurement processes. This assertion is evident in Ghana as the country's regulatory authority for public procurement. It's 2012/2013 annual report defined a set of indicators similar to those discussed in the preceding paragraph. These are tender advertisement, award publication, tender invitation and opening time, participation in the tender, tender responsiveness; procurement method; tender processing cycle time; cancelled tender procedures; protests, contract disputes resolution; and contract completion. The performance indicators outlined by the regulatory authority relates to specific procurement process activity.

This study adopts the performance indicators used by the PPA in Ghana to measure the performance of public procurement. This is because these performance indicators, when adopted by entities, will enable them to meet the criteria outlined in ISO 10845-1 (ISO,

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2010). The ISO 10845-1(2010) advocates using procedure, processes, and methods to ensure that entities have cost-effective, competitive, transparent, equitable, and fair procurement. Thus, the performance indicators that formed the basis for ascertaining the performance of procurement processes in this study are Timeliness, Cost Effectiveness, Equity and Fairness; Competitiveness; Transparency; Compliance Rate; and Ethics. Having identified the (CTP) performance indicators, it is necessary to define the indicators' metrics.

Following the criteria of the regulatory authority in Ghana whose guidelines meet the requirement enshrined in ISO 10845-1(ISO, 2010), the measurement criteria to measure each indicator are shown in Table II.

Table II: Metrics for Performance Indicators

Performance Indicator	**Measurement Criteria**
1. Process Timeliness	Adherence to planned process timelines (MC1).
2. Process cost effectiveness	Adherence to budgeted process cycle cost (MC2)
3. Process Equity	Equal time for tender preparation (MC3).
4. Process Fairness	Application of margin of preference (MC4)
5. Process Competitiveness	i. Degree of competition (at least 3 bidders per project) (MC5).
6. Process Transparency	In process defects: i. Advertisement duration (not less than 14 days)(MC6) ii. Frequency of publicity (at least once in the dailies and PPA website) (MC7) iii. Publicity Extent (at least 2 dailies and PPA website (MC8)
7. Process Compliance rate	In process defects: i. Approval compliance rate (by the relevant authority (MC9) ii. Documentation compliance rate following guidelines in the Act 663 and Act 914 (MC10) iii.Qualification capacity of bidder (MC11)
8. Process Ethics	In process defects: Number of complaints recorded (MC12)

Performance of Public Procurement in Ghana

This section presents the performance of Ghana's public procurement processes based on an assessment carried out by the PPA. To promote competitive local procurement procedures and increase the confidence in the same, PPA has sort to ensure transparency and fairness in public procurement. Following Section 3 (d) of the Public Procurement Act, 2003(Act 663) as amended, the PPA is mandated to *"monitor and supervise public procurement and ensure compliance with statutory requirements"*.

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To fulfil this mandate, an annual assessment of procurement processes and procedures by public entities is undertaken by PPA. In 2014, the PPA assessed all Ghanaian public entities. They adopted a "balanced scorecard" based on performance indicators for the assessment, after which they ranked the various entities into some pre-determined maturity levels. Therefore, it can be said that the PPA employed a combination of a balanced scorecard and Capability Maturity Model (CMM) to measure the performance of public procurement. The assessment was based on 22 Key Performance Criteria (KPC) with 50 sub-criteria. Appendix 1 presents the details of KPC and sub-criteria. Having assessed the entities based on the criteria in Appendix 1, the entities were then ranked based on a maturity criterion. This exercise led to publishing the 2014 maturity table, the only published document depicting the maturity levels in the procurement of all Ghanaian public entities totalling 546. The results of this assessment exercise served as a performance measure.

The assessment was based on the following criteria:

- The existence of procurement structure (Entity tender committee and procurement unit).
- The existence of procurement staffing (qualified or trained)
- Procurement planning (prepared plans posted at the PPA's website).
- Detailed key performance criteria (50 sub-criteria) are expected to ensure staff and structures' proper functioning. This sub-criteria can be classified under all the eight (8) identified indicators identified in Table II.

Table III shows a summary of the criteria that formed the basis of assessment and results.

Table III: 2014 Assessment Exercise Result Summary

Stage and its Characteristics	**Performance Criteria**	**Number of Entities**
Stage 1:Non-Conforming Entities	The entity does not have the prescribed structures and procurement unit. Procurement staff not qualified or trained. Procurement plans not prepared. Did not meet 26-49 out of the 50 key performance criteria expected to ensure staff and structures properly.	42
Stage 2: Conforming Entities	The entity has the prescribed structures and procurement unit, but the procurement unit is not effective. Procurement staff are not procurement professionals but have some procurement training. Procurement plans not prepared. Did not meet 16-25 out of the 50 key performance criteria expected to ensure the proper functioning of staff and	102

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	structures.	
Stage 3: Maturing Entities	The entity has a well-functioning prescribed structure and procurement unit with at least one qualified procurement professional as staff. Procurement plans prepared but not on PPA's website. Did not meet 11-15 out of the 50 key performance criteria expected to ensure staff and structures properly.	169
Stage 4: Matured Entities	The entity has well-functioning prescribed structures, and a procurement unit with all staff qualified procurement professionals. Procurement plans are prepared and posted on PPA's. Did not meet 1-10 out of the 50 key performance criteria expected to ensure staff and structures properly.	195
Stage 5: Excellent Entities	The entity has well-functioning prescribed structures, and a procurement unit with all staff qualified procurement professionals. Procurement plans are prepared and posted on PPA's. Met all the 50 key performance criteria expected to ensure staff and structures' proper functioning.	38

Source: Extracted from 2014 Maturity Table (PPA, 2014)

4.1 Selection of Case Study Entities

Out of the thirty-eight (38), excellent ranked public entities contacted to be part of this study, three (3) gave their consent, hence selecting three cases. These entities can therefore be considered benchmark entities in Ghana. Thus, the study used these three entities for the multiple case study. Especially considering that they had proper functioning structures making all relevant documents for the study available.

Sigma Level Metric as a Measure for Public Procurement

Contrary to the previous perception about Six Sigma as a strategy for purely manufacturing processes, new thinking has encouraged its application in other service-oriented areas due to the positive results it generates (Nakhai and Neves, 2009). Applications in banking, telecommunication, healthcare, education, agriculture, construction, and procurement are commonplace (Swami and Kadiwal 2020; Sánchez-Rebull *et al.*,2020; Dalalah, 2019; Antony *et al.*, 2018). Therefore, this study explores the possibility of applying the sigma level metric instead of a combination of the balanced scorecard and capability maturity model originally used to assess the performance of public procurement processes in Ghana.

To apply the sigma level metric to the procurement process, there is the need to establish the average opportunities for error of the process. This is because the criteria for establishing the number of opportunities for a process, the 'O' in DPMO, is provided by Simon (2016). They are:

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- The process customer must be directly related to each chance.
- The total number of chances to have a defect per unit.
- The chances must be observable.
- The chances must be independent of the other.
- The chances must be measurable.

Thus, using the metrics for the performance indicators, the number of chances that a process can fail can be computed. A total of eight independent performance indicators of the public procurement process that meet the above criteria were identified. Thus, these eight performance indicators were adopted as the average opportunities for error for the study. This provided the opportunity to measure the overall performance of the procurement process in a single computation.

Public Procurement Process and Sigma Level Computation

To successfully compute the sigma level of the public procurement process, there is the need to identify performance indicators; the number of activities within a specified time frame; and the number of activities that could meet any performance indicators. It is also necessary to identify the process to be measured. However, it has been argued that the tendering process is the most important process to focus on to enhance procurement performance. The tendering process stands out within the procurement process because it carries out the procurement process. Competitive tendering has been noted for its wide usage in public procurement and hence focus on it in this study.

Competitive Tendering

There are several methods for tendering, but the preference for each procedure depends on the urgency, complexity and cost associated with a particular project. Public entities often employ competitive tendering as they are mandated by law due to the cost involved and the transparent nature of that process (Adedokun *et al.*, 2013). The tendering process where an advertisement is placed in the dailies by the client inviting prospective bidders to bid after depositing a non-refundable amount for the tender document in which all necessary information about the proposed project and tendering process can be found is called competitive tendering (Adedokun *et al.*,2013). Carey and Stroud (2013) define the process as a sequence of activities representing the entire process.

The competitive tendering process (CTP) flow adopted for this study spans from tender documents preparation; advertisement; receipt of tenders, the opening of tenders, evaluation of tenders, approval for award and award of contract. It is necessary to note that this CTP follows the process outlined in ISO 10845-1 (ISO, 2010). Following the identification of key performance indicators of the public procurement process, which can also be used for the

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CTP as it is a subprocess under the procurement process, the sigma level of the process can be computed by analysing documentary evidence of the three selected benchmark entities in Ghana. A theoretical proposition is therefore developed to proceed with the research.

Development of Theoretical Proposition

Several researchers (Swami and Kadiwal 2020; Sánchez-Rebull *et al.*, 2020; Dalalah, 2019; Antony *et al.*,2018) have an advanced argument favouring the Six Sigma application to service processes for performance improvement. Since the CTP can be classified under service processes, it is logical to conclude that Six Sigma can improve process performance. A unique characteristic of Six Sigma is its ability to measure performance through the sigma level computation to ascertain real performance by combining financial, non-financial, quantitative, and qualitative measures in a single computation. Hence, it is proposed that: '*The CTP performance level can be determined by applying sigma level computation'.*

3. Methodology

Having selected the three benchmark entities for the case study, the records on the CTP's between 2013 and 2015 kept by the individual entities were studied comprehensively. The reason was that the procurement processes used for the 2014 assessment spanned from 2013 to 2015. The study focused on processes of projects that adopted either national or international competitive tendering methods of procurement. The records from the three entities were reviewed to identify the number of activities and number of process defects. This was done by screening each process to determine their compliance to the required metric of the performance indicators identified. The findings formed the basis of computing the individual sigma levels. This was done by computing the process's defects per million opportunities (DPMO) with the formula (i).

(i) Defects per million opportunities (DPMO)

$$\text{Defects Per Unit (DPU)} = \frac{DDDDDDDDDDDDDD}{AADDDDAAAAAADDAADDDD}$$

$$DDDDDDDDDDDDDD\ PPDDPP\ 00000000PPDD00000000DD00 = (DDPP00)$$

$$DDDDDDDDDDDDDD\ \ PPDDPP\ \ MM00MMMM000000\ \ 00000000PPDD00000000DD00 = (DDPPMM00)$$

$$DDPP00 = \frac{DDPPDD}{AAAADDPPAAAADD\ \ 00000000PPDD00000000DD00DDDD\ \ DD00PP\ \ EEPPPP00PP}$$

$$DDPPMM00 = DDPP00 \times 10^{6}$$

Where it is required to determine the following information from the three entities:

a. **Number of activities** is the total number of CTP's undertaken by each entity between

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2013 and 2015.

b. **Number of defects** is the total number of CTP's that did not meet any of the established performance indicators.

c. **Average opportunities for Error** is the number of performance indicators for the CTP.

4. Results and Analysis

Table IV reveals that all CTP's carried out in the three (3) cases met the requirements of seven (7) out of the eight (8) performance indicators established above. This implies that they met cost-effectiveness, equity, fairness; competitiveness; transparency; compliance; and ethics requirements. However, all three cases failed to meet the timeliness requirement fully.

Table IV: Adherence to Performance Indicators

Performance Indicators	**Measurement Criteria**	**Adherence to Performance Indicator Based on Metric**		
		Case 1	Case 2	Case 3
1. Process Timeliness	MC1	No	No	No
2. Process cost effectiveness	MC2	Yes	Yes	Yes
3.Process Equity	MC3	Yes	Yes	Yes
4. Process Fairness	MC4	Yes	Yes	Yes
5. Process Competitiveness	MC5	Yes	Yes	Yes
6. Process Transparency	MC6	Yes	Yes	Yes
	MC7	Yes	Yes	Yes
	MC8	Yes	Yes	Yes
7. Process Compliance rate	MC9	Yes	Yes	Yes
	MC10	Yes	Yes	Yes
	MC11	Yes	Yes	Yes

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8. Process Ethics	MC12	Yes	Yes	Yes

At this point, the performance level of the CTP for each case was determined by computing the sigma levels. First, the DPMO for the three cases were determined and second, their respective sigma levels.

Defects Per Million Opportunities and Sigma Level of 1, 2, and 3

The DPMO in competitive tendering for the three cases and their respective sigma levels were determined. To compute the DPMO using equation (i), there is the need to identify the number of activities, the number of defective activities, and the average opportunity of error. The sigma level of the three cases was determined using the symmetrical bell-shaped curve of standard normal distribution (Tehrani, 2010). Table V provides this information for all three cases.

Where: Case = The three selected public entities.

Several Activities = the number of CTP's carried out between 2013 and 2015 in each case. Each public entity undertakes competitive tendering for projects yearly, so the total number of processes from 2013-2015 were selected for the three case studies.

The number of Defective Activities = number of CTP's that did not meet the requirements of any of the eight performance indicators identified above.

Average Opportunity of Error = Total number of performance indicators of the CTP identified above, eight from Table IV.

DPMO for Cases 1 and 2:

$$\text{Defects Per Unit (DPU)} = \frac{7}{7} = 1$$

DDDDDDDDDDDDD PPDDPP OOOOOOOOPPDDOOOOOOODDOO = (DDPPOO)

DDDDDDDDDDDDD PPDDPP MMOOMMMMOOOOOO OOOOOOOOPPDDOOOOOOODDOO = (DDPPMMOO)

$$DDPPOO = \frac{1}{8} = 0.125$$

$$DDPPMMOO = 0.125 \times 10^{6} = 125{,}000.$$

DPMO for Case 3:

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$$\text{Defects Per Unit (DPU)} = \frac{4}{7} = 0.571$$

DDDDDDDDDDDDD PPDDPP OOOOOOOOPPDDOOOOOOOODDOO = (DDPPOO)

DDDDDDDDDDDDD PPDDPP MMOOMMMMOOOOOO OOOOOOOOPPDDOOOOOOOODDOO = (DDPPMMOO)

$$DDPPOO = \frac{0.571}{8} = 0.071$$

$$DDPPMMOO = 0.071 \times 10^6 = 71{,}429.$$

Table V: Sigma Levels for Case Studies

Case	Number of Processes (Activities)	Number of Defective Activities	Average Opportunity of Error	DPMO	Sigma Level
1	7	7	8	125,000	2.7
2	8	8	8	125,000	2.7
3	7	4	8	71,429	3

From Table IV, Case 1 and 2 recorded a DPMO of 125,000, whiles Case 3 recorded a DPMO of 71,429. This means that at the current level of performance, in a million CTP's undertaken by Case 1 and 2, 125,000 processes did not meet their planned deadlines. Similarly, in a million CTP's undertaken by Case 3, 71,429 of the processes did not meet their planned deadlines. This information was used to determine the sigma level of the CTP's for the three cases. Thus, the sigma level for Case 1 and 2 is 2.7, and that of Case 3 is 3, as shown in Figures 1 and 2, respectively.

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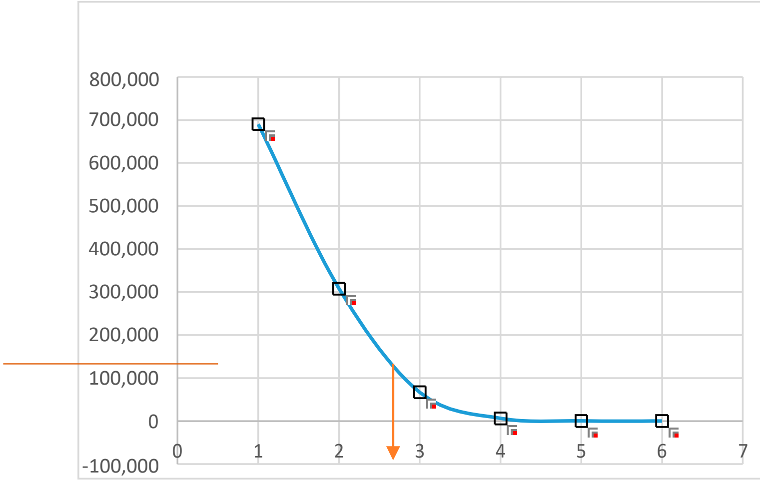

Figure 1. Sigma Level for Case 1 and Case 2

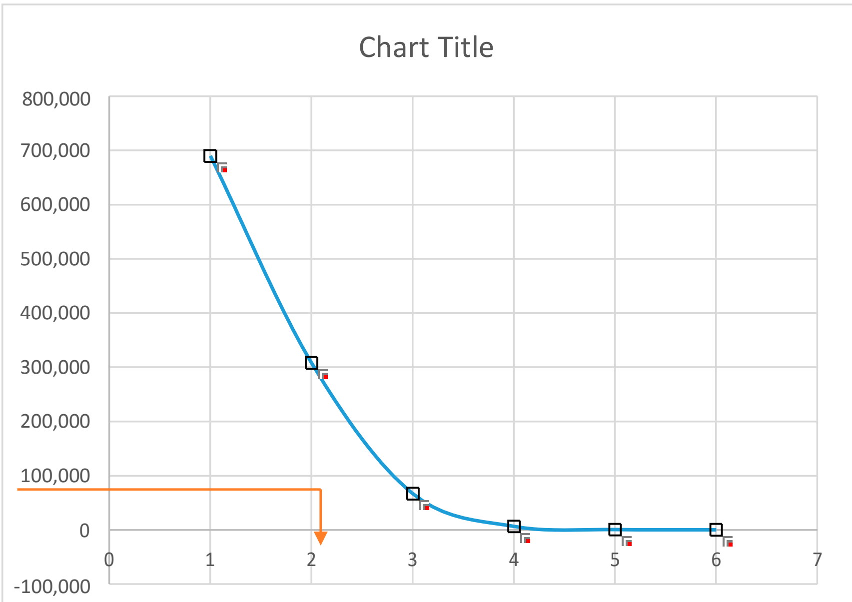

Figure 2: Sigma Level for Case 3

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5. Discussion

Sigma level computation can be applied to the CTP to measure the performance level of the same. This assertion has been authenticated as the sigma level for the CTP of three cases has been determined. The study has shown that the performance level can be measured by including all necessary performance criteria. This simplifies the computation process and also provides ease in understanding the measure. This finding has also confirmed the findings in literature where Six Sigma was identified as a performance improvement strategy applicable to service processes (Swami and Kadiwal 2020; Sánchez-Rebull *et al.*, 2020; Dalalah, 2019; Antony *et al.*, 2018). Further, it authenticates the theoretical proposition*: 'The CTP performance level can be determined by applying sigma level computation'.*

Case 1 and 2 had a sigma level of 2.7 because all their processes failed to meet the timeliness performance indicator even though they had different processes. Case 3, on the other hand, had a sigma level of 3 because not all the processes failed to meet the timeliness performance indicator. The sigma levels varied because they represented the real level of performance based on how well the processes met the performance indicators. Thus, a sigma level scale can replace the qualitative scale originally used in ranking the entities.

From above, it has become clear that all three cases are operating at a maximum sigma level of 3. It is important to note that all three cases used for the study have been ranked excellent in procurement by the regulatory authority. However, these entities perform at a sigma level of less than or equal to 3, a wide deviation from the 6 sigma level target. At this sigma level, it would be considered a flaw for such entities to be ranked excellent and hence cannot be considered a benchmark process. This relates to their real performance because the entities hardly met their planned timelines.

6. Conclusion and Future Research.

In this paper, parameters for successful sigma level computation of the competitive tendering process have been established. The CTP performance level has been measured. Therefore, the paper has shown that sigma level computation as a measure of performance improvement is a better option. It combines all defined performance indicators, including financial, non-financial, quantitative, and qualitative indicators. It harmonises all performance indicators to promote consistency, accuracy, clarity and enhance uniformity in understanding irrespective of one's professional background. It has been revealed that it is possible to establish a benchmark employing sigma level computation when assessing the performance level of

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procurement processes to accurately ascertain the performance level and set realistic objectives for performance improvement.

Since the cases selected based their CTP on the guidelines outlined in ISO 10845-1 (2010), the findings mirror the situation in best-performing entities according to ISO 10845-1 (2010) standards. This conclusion is based on analytical generalisation. The results in individual cases support the literature findings and replication logic as the same methodology was used in all three cases.

Implication for Researchers and Practitioners

Sigma level metrics should be considered when measuring the performance of procurement processes. The study has shown that computing the performance level of the procurement process by applying sigma level computation is possible even though it is basic. This is because it has successfully combined all the performance criteria (financial, non-financial, quantitative, and qualitative) in a single measure. This is an improvement on existing measures as they are cumbersome, making it difficult to understand. It could be a starting point for other research in Six Sigma application to public procurement.

This research proposes an alternative and better way of measuring the level of performance of the procurement process using a scale that will be understood and interpreted equally by professionals from different backgrounds. Additionally, the research concluded that it is worthwhile to apply sigma level computation to the procurement process to encourage efficient performance.

The possibility of establishing a performance benchmark in the procurement process, especially concerning CTP, provides a significant tool in public procurement to measure real performance levels. This will assist in giving a realistic impression on the performance of procurement process and also provide a definite focus for all involved in the process. Hence, the need for the public entities to progress from meeting perceived performance improved levels in their process improvement programs to real computed improved levels by adopting the sigma level metric.

Public procurement has not yet fully embraced implementing Six Sigma programs partly because of the cost implications. Implementing only the sigma level metric can be a forerunner to major Six Sigma projects for public procurement processes for entities lacking the funds to implement the complete Six Sigma projects. This will provide a structured approach to measuring performance improvement and create awareness of Six Sigma

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implementation benefits in public procurement. The more procurement processes apply the sigma level metric, and the more procurement processes will aspire to meet near perfection. Quantity surveyors, project managers, procurement practitioners, and quality management experts will benefit from this study.

Limitation and Future Scope

The study remains confined to the national and international CTP's of public works procurement in best-performing entities according to ISO 10845-1 standard. The performance level derived from the Sigma level computation is limited to 2013 to 2015. Future studies will apply the same concept to the remaining public entities in Ghana and establish a new measure in public procurement.

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Appendix 1: Details of Key Performance Criteria for the 2014 Maturity Table

Key Performance Criteria	**Detailed key performance criteria**
1A Leadership	1A1- Procurement Entity responds to the needed training advice to develop a sustainable training strategy and capacity to manage procurement operations. 1A2 - The procurement entity appreciates the Sustainable Public Procurement (SPP) policy, and management is committed to it. 1A3 - Procurement entity develops sustainability strategy in line with sector priorities with resources allocated to them. 1A4 - Timely information on procurement activities is provided by Internal audit to enable management to improve performance. 1A5 - Management complies with procurement audit reports and suggested improvements. 1A6 - Procurement Entity keeps records for all phases of procurement activities.
1B Human Resources	1B1 - Procurement Entity ensures that staff at the Procurement unit have the required qualification for procurement professionals and competency for the intended job. 1B2 - Procurement Entity ensures a clear career progression for Procurement staff. 1B3 - Procurement Entity implements programmes to enhance and inform private sector participation in public procurement. 1B4 - Entity builds the capacity of staff in Sustainability or SPP issues 1B5 - Procurement Entity has trained Auditors in procurement processes to aid in monitoring compliance. 1B6 - Procurement Entity has a standard performance evaluation procedure for procurement staff that addresses capacity development issues.
1C Monitoring and Control Systems	1C1 - The payment periods set by the Procurement Entity takes cognisance of the payment procedures of any relevant state institution. 1C2 - Procurement Entity ensures that all contracts are recorded in the approved budget in comparison with actual contract sum. 1C3 - Entity ensures effective monitoring of SPP implementation. 1C4 - The procurement Entity has clearly defined methods of administering contracts, including inspection and acceptance processes, procedures, and methods to review and issue contract amendments on time. 1C5 - Procurement Entity uses available media outlets for the dissemination of procurement information.

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1D Ethics and Compliance with Regulatory Framework	1D1 - Procurement Entity complies with the applicable regulations of the Public Procurement Act. 1D2 - Procurement entity uses the Standard Tender Documents and includes SPP criteria. 1D3 - Procurement Entity implements appropriate procurement methods. 1D4 - Procurement Entity seeks approval from the PPA for the use of Restricted Tendering and Single Source procurement methods 1D5 - Procurement Entity Tender Committee performs its function strictly in the procurement process as set out by Act 663 as amended 1D6 - Procurement Entity ensures the required anti-corruption provisions on conflict of interest, corruption, and unethical behaviour are clearly stated in tender documents
1E Complaints Appeals and Dispute Mechanism	1E1 - Procurement Entity handles complaints relating to procurements appropriately 1E2 - Procurement Entity can handle complaints and enforce decisions in an efficient, fair and transparent manner 1E3 - Procurement Entity makes public the decisions on complaints 1E4 – Procedures for dispute resolution exists and provide for a fair and efficient process to resolve disagreements amicably, enforcing related outcomes
2A Information	2A1 - Procurement Entity ensures timely dissemination of procurement information through available systems for information dissemination.
3B Marketplace	2B1 - Procurement Entity frequently interacts with the Private Sector to improve their responsiveness and competitiveness, promoting sustainable products, works and service
2C Data Analysis	2C1 - Procurement Entity has a mechanism to ensure data quality (reliability and validity) 2C2 - Procurement Entity has a system in place to collect data related to procurement performance and regular reports
3A Procurement Planning	3A1 - Procurement Plan is well defined and linked to the budget formulation process based on the accepted framework 3A2 - Total Value of Procurement plan against the total actual value of executed packages in the Procurement plan for the year
3B – Notice	3B1 - Publication of procurement notices are mandatory and publicly advertised on time following the respective procurement methods and thresholds
3C - Preparation of Tender Documents	3C1 - Tender documents contain a clearly defined scope of work, neutral technical specifications and conditions to enable bidders to respond adequately
3D - Invitation to Tender	3D1 – Transparent and fair rules apply for the selection of bidders 3D2 - Procurement entity ensures that sustainable specification criteria are indicated in the tender documents. 3D3 - Appropriate Margins of Preference are applied following the Guidelines on same.
3E - Submission of Tender	3E1 - Consistency in the quality of tenders submitted is ensured by the Procurement Entity.

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3F - Tender Opening	3F1 - Procurement Entity bids are opened at the same time as the deadline for the receipt of bids 3F2 - Opening of bids is conducted publicly following defined procedures specified in the bid documents 3F3 - Bids received are registered, securely stored and kept confidential throughout the bidding process 3F4 - Procurement Entity keeps records of bid opening procedures
3G - Tender Evaluation	3G1 - Procurement Entity applies only the pre-disclosed criteria and clear methodology in Tender documents for evaluation.
3H - Contract Award	3H1 - All bidders are informed on the time of bid results and contract award.
4A- Planning and Mobilisation	4A1 - Procurement Entity makes advance Payments on submission of acceptable guarantees. 4A2 - Existence of contract administration and quality control mechanisms at the entity 4A3 - Contract plan with milestones and outcomes are clearly defined and reviewed
4B – Implementation	4B1 - Effective systems for problem-solving and contract amendment are in place.
4C – Supervision	4C1 - Project outcomes are achieved on time based on the plan 4C2 - Procurement entity ensures key social and environmental impacts are dressed on projects 4C3 - Close project implementation follow-ups are undertaken with suppliers, contractors and consultants 4C4 - Procurement entity ensures that there are effective contract risk management schemes or mechanism 4C5 - Procurement entity ensures a fair and appropriate contract closure at the entity
4D – Inspection	4D1 - Physical verification of goods delivered and inspection of works completed are undertaken according to the contract provisions.
4E - Inventory Control and Disposal	4E1 - Goods/materials are stored and issued in compliance with the stock control policy 4E2 - Procurement entity ensures effective, sustainable stock disposal solutions by suppliers 4E3 - Procurement entity ensures an effective sustainability performance reporting system 4E4 - Disposal of goods and equipment made in compliance with provisions of PPA guidelines
4F – Reporting	4F1 - Effective monitoring and evaluation of projects is in place

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DII-2021-005

The Impact of Project Cost Management on Contractual Disputes in South Africa

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Abstract

Cost management is essential in the construction industry and could cause contractual disputes if not done correctly. This study investigates how project cost management contributes to contractual disputes in the construction project environment. A qualitative approach was used to interview 11 construction professionals. The data received was then analysed using content and narrative analysis methods. It was found that cost management contributes insignificantly to contractual disputes; however, measures such as the engagement of contract manager, good change control system, approval of project scope, compliance with the terms and conditions of the contract, good project management, competent consultants and contractor, effective communication before and during project execution can be put in place to minimise the incidence of disputes. It was also revealed that construction stakeholders prefer the Alternative Dispute Resolution (ADR) method, such as mediation, to resolve cost-related contractual disputes when they occur. Only 11 construction professionals were interviewed; hence the findings may not be generalizable as the opinion of the construction professionals in South Africa. The construction stakeholders should not put all their efforts into the management of project cost in an attempt to prevent the incidents of contractual disputes; instead, they should institute other stringent measures that prevent poor scoping, poor cost estimating, and ineffective project management practices to minimise the incidence of contractual disputes in their projects. The paper gives an insight into measures that the construction stakeholders must take to prevent cost-related contractual disputes aside from effective cost management.

Keywords: Cost control, Cost management, ADR, Disputes

1. Introduction

In the construction industry, disputes are bound to happen if the project cost is not managed well. One of the essential aspects of a construction project is cost management (Bridges,

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2018). Managing project cost sets the foundation for staying within the client's budgetary lines, executing the project, and completing it within the budget (Bridges, 2018). Project cost management is a process of planning and controlling the budget that has been given by the client (Bouvrie, 2017). According to Bouvrie (2017), several activities are included in managing cost (cost planning and controlling costs): planning, estimating, budgeting, financing, funding, controlling, and managing a project. From a Quantity surveyor's perspective, it is crucial to master project cost management; this includes activities and tools to help the Quantity surveyors complete the project within the proposed budget (Averous, 2014). There are three main processes that the Quantity Surveyor must do to ensure proper cost management, and it is as follow: project cost estimating, project cost budgeting, and project cost control (Averous, 2014).

Project cost needs to be managed by the Quantity surveyor to ensure that possible disputes that may arise from improper cost management are kept at a minimum. Disputes can occur at any time within a project if one of the parties is unwilling to cooperate with what was contractually agreed on. Disputes can be solved by using alternative dispute resolutions, which will help both parties solve any disputes that will possibly arise between the parties (Staff, 2019). The different alternative dispute resolutions that can solve disputes between parties are mediation, adjudication, and arbitration. It would make more sense to use mediation and conciliation to resolve disputes (Eskridge, 2018). According to Eskridge (2018), one of the most economical ways of resolving a dispute between parties is mediation. Disputes can arise when costs are not managed correctly or if the project's cost exceeds the budget that was proposed initially.

The construction industry is one of the biggest industries in South Africa; although the South African construction industry is in recession, the growth rate of the construction industry is still 2,4% (Njobeni, 2019). The South African Construction Industry is massive. Many funds are needed to ensure that all the construction projects underway have the necessary funds to complete the project. Thus, project cost management is critical in the construction industry to ensure that the project is completed within the client's budget. Project cost can cause disputes between parties if it is not managed correctly. Disputes can have a costly delay on a construction project, and these disputes that may arise can be minimised by proper cost management (Staff, 2019). Through planning, estimating, budgeting, and controlling costs, the project will be completed within the budget given by the client, which means that minimal disputes will arise from a cost perspective (PMBOK, 2017). Disputes are created if the parties do not fulfil their part of the contract and can be minimised through proper management.

1.1 Objectives

The objectives of this study are;

1. To appraise the extent of contractual disputes are caused by cost management in projects.
2. To find out how cost-related contractual disputes can be handled when they occur in a project.

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3. To determine measures that can be taken to minimise cost-related contractual disputes.

2. Literature review

2.1. Project cost management

In the construction industry, the management of cost in a project is crucial. The feasibility of a project is depended on the cost and the financial viability of the project. Thus, for this reason, a project will not be completed if the final payments are not yet done and the financial books of the project have not yet been audited (Steyn *et al.*, 2017). The managing of costs in a project starts at the beginning of the project (initiation face), where the financial viability studies are done to determine what costs are required in the project and what process need to be followed to ensure the correct procedure of cost controlling is applied (Steyn *et al.*, 2017). Project cost management can be defined as estimating, planning, budgeting, financing, controlling, and managing costs in a project to ensure that the project can reach completion within the client's proposed budget (Bouvrie, 2017). Throughout the project's life cycle, project cost management ensures that the forecasted costing follows the project budget and completion.

According to the PMBOK guide (2017), three main processes ensure that project cost management is done correctly by looking at each process's inputs and outputs and their techniques and tools used in that process. The three main strategies used in project cost management are cost estimating, cost budgeting, and cost control, as indicated in Figure 1.

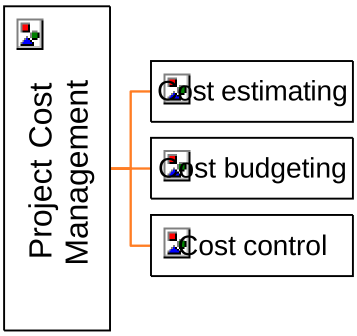

Plate 1: Overview of Project Cost Management
Source: PMBOK guide (2017: 64)

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In combining these processes, project costs can be managed well and keep the project within its needs. Project cost management is concerned about what the project will cost to construct and considers the costs of decisions based on the project's costs and operational expenditures like maintenance, taxes, and water and electricity (PMBOK, 2017). Cost management planning starts early in the project, setting the framework for the cost management processes to be efficiently coordinated (PMBOK, 2017).

2.2 Cost estimating

As defined above, project cost estimating is where the Quantity Surveyor predicts what the project will cost, the quantities, and the pricing of resources required by the project's scope (Cost Engineering, 2018). We need to do cost estimating on projects to know if they will make the right decision on their investments, do budgeting, compare different investment options against each other, and do proper cost control. The process of cost estimating should consider all the variations in a project and the possible expenses (Steyn *et al.*, 2017). Several costing alternatives need to be identified in the process of cost estimating (PMBOK, 2017). Like any other process, the cost estimating process requires inputs that transform into outputs using tools and techniques; this will help the project get a more accurate estimation of the cost, which will benefit the project in the future. The tools and techniques that are usually used in the industry are the methods of "top-down" and "bottom-up" (Steyn *et al.*, 2017). The analogous estimating method (top-down method) uses historical cost data of a project similar to the current project as a basis for the new project. This method is valuable if the information regarding the projects is unclear or limited. The estimator should consider that historical cost is being used; thus, an escalation of prices should bring the final cost up to date with current market conditions. An experienced estimator is required for this estimation method to ensure that a trusted result is obtained (Steyn *et al.*, 2017).

The bottom-up method of estimating is the most accurate and the most time-consuming cost estimating approach. It includes the whole project team participating in the estimating process (Billows, 2017). This method is used in the Work Breakdown Structure (WBS) to estimate the cost of all the activities separately within the WBS. The parametric modelling (bottom-up) estimating method uses standard cost parameters known for specific activities. Steyn *et al.* (2017) state that the bottom-up method is a compelling method to use in the first/initial estimate and the last estimation to determine how accurate this method is (Steyn *et al.*,2017). The parametric modelling can only be reliable if the information of the parameters is up to date. The information gathered must be applicable, and the effort level for the parameters should be low to measure and quantify. Cost estimating software can also be used for costing; using this tool can benefit the estimator in accurate and reliable cost

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estimating with appropriate spreadsheets. The estimator can also use the computer software to store historical cost estimations, which can be used in future projects, which only need additional escalation rates (PMBOK, 2017).

2.3 Cost budgeting

As defined by the Project Management Body of Knowledge PMBOK (2017), cost budgeting forms the cost baseline for the project, in which the performance is measured. The cost budgeting process uses the WBS to show each activity's cost; this can be grouped to get the project's total cost (Steyn *et al.*,2017). Before a cost budget can commence, the cost estimation needs to be completed for cost budgeting.

2.4 Cost control

This term can be defined as managing the financing aspects of a project and controlling the cost changes to ensure that the project can reach the completion date within the required budget given by the client (Steyn *et al.*, 2017). According to PMBOK guides (2017), cost controlling will include: the factors that are responsible for the creation of changes within the cost baseline, that all the parties are in agreement with all the changes that are requested, the occurrence of changes that need to be managed, to inform the required stakeholders of the changes that are approved, understanding the variances from the baseline of cost by monitoring the cost performance (PMBOK, 2017). Cost control forms part of integrated change control by understanding that if there is a negative cost variance, it can influence the quality of the project.

The techniques and tools used in controlling the project's cost are using a control system that documents the cost changes in the project. This system defines the procedures to change the cost baseline (PMBOK, 2017). One of the most common techniques or tools for cost control used in the industry is analysing performance measurements. This tool helps assess the project manager with the magnitude of all the variances in a project. According to PMBOK (2017), the earned value techniques are compared to the cumulative value of the work performed at the initial budget, the cost of work, and the actual cost of the work performed on-site. There are different types of measuring the performance of cost; these types are as follow:

- Estimate to completion and the estimate at completion
- Cost and schedule variances
- Cost performance index
- Schedule performance index

Suppose an estimator and project manager have the required experience and knowledge. They can use forecasting, which will include predictions of estimating and the conditions that may occur in the project's future (PMBOK, 2017).

2.5. Disputes in construction projects

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Disagreements among parties in a construction project are not uncommon due to the various stakeholders' irreconcilable needs and expectations (Barough *et al.*,2012; Trangkanont, 2017). Disagreements make disputes inevitable. The dispute significantly affects organisations and construction projects, bringing about disaffections and unfriendly relationships and organisation (Jannadia *et al*., 2000). The project level disputes are believed to cause poor project outcomes, delay project completion times, increase project costs, and inconvenience the beneficiary communities and the public (Anderson and Polkinghorn, 2002; Chaphalkar and Sandbhor, 2015). According to Maru (2019), the origin of construction disputes is complex and often originates from improper allocation of project risks and ends up causing disputes among the parties (see Figure 2). Maru believes that if the project risk is not assigned clearly among the parties, it will generate conflicts. If the conflict is not adequately addressed by the parties, one or both parties may claim compensation. If the claim is not resolved adequately, it will bring about disputes among the parties.

Figure 2: Origin of construction disputes Source: (Maru, 2019)

Chaphalkar and Sandbhor (2015) opine that many factors influence the occurrence of disputes. Several researchers have attributed the causes of disputes in construction projects which is summarised in Figure 3.

Cheng *et al* (2009)	Trangkanont (2017)	Chaphalkar and Patil (2012)	Maru (2019)
• **Owners causes** (eg. unclear tender documents, inspection delays, etc) • **General contractor causes** (eg. collusive tender, delayed contract time) • **Caused by both parties** (eg. default contract, payment disputes) • **Act of God causes** (eg. severe weather, unknown site conditions, etc)	• **Contract related** causes (eg. Risk allocation, Ambiguities in contract documents) • **Owner related causes** (eg. scope changes, variations) • **Contractor related** (eg. Delays in work progress, time extensions) • **Design related** (eg. Design error, Quality of design) • **Human behaviour related causes** (eg. Lack of communication) • **Project related causes** (eg. site conditions) • **External factors** (eg. weather, legal)	• Change in design, drawings, and specifications • Change in quantity of items during execution • Change in scope of work • Unforeseen circumstances (eg. reworks, poor workmanship, etc)	• **Employer related causes** (Owner interference, slow decision making) • **Contractor related causes** (Site management, Financial difficulties, Construction methods, etc) • **Consultants related causes** (eg. poor contract management, variations due to design errors, etc)

Figure 3: Causes of construction disputes Sources: (Maru, 2019; Trangkanont, 2017)

From figure 3, it is clear that the root causes of construction disputes are multi-faceted, from owner-related causes to act of God cases. Cheng *et al.* (2009) suggest that contractual disputes among parties can be caused by owners actions (such as unclear tender documents,

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inspection delays); general contractor's actions (such as collusive tender, delayed contract time); actions of both parties (such as default contract, payment disputes); and the act of God (such as severe weather and unknown site conditions). Manu (2019), however, categorises the causes of disputes among parties into three main areas; namely, employer-related causes (owner interference, slow decision making); contractor-related causes (Site management, financial difficulties, construction methods, etc.); and consultants-related causes (poor contract management, variations due to design errors, etc.). Irrespective of the cause of the disputes, du Preez (2014) suggests that disputes can be settled among the parties through different means provided the required information is available.

2.6. Dispute resolution methods

Researchers have proposed various methods that can be used to prevent and resolve construction disputes among parties (Zaneldin, 2006). In most cases, they aim at a dispute resolution method of speed, confidentiality, continuity, effectiveness, equitability, practicability, and control (Ng *et al.*, 2007; Cheng *et al.*, 2009; du Preez, 2014). Ng *et al.* (2007) propose dispute resolution processes comprising negotiation, standing neutral non-binding resolution, and binding resolution and litigation. However, Manu (2019) states the most used dispute resolution procedures as prevention; Alternative Dispute Resolution (ADR) (negotiation; adjudication; arbitration; mediation; and expert determination), and litigation. Thus, Kassab *et al.* (2006) suggest that an ADR is the famous dispute resolution method for resolving construction disputes due to the cost and time involved in the litigation process.

According to Kora (2017), parties use ADR to avoid going to court if a dispute occurs between these parties. The definition of the process of ADR is to give the parties a chance to control the outcome of the dispute and take responsibility for the outcome (Bevan, 1992). The idea of ADR is to resolve a dispute privately and to prevent unnecessary costs when going to court. ADR methods make use of the significant features that are being used in the construction industry. These features are known as the four C's: Consensus, Confidentiality, Continuity, and Control. ADR is the best option because it is more cost-effective than going to court and preventing an unpleasant atmosphere (Kora, 2017). A third party is provided by the ADR methods to assist the parties in dispute to reach a mutual agreement by suggesting a possible solution or positive outcome for both parties (Du Preez, 2012). The construction industry in South Africa makes us of the following common ADR methods: Mediation, Conciliation, Adjudication, Arbitration, and Negotiation.

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2.6. Methodology

The term methodology can be defined as the action that takes place when a research problem is investigated, and the investigation on how rationale the application is for the specific techniques/ procedures, process and analysed information is applied to understand the problem that is identified within the study (Kallet, 2019). The approach adopted for this research is the deductive approach because assumptions are made stating that the contractual disputes between the parties (client and the contractor) will be less if proper cost management is done. According to Bryman and Bell (2015), this type of approach is relevant to the hypotheses, meaning an inductive approach which is the study contributes to a new emergence of theories. In contrast, the deductive approach tests if the assumptions made are valid. Thus the deductive approach is a more realistic approach to be used to gather information for this study. A face-to-face interview was done with the selected respondents with the aid of an interview guide. The respondents were allowed to express their opinions on the subject under consideration freely. The respondents were construction stakeholders such as contractors, Quantity Surveyors, Project Managers, and Lawyers. Selective and random sampling methods were used to select the respondents; thus, respondents were contacted for the interview based on their knowledge of project cost management and dispute and their availability. The selective sampling method is used when a specific group is interviewed, based on some of the characteristics that they have in common (Bryman and Bell, 2015). According to Stat-trek (2019), one of the key benefits of these sampling methods is that they can guarantee that the sample will represent the population. Twenty (20) individuals were earmarked for an interview, of which 11 of them responded, giving a response rate of 55%. Data gathered was analysed using the content and narrative analysis method. The narrative analysis method focuses on the experience shared by the persons interviewed, whilst the content analysis method was used to analyse the information in texts or physical items (Socialcops, 2018). Thus, the analysis method adopted for this study is appropriate as the gathered data are narrated and texts.

3. Findings and discussions

3.1. Characteristics of the interviewees

From Table I, it is evident that most of the interviewees are Quantity Surveyors (46%), and the majority (55%) have between 5 to 10 years of experience in construction. The majority (73%) of the respondents are from construction firms.

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Table I: Characteristics of the interviewees

Features	No of interviewees	Percentages	Interviewees code
Profession			
Quantity Surveyor	5	46%	QS1-5
Project Manager	2	18%	PM1 & 2
Contractor	3	27%	Cont1 - 3
Lawyer	1	9%	Law1
Experience			
1 – 5 years	1	9%	
5 – 10 years	2	18%	
10 – 15 years	6	55%	
over 15 years	2	18%	
Organisation			
Construction firm	8	73%	
Quantity surveying firm	2	18%	
Law firm	1	9%	

3.2. The effect of project cost management on contractual disputes

The interviewees were asked to express their opinion on the extent to which cost management contributes to a contractual dispute. The opinions of the respondents are summarized in Table II. Most of the interviewees believe that cost management plays little role in contractual disputes.

Table II: Effect of cost management on contractual disputes

Interviewees	Interviewees responses
Q1–3, PM 2, Cont2	*No effect*
Q4, PM 2, Cont1&3	*Little effect*
Q5, Law1	*Significant effect*

QS2 & PM2 explained that the project budget is set, and as such, the project team controls the project cost to ensure the cost does not exceed the approved budget. Even if the cost exceeds the budget, there is documentation and an approval process for the additional fund, which will not generate any dispute between the client, contractor, and the consultants.

As QS2 states;
We have VOs (variation orders) forms we always have to fill and submit to the client. In cases where additional funds are required, the client has to approve before the contractor is instructed to execute the works for which the additional fund is required, so I do not see how this will cause disputes among the project team and the sponsor.

Also, *Cont1 and Cont3* opined that in most cases, they required approval from the Project manager before they executed any work that was not budgeted for in the Bill of Quantity document. Therefore dispute can only arise where the contractor executes unbudgeted works without seeking approval from the authority concerned. Even in these situations, disputes do

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not escalate to a higher level as there is evidence of work done. However, according to *QS5*, the cost estimating process is the most crucial process. The management team uses the estimations to calculate all costs correctly, avoiding disputes due to under or overpayments for certain trades. He believes that if the cost estimation is not done correctly from the onset, it may generate disputes between the client and the Quantity Surveyor (QS) because the client may blame the QS for not being professional. The client may then argue for the person responsible for paying any additional cost due to the QS mistakes.

QS5 states;
In most cases, the cost management process will have significant effects on contractual disputes due to the negligence of the QS by failing to do a correct estimate for the project scope before approval and tender because no client is prepared to pay for omitted works as a result of the consultant's mistakes.

Law1 also believes the way project costs are managed can contribute significantly to contractual disputes. He will not advise his client to accept expenses attributable to the mistake of consultants who are also being paid for their professional services. This assertion supports Maru's (2019) view that consultants cause disputes among the client and the contractor because of poor contract management and variations due to design errors. Again project consultants' design errors and design quality, changes in design, drawings, and specifications have been identified as major sources of dispute in the project environment (Chaphalkar and Patil, 2012; Trangkanont, 2017). Therefore, Steyn *et al.* (2017) suggest that project cost management should begin at the initiation phase and be monitored and controlled throughout the project execution to ensure the project is completed within the client's allocated budget. All the respondents except Law1 indicated that contractual disputes are not often caused by cost management because the companies have a specific cost management process to prevent disputes. *QS2, QS3 & QS5, PM1and PM2* indicate that most of the cost-related disputes in the project are between the contractor and subcontractor, mainly arising out of claims. A sub-contractor may submit a claim for work done of which the main contractor may dispute, or the main contractor may dispute the quantum of works claimed by the contractors. These situations do not generally happen between the clients and the main contractors as the QS agreed with the main contractor the claimed amount before the claim is forwarded to the client. This situation was also observed by Maru (2019), where the contractor's lack of communication and delayed payments to other parties as a source of project disputes.

In other instances, as suggested by *PM1, Cont1, Cont3, QS2, and QS5*, the responsible party for most of the cost-related disputes that may occur, is the clients. Because clients normally request changes within the project scope when the construction phase has already begun, these scope changes will increase the project cost. Clients are sometimes reluctant to make

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payment for these changes because of a lack of knowledge regarding the cost of scope changes. It has also been identified that client activity such as unclear tender documents, scope changes, and variations contribute to disputes (Cheng *et al.*, 2009; Trangkanont, 2017), thus agreeing with the findings of this study. Law1 stated that the management should ensure regular cost reports to avert contractual disputes between the parties.

3.3 Resolving contractual disputes

The interviewees were again asked to express their opinions on the best way to resolve disputes when they occur between the parties. All the interviewees stated alternative dispute resolution methods as the best approach to resolving the parties' disputes. Law1 stated that he will always advise his clients to use ADR as it is cheaper than the normal court system and quicker.

He states;
"The normal court system is very expensive, and as such, I will always advise my clients to make use of the ADR system to resolve disputes if available because it is far cheaper and in terms of timeframe for resolving disputes, it is quicker as compared to the court system. My friend (referring to the interviewer), in the court system, simple disputes can take years to resolve, and you must pay for the services of a lawyer any time the matter is called".

PM1, PM2, Cont3, and Cont5 also stated that they preferred the ADR method, and in most cases, they resolved the disputes arising out of the contract by themselves without even going to the ADR system to the fullest. They will never use the standard court system to resolve disputes with the client unless it is inevitable.

As Cont3 puts it;
"We resolve disputes arising out of the contracts ourselves without even making use of the ADR system. You just have to be flexible and accept "give and take" situations to make things easy because it also costs using the ADR method".

The use of ADR is the best way of resolving a cost-related dispute between parties. The method of ADR that they choose to use is the negotiation process is the mediation. This method can resolve a dispute faster and ensures that all parties agree with the outcome of the dispute. This finding also supports the findings of Du Press (2012), who opines that the best method of resolving contractual disputes among parties is the ADR as it is cheaper and faster. Again Manu (2019) and Kassab *et al.* (2006) suggest the most used construction dispute resolution method among parties as ADR.

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3.4 Measures to minimise cost-related disputes

Respondents responses to measures to minimise cost-related disputes are presented in Table III. In answer to the measures that can be taken to reduce cost-related disputes, respondents stated using a contracts manager as a fundamental instrument to help minimise disputes between the parties and follow the required steps set out in the contracts signed between the parties.

Table III: Measures to minimise cost-related disputes

Interviewees	**Interviewees responses**
PM2, Cont2, QS4	*Engagement of contract manager*
PM1, Cont1, QS3	*A good change control system*
PM1, Cont2, and QS3	*Approval of project scope*
Law1, Q1, Q2, and Cont3	*Compliance with the terms and conditions of the contract*
PM2, Cont4	*Good project management*
PM1, Cont3, Cont5	*Competent consultants and contractor*
Cont5	*Effective communication*

QS4 stated that if the contractor or the client has a contract manager, it makes things easier. The contract manager ensures both parties are not in breach of the contract terms and will advise them when imminent violations. PM2, Cont2, and QS3 opined that the approval of project scope is also a critical element in reducing cost-related disputes. The architect and the QS will appropriately design and cost the approved scope to prevent omissions that usually underpins disputes due to additional costs for variation works.

As PM1 puts it;
"If the project scope is comprehensive and approved by the various stakeholders before design and costing are done, it will go a long to prevent cost-related disputes at the construction phase because everything that has been agreed on will be incorporated into the design and priced for before the commencement of the project, thus eliminating the incidence of scope omissions and variation orders which tends to generate dispute between the parties."

On the other hand, Law1, Q1, Q2, and Cont3 stated that compliance with the terms and conditions of the agreed contracts is the best way to prevent cost-related disputes. If all the parties follow the agreement to the latter, no dispute related to cost will arise as there will be no breaches.

As Cont3 opines;
"If everyone obeys what is agreed upon in the contract from the beginning, how will dispute arise?"

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Other respondents mentioned the stringent change control system as the best way of preventing cost-generated disputes among parties. They believe that if the changes are made to go through the required process, reasons are assigned to the changes, and the cost is done effectively before submitting it to the client for approval. There will be no disputes because the client would be aware of those changes before the professional team instructs the contractor to execute the work. In this case, the client will not be reluctant to make payment when the contractor claims those works.

As PM1 states;
"On my project, I ensure all the change request either from the client or project team are properly submitted. I have come up with a change request form that everyone who requests for change must use. The form has a section for reasons for the change and the timeframe for executing the changes. I then ask the QS to do the cost analysis before submitting the changes to the client. So the client becomes aware of the reasons as well as the cost implication of the changes requested. I only ask the contractor to do those changes only when I have received approval from the client. I do this for all the negative or positive changes in terms of cost or time. This procedure always saves me from encountering disputes with the client and the contractor."

Other stated measures include good project management and the engagement of competent consultants and contractors to prevent cost-related disputes among the parties. All professionals should get information about the project timeously. It has been observed by Staff (2019) that cost-related project disputes could be reduced through proper cost management. Again, if effective cost planning, estimating, budgeting, and controlling are carried out in project execution, cost-related disputes in the project will be minimal (PMBOK, 2017). Quantity surveyors are advised to master project cost management to complete the project within the proposed budget if cost-related disputes are minimised (Averous, 2014).

4. Conclusions and recommendations

It is evident from the study that the cost management aspect of the project has little or no effect on the contractual disputes. However, measures must be put in place to ensure project costs are well-developed to eliminate ambiguities. The implication is that project stakeholders must not spend all their time in the management of the project at the execution phase in their bid to prevent cost-related contractual disputes but must also concentrate on other measures such as the engagement of contract manager, good change control system, approval of project scope, compliance with the terms and conditions of the contract, good

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project management, competent consultants and contractor, effective communication before and during project execution to minimise the incidence of cost-related disputes.

However, suppose disputes arise during the project. In that case, project stakeholders prefer to use the ADR methods such as negotiation and mediation to resolve these disputes as the project stakeholder prefers it. Therefore, it is recommended that construction stakeholders should not put all their efforts into managing project costs to prevent contractual disputes. Instead, they should institute other stringent measures that prevent poor scoping, poor cost estimating, and ineffective project management practices to minimise the incidence of contractual disputes in their projects. It is also recommended that more participants should be included in future research related to this topic.

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Success Rate and Implications of Contractual Claims Decisions on Contractors in South Africa

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Abstract
Contractual claims are essence issues and normally disputed as they cause losses if the contractual claims fail to be honoured. The completion of projects can be best without any arising contractual claims by the contractors. However, this appears to be too ideal and almost impossible. Contractual claims have connotations of time and monies, which are to be honoured by the client to the contractor as a payment or compensation for the incurred cost. The present article establishes the success rate or extent to which contractual claims are honoured and the implications of the client's decisions on contractual claims that are not honoured. The questionnaire was distributed to professionals involved in the administration of contractual claims in projects. Descriptive analysis was used to analyze data. Findings revealed that most contractual claims are honoured in full when they are small in numbers, and when contractual claims increase, the success rate also decreases. The findings further indicated that most projects end in cost and time overruns due to clients' decisions on contractual claims. It is expected that the findings of this research will help construction stakeholders to avoid the main causes of contractual claims, and thus increasing the chances of contractual claims being honoured and improving the overall performance of construction projects concerning minimized delays and cost overruns.
Keywords: Contractual claims, success rate, the decision on contractual, implications, honoured

1. Introduction

In any economy, the construction industry is a major contributor to the gross domestic product. However, the performance of the construction is hindered by the prevalence of contractual claims made by contractors that are not honoured (Braimah, 2013). Construction projects are fraught with complexities related to standards, advanced technologies, clients' desired additions, and uncertainty in terms of time and budget constraints (Jaffar *et al.*,2011). Unfortunately, most traditional construction contracts do not incorporate or embrace these changes, leading to conflicts and contractual claims from contractors (Sakal, 2005). Given a

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construction contract's unique and complex nature, contractual claims are inevitable and a common occurrence (Jaffar *et al.*, 2011; Du Preez, 2014). The successful completion of construction projects is, therefore, a paramount concern.

The first thing to remember is that contractual claims are nothing other than asserting a right, which is considered your right under the contract, to additional time or money. A contractual claim is not a dispute, nor need it be contentious. It does not mean that you are aggressive or looking for a fight. Contractual claims are very common in today’s business environment; indeed, some parties are surprised if they do not receive a claim.

Disputes on projects erupt due to different perspectives on various aspects related to design and construction. Further, the incline complexity of construction processes, documents, and their conditions have contributed to higher possibilities of disputes, conflicts interpretation, and adversarial attitudes (Jaffar *et al.,* 2011). The exhausting and expensive litigation process does not make this easier as the unsettled contractual claims that result in disputes can take time to resolve. These have made contractual claims an inevitable burden in implementing current construction projects. Contractual claims are lifeblood issues normally disputed as they cause losses if the contractual claims fail to be honoured.

Researchers have conducted several studies on claims in the construction industry and their impacts on society. Maduranga *et al.* (2017) studied different delays which may result in contractual claims on construction projects. Most of these delays exceeded the original contract duration by over 100% and resulted in additional costs of the original contract values. However, most contracts in the construction provide that the contractor may only recover the cost incurred if they can substantiate it with evidence. The contractor would not be entitled to additional cost for preparing any contractual claims unless additional cost resulted from unreasonable actions or inactions with the contractual claims.

Other studies have identified causes of contractual claims related to financial, social, industrial, political, organizational behaviour, contractual, environmental, and project-related factors (Love *et al.,*2011; Fawzy *et al.,* 2013). Every construction site is different and is never the same as the other sites. The nature of construction activities vary. Therefore, the preparation of a construction contract can be recognized as allocating risks to the parties involved in the contract, the client and the contractor. These risks include unforeseen ground conditions, site instructions, variation orders, the time of completion, the final cost, the quality of the works, client-initiated changes, errors and omissions in drawings, mistakes in specifications, inflation, inclement weather, delayed payment, changes in regulation, third

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party interference, professional negligence, shortage of materials, labour problem, defects in works, and poor workmanship.

Bakhery *et al.* (2014) did a study regarding contractual claims problems experienced by contractors in the construction industry. He further stated that the frequency of contractual claims is unavoidable given the form of contracts, their complexity, the number of parties involved, the risk and the pressure of time contract document, and the realization of work. Delay and interruption of contractual claims create contractual conflicts in the delivery of the project (Aibinu,2009). An attempt has been made to understand and evaluate the relationship between contract conditions and different claims usually encountered in construction disputes (Moza *et al.*, (2018). Contractual claims are considered to be the most disruptive and hostile event in the project. In the construction industry today, projects are subject to more contractual claims than in any history, and the number of contractual claims within the construction industry continues to increase.

Shen *et al.* (2016) modelled and empirically tested the causes of contractual claims in international projects with industry surveys, structural equation modelling, and case studies from the Chinese contractors. In construction projects, conflicts are inevitable and not well managed can result in a dispute. Disputes are one factor that affects the successful completion of the project (Cakmak *et al.*,2013). Delays on construction projects are a universal phenomenon and are always accompanied by cost and time overruns. Construction contracts have an unbearable effect on parties the client, contract, and consultant to a contract in terms of growth in adversarial relationships, disrupt, litigation, arbitration, cash flows problems, and a general feeling towards each other.

However, few studies have systematically addressed the success rate of honoured contractual claims and the implications of client decisions on contractual claims. Therefore, the paper addressed a clear need to measure the success rate of contractual claims and implications that come from the decision of not honouring the contractual claim

This study investigates the success of the nature of common contractual claims and what drives those contractual claims that are not honoured by the client. The research will further discover whether claims are honoured in full or not and outline the factors that influence client decisions on claims. Finally, the research will determine how the contractors are affected by the claims that are not honoured. This research is important as it will help the contractors and the client understand claims and the type of claims they are entitled to claim accordingly. This will reduce the number of claims that are not honoured in the construction industry.

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As an expendable part of the contract system, contractual claims negatively impact the projects and are inevitable in construction industry projects (El-adaway, Kandil 2009). LaBarre and El-adaway (2013) stated that allocating risks between the client and the contractor in the construction process involves contractual claims.

2. Theoretical Background

The success rate or the extent to which contractual claims are honoured

Contractual claims are considered to be one of the most disruptive and unpleasant events in the project. Yusuman and Adnah (2013) further say the construction industry is complex and unique. On this basis, the success of a project involves various aspects and the roles of various stakeholders determining the project's direction. Most construction projects experience a common delay. On-time project completion has always been an indicator of a project’s success. However, any construction project will be subject to unpredictable circumstances that may hinder the smooth passage of the construction process. Completing a construction project on time is the shared goal of both the owner and the contractor. If the project is delayed, each party will incur additional costs and lose potential revenue. It is well-known that construction time performance is the basis for classifying whether a project is “successful” or not, along with the cost and quality of the project.

Tochaiwat and Chovichien (2014) conducted a survey, indicating that the contractual claims' frequency and severities have a high effect on the project. The frequency score shows that the contractual claims contributed 73% or about three-fourth of the overall contractual claims in one project. This emphasizes the importance of good preparation of contract at the beginning of the project. A well-drafted contract can help both the Employer and the Contractor settle the changes that occurred before they become contractual claims or disputes, which consume more time and cost from both parties to resolve.

Abdul Aziz *et al.* (2007) say claims are indeed prevalent in the construction industry. The word ‘claim’ has connotations of time and monies in particular, of which to be honoured by the client to the contractor as payment or compensation for their work done. The payment is so important to meet the necessities of their living. Therefore, disputed claims should be handled and brought to their minimum to get the payoff, rather than proceed to litigation that usually consumes more time and resources. Researchers have conducted several studies on claims in the construction industry and their impacts on society.

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The study was done by Abdul Aziz et al. (2007) further shows that 53% of the contractual claims submitted are honoured in a month after submission, and 47% receive their claims within two months. Abdul Kadir *et al.* (2005) showed that late progress by the client to the contractor was ranked third out of the five most frequent project delay factors, which directly affects the payment to subcontractors, suppliers, and workers.

Voyton (2004) did a study which shows that due to the increase in the demand for general contractors to compete and ''win'' the best job for the lowest price, dispute resolution is gaining importance in maintaining success for the general contractor by reducing the chance of contractual claims for the contractor. She further determined whether partnering in construction projects influences the number and magnitude of contractual claims filed or paid by the contractor and owner. Finally, this study demonstrated that the project where partnering was used had fewer contractual claims.

Abuinu (2006) did a study which the results indicated that the contractors received an unfavourable outcome from the contract administrator's decision on their claims for the delay; the intensity of conflict was lower when there was pre-contract negotiation and pre-contract agreement regarding the rules for quantifying and assessing the impact of anticipated delays than when there was none. It further discovered that the higher the level of pre-contract negotiation and pre-contract agreement on the rules for quantifying and assessing delays, the higher the contractors perceived the quality of the decision-making process for delay claims during the construction phase. Lastly, the higher the contractors perceived the quality of the decision-making process for delaying contractual claims, the lower the intensity of the conflict.
A study conducted by Ujene and Udike (2016) evaluated the nature and influence of contractual claims on the performance of traditional projects. The study results indicate that extra-work, change orders and delay or extension claims are most frequent, and the average estimated claim values vary between 6.9% and 30.7% of the bid price. Extra work claims usually have the highest contractual claims varying up to 4.5% higher than the mean estimated value of 30.7% of the bid price. Delay and extension of time contractual claims ranked next, with the professionals perceiving that the value can vary up to 18.4% above the estimated mean value of 23.9% of the bid price. The results also show that different site condition claims and change order claims ranked third and fourth, respectively. The professionals perceived that different site condition contractual claims could vary up to 8.8% above the mean value of 22.5%, while the clients perceived that change order claims could vary up to 4.5% above the mean value of 22.4%. The results also show that tort actions, statutory, contractual claims, and quantum merit claims have the least mean values of 11.3% and 6.9%, respectively. The study done by El-Adawa, (2008) indicates that claims are

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unavoidable in today’s construction industry because they represent the administrative process required to handle the results and implications of design changes, defective specifications, quantity variations, delays, disruptions, and accelerations.

A survey conducted in Western Canada shows that most contractual claims in construction projects involved delays, which in many cases go beyond the original contract duration by over 100%. In comparison, more than half of the claims were an additional cost of at least 30% of the original contract value. Other research works conducted in the United States and Thailand also observed that the average cost growth caused by claims was about 7% of the original contract value (Bakhary *et al.*,2013). Parikh and Joshi (2013) also did a study that indicated that most contracts result in problems, increasing contractual claims and disputes among stakeholders due to various unanticipated and indefinite parameters. (Aibinu, 2009; Shrestha *et al.*,2014) said delays in contractual claims are the major sources of conflict and contract disputes in construction projects (Aibinu, 2009; Shrestha *et al.*,2014). Adindu and Ibironke (2012) and Bakhary *et al.* (2013) have investigated contractual claims. Still, they have neither looked at them from a delivery method view nor their influences on project performance. Hence, this study focuses on the success or extent to which contractual claims are honoured.

Implications of client decisions on contractual claims not honoured

The most common problems in construction projects are time and cost overruns. Cost and time overruns have become an integral part of construction projects worldwide, followed by contractual claims. Gardezi *et al.* (2014) stipulated that delayed payments after result in disputes between the Client and Contractor, leading to slow down of progress, termination of Contract, Arbitration, Litigations, claims for a time extension, and cost overrun. Andindu and Oyoh (2011) did a study that noted that contracts are often executed under various conditions involving a lot of unforeseen, unexpected, frequently undesirable, and often unpredictable factors that manifest in various ways, leading to losses and expenses.

Ojo (2014) stated that construction projects are dynamic and unique because they are contractual, complex, and lengthy subsequent them vulnerable to risk variables and unfavourable disputes to the project objectives. Most construction contracts run into problems, increasing contractual claims and disputes among parties to the contract due to unanticipated and indefinite parameters. A construction project is considered successful if it is completed within time, budget and quality. Time and cost overruns have significant implications from an economic and political point of view. In general, time and cost overruns reduce the productivity of available economic resources, edge development, and diminish the economy's effectiveness (Shanmugapriya and Subramnian, 2013).

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(a) Cost overruns

Cost overrun is defined as the excess of actual cost over budget. Despite their negative impact on the construction project, cost overruns have become a natural part. Rosenfeld (2013) did research which examined and identified 15 the root causes of the cost overruns which three of which are most prominent (1) Premature tender document (2) Too many changes in clients' requirements and definitions (3) Tender-winning prices are unrealistically low. These root causes were perceived as one of the greatest parts of the problem in construction projects. Long *et al.* (2008) did a study that found 5 significant factors causing cost overruns in construction projects: inadequate site management and supervision, lack of project management support, client's financial difficulties, contractors' financial difficulties and changes in design. Enshassi *et al.* (2009) did a study that identified 10 major factors causing cost overruns. These factors include the increment of materials prices due to continuous border closures, delay in construction, raw materials supply and equipment by contractors, instabilities in the cost of building materials, problems of the local currency concerning dollar value, project materials control by some suppliers, constraints in resources, funds and associated auxiliaries not complete, lack of cost planning/monitoring during pre-and post-contract stages, improvement s to standard drawings during constructions stages, design changes.

Olawale and Sun (2010) conducted a study that identified 21 major factors causing cost overruns are changed in design, risk and uncertainty associated with projects, inaccurate evaluation of projects time and cost, non-performance of subcontractors, the complexity of works, a conflict between project parties, disagreement in contract documentation, contract, and specification interpretation disagreement, inflation of prices, financing and payment, lack of proper training and experienced project manager, low skilled manpower, unpredictable weather conditions, dependency om imported materials, lack of appropriate software, unstable interest rate, fluctuation of currency/exchange rate, weal regulation, and control, project fraud and corruption and unstable government policies. The research did previously discover reasons for the difference between the tender sum and the final account. Cost overruns are also considered one of the problematic factors, which delays the project progress since it decreases the contractor profit leading to huge losses(Enhassi, 2009).

(b) Time overruns

Time and cost are the most important factors to be considered in every construction project. Al-Gahtani and Mohan (2007) defined time overruns as the time increased to complete the project after the planned date, caused by internal and external factors surrounding the project. Delay of project and cost overruns is one of the most important in the construction management field.

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Research done in Palestine indicated that the parties of the project (client, consultant, and contractor) don't give significance to evaluate the time and cost overruns at the end of the project. One of the most significant objectives and policies of public and private sectors dealing with the execution of the projects is to upgrade the project's performance by reducing costs, completing projects within assigned budget and time constraints, and improving quality. Projects completed within time and budget are considered the most important factors of successful projects. These help decrease problems for all parties and give new chances to construct other related projects. Therefore it helps to increase the profits and development of the construction industry (Al-Najjar, 2008).

(c) Terminations

In (2012), Mohammed Mahdi Hosseini indicated that unfair termination of contracts by employers due to uncertainty in some clauses in the standard form of contracts is the other implication of claims that are not honoured. Cost and time overruns have become an integral part of construction projects worldwide, followed by various claims. Gardezi *et al.* (2014) stipulated that delayed payments after result in disputes between the Client and Contractor, leading to slow down of progress, termination of Contract, Arbitration, Litigations, claims for a time extension, and cost overrun. Andindu and Oyoh (2011) did a study that noted that contracts are often executed under various conditions involving a lot of unforeseen, unexpected, frequently undesirable, and often unpredictable factors that manifest in various ways, leading to losses and expenses.

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2. Research Method

This study used a quantitative technique to quantify the success rate of contractual claims that are not fully honoured, factors influencing client decisions, predominant contractual claims, drivers, and implications by generating numerical data or data that can be transformed into usable statistics. It will also help the researcher quantify the experience, opinion, view, and other defined variables. The researcher selected this method because it uses measurable data to formulate facts and uncover patterns in research. The research process can be quantitative or qualitative; however, the quantitative method is used. Creswell (2011) agreed that the two basic research requires quantitative and qualitative research.

Questionnaires were distributed using email in google form format where respondents were required to open the link and proceed with answering. In addition, hard copies were also printed and distributed to the different respondents, and those copies were collected after the follow-ups of confirmation if they were completed. Saunders *et al.*. (2009) stated that questionnaires are usually preferred for descriptive and exploratory research.

Data collection

In this study, primary data was collected using questionnaires to investigate to what extent claims are honoured, decisions on claims, predominant claims, and implications of claims not honoured. This technique chosen for this research was considered the most effective way of meeting this research study objective. The research study was carried out in South Africa due to the country's large concentration of construction companies. The research is based on construction and engineering projects in the construction industry.

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Questionnaires are adopted as a research technique of data collection in which personnel is asked to respond to a set of questions in a predetermined order (Saunders *et al.*,2009). In addition Bhattacherjee, (2012) defined questionnaires as a research instrument consisting of a set of questions intended to solicit a response from respondents. Questionnaires were distributed using email in google form format where respondents were required to open the link and proceed with answering. In addition, hard copies were also printed and distributed to the different respondents, and those copies were collected after the follow-ups of confirmation if they were completed. Saunders *et al.* (2009) stated that questionnaires are usually preferred for descriptive and exploratory research.

Sampling strategy

The study adopted a purposive sampling method to target construction professionals more involved in administering contractual claims in the construction project. Purposive sampling is a form of non-probability sampling in which decision is taken by the research concerning the individuals to be included in the sample, based upon a variety of criteria which may include specialist knowledge of the research objective, or capacity and willingness to participate in the research (Price, 2009). The construction professionals targeted for this research who are role players in contractual claims are Project Managers, Contracts Managers, Engineers, Quantity Surveyors, Claims Managers, Contract Administrators, Site Agents, and all parties involved in contractual claims. There are two major sampling strategy groups: probability sampling (Random sampling) and non-probability sampling (purposive sampling). Teddie and Yu (2007) stated that probability sampling is generally used in quantitative research, including selecting a relatively large number of units from a population. In addition, Copper (2007) further states that probability sampling is based on random selection.

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Participants	Participants	Frequency
Chief Advisor Contract Management	1	1%
Chief Engineer	1	1%
Claims Manager	7	6%
Contract Administrator	5	4%
Contract Manager	23	20%
Cost Engineer	2	2%
Legal Advisor	1	1%
Planner	4	4%
Project Engineer/Manager	21	18%
Quality Advisor	1	1%
Quantity Surveyor	48	42%
Site Agent	1	1%
Total Respondents	**115**	**100%**

Table 2.1: Summary of Participants

Data analysis

The quantitative data collected in this study also used descriptive statistics. The research used descriptive because it describes what the data is showing and provides the researcher with an overview of the data. In this research, descriptive statistics were presented using frequency tables, charts. In addition, it was further used whereby mean, median, and standard deviation were calculated through SPSS. According to Naoum (2007), the descriptive statistics method is the simplest method of analysis that provides a general overview of the results. This method is used to present quantitative descriptions in a manageable form and helps to simplify data sensibly.

The mean value was used to rank the frequency level of each answer in the Likert scale questions. Okoro (2015) described the mean value as the average score obtained from all the response weighted. Questions related to the last projects respondents completed were scaled from 1-5 were 1=Project 1, 2= Project 2, 3=Project 3, 4= Project 4, and 5= Project 5. The other scale was used to measure the level of agreement using 1= Never, 2= Rarely, 3 =Average, 4= Frequent, and 5= Very frequent

3. Results

Success rate or the extent to which contractual claims honoured

Respondents were required to indicate the extent in which contractual claims were honored in last Five (5) projects that they did. Table I is the summary of response which indicate that

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contractual claims honored in full (100%) ranked first with the Mean (x) =2.66 and Standard deviation (SD) =1.654, Project 1 =19.1%, Project 2 =7.0, Project 3 =6.0 %, Project 4 =4.3% and Project 5 =12.2%. Partial (60%) ranked second with Mean (x) =2.28 and Standard deviation (SD) =1.654, Project 1=19.1%, Project 2 =7%, Project 3=6.1%, Project 4 =4.2 and Project 5 =12.2%. Partial (40%) ranked third with the mean (x) =1.81 and Standard deviation (SD) =1.096. None (0%) ranked fourth with Mean (x) =1.67 and Standard deviation (SD) =1.065. Lastly, Partial (20%) claims honored ranked fifth with the mean (x) =1.56 and Standard deviation (SD) =0.746.

Table I: The success rate of contractual claims honoured

Code	Success rate or Extent honored	Components 1	2	3	4	5	X	SD	Rankings
EH1	Full (100%)	19.1	7.0	6.1	4.3	12.2	2.66	1.654	1
EH2	Partial (60%)	26.1	9.6	15.7	3.5	7.0	2.28	1.365	2
EH3	Partial (40%)	22.6	8.7	5.2	3.5	0.9	1.81	1.096	3
EH4	Partial (20%)	17.4	7.8	4.3	0.0	0.0	1.56	0.746	5
EH5	None (0%)	11.3	3.5	2.6	0.0	0.9	1.67	1.065	4

The results indicated the success rate of contractual claims as follows. If the claims are small in numbers, they are honoured at 100%. When they increase, they are honoured at 60%, 40%, and 20%. The results further indicated that other contractual claims are honoured at 0%, meaning they are not honoured at all.

Implications of client decisions on contractual claims not honoured

Respondents were required to indicate from the last five (5) projects the non-award implications that occurred in their projects. This questionnaire was designed to determine non-ward implications due to claims that are not fully honoured. Table II indicate that delay in time ranked first with the mean (x) =3.13 and Standard deviation (SD) =1.680. Cash flow problems ranked second with the mean (x) =2.95 and Standard deviation (SD) =1.724. None of the listed implications ranked third. Arbitration ranked fourth, Litigation ranked fifth, and termination of the contract ranked last, with 20.9% occurring in Project 1 and 0% on Project 4 and 5.

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Table II: Non-awarding Implications

Code	Non-award implications	Projects							
		1	2	3	4	5	X	SD	Rankings
NAI1	Cash flow problems	24.3	7.8	9.6	4.3	24.3	2.95	1.724	2
NAI2	Delay in time	22.6	8.7	7.8	11.3	26.1	3.13	1.68	1
NAI3	Termination	20.9	8.7	0.9	0.0	0.0	1.34	0.539	6
NAI4	Arbitration	20.0	12.2	7.8	0.9	0.0	1.74	0.846	4
NAI5	Litigation	7.8	0.9	3.5	0.0	0.0	1.64	0.929	5
NAI6	None of the above	8.7	3.5	3.5	0.9	7.0	2.74	1.701	3

Respondents were required to indicate from the last five projects the extent to which they suffered the implications: the cost and time overruns in their projects. Table III shows that Cost overruns between 15%-20%, respondents indicated that from their last five projects, Project 1=34.8%, Project 2=8.7%, Project=7.8%, Project 4=5.2% and Project 5=12.2%. Cost overruns>20%, respondents indicated the implications of cost overruns in Project 1=34.8%, Project 2=17.4%, Project 3=4.3%, Project 4=0.9% and Project 5=6.1%. Cost overruns between 15%-20% ranked first with the Mean (x) score of 2.29 and Standard deviation (SD) =1.570. Cost overruns>20% ranked second with the Mean (x) score of 1.84 and Standard deviation (SD) =1.236.

Table III shows time overruns and penalties from the last five completed projects. Respondents indicated that Time overruns between 15%-20% on Project 1=36.5%, Project 2=9.6%, Project 3=7.8%, Project 4=4.3% and Project 5=9.8%. Respondents indicated that Time overruns>20% were 29.6% from Project 1, 6.1% for Project 2, 7% for Project 3, 5.2% for Project 4 and 7.8% for Project 5. Penalties for Project 1=333.9%, Project 2=11.3%, Project 3=4.3%, Project 4=1.7% and Project 5=4.3%. Apart from time and cost overruns, implications ranked first with the Mean (x) score of 2.45 and Standard deviation (SD)=1.594. Time overruns>20% ranked second with a mean (x) score of 2.20 and Standard deviation (SD)=1.514. Time overruns between 15%-20% ranked third with a mean (x) score of 2.13 and Standard deviation (SD) =1.480. Lastly, penalties ranked fourth with the Mean (x) score of 1.77 and Standard deviation (SD) =2.45

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Table III: Time Overruns and Penalties

Code	Implications	Projects 1	2	3	4	5	X	SD	Rankings
IM3	Time Overruns-15%-20%	36.5	9.6	7.8	4.3	9.8	2.13	1.480	3
IM4	Time Overruns >20%	29.6	6.1	7.0	5.2	7.8	2.20	1.514	2
IM5	Penalties	33.9	11.3	4.3	1.7	4.3	1.77	2.450	4
IM6	None of the above	11.3	3.5	2.6	3.5	4.3	2.45	1.594	1

Therefore, the result indicated that the non-awarding implications of contractual claims that are not honoured result in delay in the completion of the project, cash flow problems, none of the implications found from literature, arbitration, litigation, and lastly, termination of the contract. The results further indicated that the cost overruns are between 15%-20%, and time overruns are above 20%, meaning projects are not completed on time.

4. Findings

According to Abdul Aziz et al. (2007) and Parikh and Joshi (2013), contractors received unfavourable outcomes from the client on contractual claims in the literature review. This meant some of the contractual claims were honoured, and some were not honoured in full. According to Abuinu (2006), about 50% of contractual claims that the contractors submit are honoured.

Firstly, the findings indicate that most of the contractual claims submitted to the contractor were honoured by the client in full. The second extent honoured is 60%, and the third is 40%. These findings indicate those contractual claims paid in full and those paid partially at 60% and 40%. The findings further indicated that from 1 to 5 numbers of contractual are submitted projects are honoured in full, whereas when they are more than 20, they are honoured at 60%. This meant that when contractual claims increase in number in the project, their chances of being honoured in full also reduce.

Gardezi *et al.* (2014) stipulated that delayed payments after result in disputes between the Client and Contractor, leading to slow down of progress, termination of Contract, Arbitration, Litigations, claims for a time extension, and cost overrun. Andindu and Oyoh (2011) noted that contracts are often executed under various conditions involving a lot of unforeseen, unexpected, frequently undesirable, and often unpredictable factors that manifest in various ways, leading to losses and expenses. Therefore literature review indicated that cash flow problems, delay in time, termination, arbitration, litigation, penalties, time, and cost overruns are the non-awarding implications.

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Secondly, the findings indicated that one of the most implications in projects is projects result in late completions due to contractual claims that are not honoured. The findings further indicated that cash flow problems of contractors' to finance the project become difficult to conclude the projects. Thirdly, the non-awarding implications found from the literature indicated that none of them are non-awarding implications on the project. Lastly, the findings indicated that projects end in a dispute where arbitrations are adopted. If parties are still in disagreement, it is further referred to litigation, and the contract can be terminated.

5. Contribution to Knowledge

Much research has been conducted on contractual claims in the construction industry and their impacts on the projects. However, few studies have systematically addressed the success rate of honoured contractual claims and the implications of client decisions on contractual claims. Therefore, the study established the success rate of contractual claims. These factors influence those contractual claims decisions when honouring contractual claims, the predominant or common contractual claims, the drivers behind contractual claims that are not honoured, and implications of client decision on contractual claims not honoured.

6. Conclusion and Recommendations

In conclusion, this study showed the highest success rate on a smaller number of contractual claims honoured by the client and the contract form, resulting in most clients submitting contractual claims. This study was able to determine the drivers and implications of non-awarding claims. From the above findings of the study, the following recommendations were able to be made: The contractors' should consider the factors influencing the client decides on contractual claims. The success rate of contractual claims can be improved by considering the directives from the contract conditions. The client should consider the drivers and predominant contractual claims to reduce the project's high rate of contractual claims. Both contractors and client should understand their obligations in the form of contracts used in the project.

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DII-2021-013

Nigeria Public Transport System and the Global Smart City Crusade: A Review

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Abstract

Public transport in Nigeria has turned mean road transport system as the government policy seems to give more attention to it than the other modes. This can be attributed to the histrionic increase of automobile ownership that placed continuous pressure on urban roads that are ill-designed and inadequate to meet the supper imposed traffic characterised by congestion and gridlock. This paper seeks to benchmark the Nigerian public transport system with the present-day Smart City mobility crusade. The study revealed that the few available bus operation in the country are rickety second-hand vehicles with smoking engines coupled with poor IT infrastructure facilities, which pose health risks to motorists, commuters and even the ecosystem. However, the major approach is developing rapid transit systems like light rail, metro rail, or rapid bus transit, which hitherto wholly depend on fossil fuel that is not environmentally friendly. The global environmental pollution and urban traffic gridlock challenges of automobile necessitated the crusade for smart cities and green mobility that are IT-based. Therefore, African countries like Nigeria should awake from their slumber and join the race toward the smart city and smart governance status through Intelligent Transport System adoption.

Keywords: Public Transport, Smart City, Vehicle Automation, Urban Mobility, and Hybrid Bus.

1. Introduction

Mobility and accessibility are essentially the life wire of any community or nation as they determine the achievement of socio-economic goals. For instance, passenger transport service demand global is predicted to grow from 26 trillion passenger kilometres in 1990 to 103 trillion passenger kilometres in 2050 on average (Schafer and Victor, 1997; USA DOT, 1999).In fact, in some countries like Nigeria, about 80 percent of goods and services are transported on roads, 95 percent of workers commute on roads by private vehicles and public buses. Roads bear the largest share of non-work and pleasure trips, as Winston (2013) observed. Public transport means how larger proportions of the urban populace gain spatial access to the goods, services, and activities they need for their livelihoods and well-being

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(Fitzgerald, 2012). Public transportation, therefore, plays a very important role in both developed and developing countries of the world.

Public transport (commercial vehicles and mass transit) is the transport of passengers by group travel systems available for the general public, typically operating on a schedule of established routes. These include trolleybuses, city buses, trams (or light rail), passenger trains, rapid transit (metro/subway/underground, among others), and ferries. Public transport between cities is dominated by airlines, coaches, and intercity rail in some countries. High-speed rail networks are being developed in many parts of the world.

Public transport systems generally run along fixed routes with setpoints of presenters exchange on schedule, with the most frequent services running headway. However, most public transport trips include other modes of travel, such as passengers walking or catching bus services to access train stations. Paratransit is sometimes used in areas of low demand and for people who need a door-to-door service.

Generally, a resilient transportation system offers a diverse range of choices: the train is out of service. There are easily available substitutes like taking a bus. Multiple energy sources can fuel resilient transportation. For instance, if oil prices skyrocket, the system should run on renewable energy like solar, hydrogen cell, biofuel series or wind. Resilient transportation systems use fossil fuels frugally to mitigate climate change challenges, reducing the likelihood of future disasters that may threaten transportation infrastructure or fuel sources. The most resilient systems are seamlessly connected -offering maximum mobility at every scale and for every mile of the journey; that is where China is far ahead of the United States in resilient transportation systems.

The conversion of hybrid-powered buses will reduce particulate matter carbon monoxides in the dirtiest and most populated regions of the world and provide health benefits to millions of people. For instance, more than 100,000 electric buses, about one-fifth of the nation’s total, are on roads presently in China. At this implementation rate, China’s entire bus fleet could wholly be electric by the year 2025. Appreciably, global transportation systems engulf a huge portion of public and private spending of about $1.2 to $1.4 trillion each year. The development of city bus systems can be significantly strengthened by evaluating implemented novel bus reform practices and challenges faced in other urban centres. In recent years, the global impacts of bus reform initiatives reinforce that city bus systems will continue to be the hub of urban mobility.

Inadvertently, the bus transport system in Nigeria is least to be desired comparatively. It is still wholly dependent on fossil fuel (which is not unconnected to the abundant local crude oil deposit), poor operation, and service delivery. The lack of innovative and poor policy

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implementation is bedevilled by poor funding and adequate infrastructure. These are the bases for this paper as a pathfinder into a robust public transport system in the country.

The Smart City Crusade

The definition of a smart city in an information and communications technology (ICT) environment is highly subjective (Cellary, 2013). It is equivalent to almost anything considered modern ingenuity, and Meijer and Bolivar (2016) view it as synonymous with efficiency when linked to devices. More recently, smart growth implies greater city efficiency (Batty *et al.*,2012). The “smartness” of a city describes its ability to bring together all its resources, to achieve the goals effectively and seamlessly and fulfilling the purposes it has set itself (ISO 2014b). The European Commission programs on Information and Communication Technologies Policy Support Programme FP7-ICT and CIP ICT-PSP approach smart cities as a “user-driven open innovation environment” (Schaffers *et al.*,2011). The city is seen as a platform that enhances citizen engagement and is willing to “co-develop”. “Openness” is conceptualized to apply various forms of relationships between people, services, infrastructure and technology (Lee *et al.*,2014).

The International Telecommunications Union (ITU, 2014a) emphasises Information and Communication Technologies (ICT). It considers a smart, sustainable city an inventive city that uses ICT and other means to improve quality of life and efficiency of urban operation and services and competitively. This is while ensuring sustainable development of the present and future generations concerning economic, social and environmental aspects. These models amalgamate a smart city ecosystem into eight (8) components:

i. Smart infrastructure: city social facilities with embedded smart technology (such as sensors and smart grids).
ii. Smart mobility: transportation networks with enhanced embedded real-time monitoring and control systems.
iii. Smart Environment: innovation and ICT based natural resource management and waste recycling systems with emission and pollution control.
iv. Smart Services: technology and ICT for health, education, tourism, safety, response and surveillance.
v. Smart Governance: technology and ICT based service delivery, participation and engagement.
vi. Smart People: people-oriented e-interaction, creativity and open innovation.
vii. Smart Living: innovation for enhancing the quality of life and urban livability.

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viii. Smart Economy: e-business and faceless transaction.

Figure 1: Smart city components
Source: After Schaffers *et al.*,(2011, pp.431-446,),

The concept of Hybrid Buses

The transportation system has contributed significantly to global greenhouse gas (GHG) emissions, increasing by 2.1% per year. To reverse this trend and reduce local air pollution, there is a global crusade for the general automobile sector to shift from conventionally fuelled vehicles (petrol and diesel) to alternatives such as hydrogen or hybrid electric vehicles, or those fuelled by biofuel series. While battery-electric buses are currently operating in several cities globally, hybrid buses are becoming more common in smart cities. In Europe, for instance, Luxemburg and Italy, in particular, are forerunners in introducing this technology. BEVs (battery or blade electric vehicles), PHEVs (parallel hybrid electric vehicles) and CHEVs (complex hybrid electric vehicles) are present in many public transport systems as in Beijing (China) and New York (USA).

Electric vehicles are more comfortable for passengers because they do not vibrate or make noise as much as regular buses. Generally, introducing electric and hybrid vehicles in public transport requires new and costly infrastructure, and their routes are pre-determined, as revealed in figure 2. Cities also need to introduce electric charging stations along these corridors.

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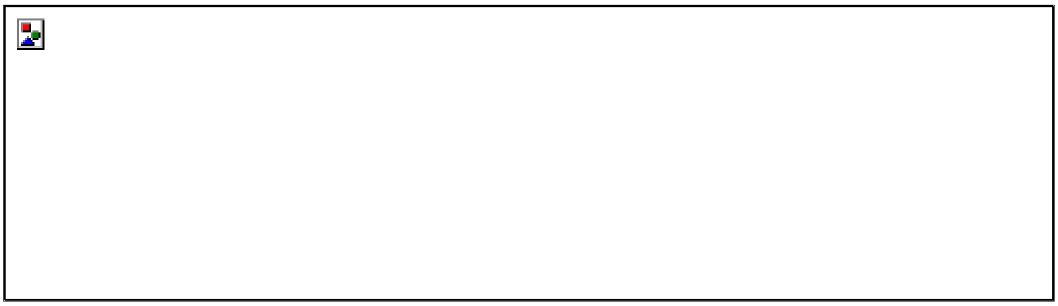

Figure 2: Guangzhou's BRT occupies the middle lanes of a road, so they don't have to weave in and out of traffic to pick up passengers. Passenger boarding zones must be safe and well-designed as well.

(Source: ITDP) and Seventh Framework Programme (FP7) of the European Commission.

Sustainable Urban Mobility Plan (SUMP) has proven to be one of the ideal legal frameworks, and by developing a SUMP, cities need to establish clear short, medium, and long-term targets. Citizens should be encouraged to use more sustainable forms of transport that improve accessibility, reduce greenhouse gases, reduce travel times and congestion. The municipals deploying clean vehicles for public transport should be part of an integral city strategy for clean vehicles in refuelling or charging infrastructure provision. Measures such as low-emission zones can prompt the public transport sector to replace vehicles with cleaner alternatives.

In Hangzhou in 2005, the introduction of electric and hybrid vehicles began, making it one of the leading cities in the deployment of low carbon transport in China. In September 2014, Hangzhou also ordered 2,000 all-electric buses, and presently, there are more than 1,500 clean buses (around 21% of the bus fleet) circulating the city. The city also introduced 500 electric taxis currently in circulation, travelling an average of 230km per day. Another important factor for the successful deployment of electric buses on the streets of Aachen was the charging infrastructure which has greatly reduced the socio cost of the transport sector and the enhancement of the state economy and the country at large, as illustrated in Figure 3 (CIVITAS 2013). The main objectives of this measure were:

i. To reduce noise emissions in public transport by implementing hybrid buses,
ii. reduce CO2 and particle emissions in public transport by about 20%,
iii. reduce the energy consumption of buses in public transport by 20%,
iv. increase the understanding of the decision-makers an innovative, low emission bus technology concerning the future fleet, and
v. initiate the renewal of the public transport fleet (launch of the tendering process).

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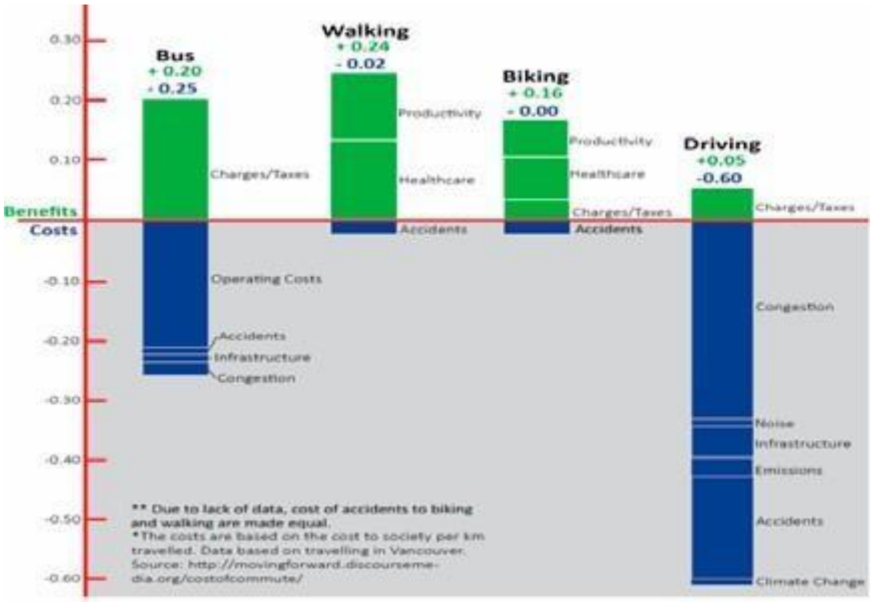

Fig. 3: Hybrid bus social benefits above private driving.
Source: Energy Innovation (http:/.energyinnovation.org)

ITS and the Urban Transport

Intelligent Transport Systems (ITS) can be generally defined as applying advanced telecommunications, computing, and sensor technologies to improve the transport system's safety, efficiency, and sustainability. It also refers to the deployment of advanced information and telecommunication technologies to enhance the transport system's safety, efficiency, reliability, and user and environmental friendliness.

ITS include an expansive and growing suite of technologies and applications such as real-time traffic information systems, in-car navigation (telematics) systems, vehicle-to-infrastructure integration (VII), vehicle-to-vehicle integration (V2V), adaptive traffic signal control, ramp metering, electronic toll collection, congestion pricing, fee-based express (HOT) lanes, vehicle usage-based mileage fees, and vehicle collision avoidance technologies.

The fact remains that the present state of the public transportation services cannot cope with the complex demand challenges placed on them by the teemed urban population. To minimize some of these challenges, transport managers have begun to apply ITS technologies. More so, in today’s society, where the public relies increasingly on the transport network, there are serious challenges of congestion and safety due to automobiles

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in many countries of the world and Nigeria. Technology provides a wide variety of options to address existing and future automobile concerns, and ITS is seen at the forefront, as displayed in figure 4.

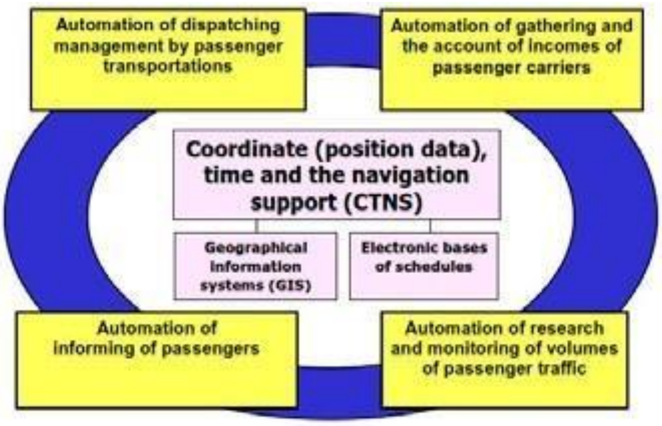

Figure 4: Interaction with base technologies
Source: After Efimenko (2007 pp5)

ITS aims to use diverse IT technologies to increase mobility and enhance transit operations by making travel safer, more efficient, environmentally sound, cost-effective, convenient, and comfortable. The strategies include; fleet operation management, fare collection, and customer information, otherwise known as Travellers Information Systems. Fleet Management and Operation includes five different technologies, as follows: automatic passenger counters (APC), automatic vehicle location (AVL), geographic information systems (GIS), scheduling and dispatching (S&D), and signal priority (SP). Scheduling/dispatch software is used to aid in designing and modifying transit routes. It can also be used to route, schedule, and dispatch vehicles in demand response operations. It often is combined with GIS and AVL to coordinate different transit functions. Combined technologies such as computer-aided dispatching and AVL can increase the efficiency of transit operations, enhance safety, improve service, and cut costs. At the same time, travellers information systems provide customers with information for planning their trips and during their trips. Transit information can be static, like route maps, or dynamic such as route delays and other real-time information. Travellers may access information from differing locations such as home, work, transportation terminals, wayside areas, and onboard vehicles, as illustrated in Figure 5.

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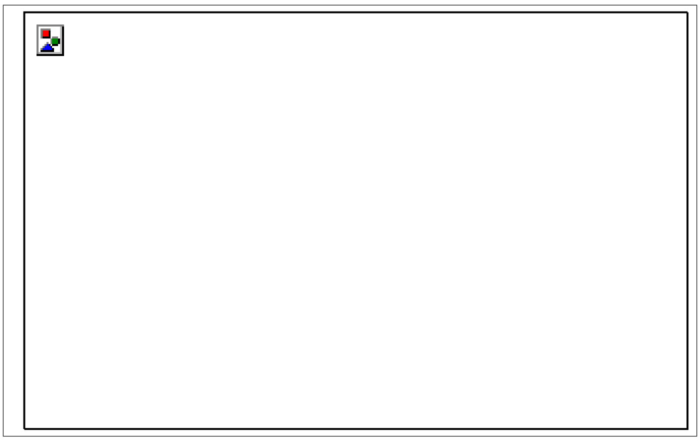

Figure 5: Navigation system for passengers
Source: Efimenko (2007 pp5)

An electronic fare collection is a system in which cards are used for coins or tokens to pay for transit rides. The purpose of an electronic fare collection system aims to reduce the expenses in handling and to protect transit revenues, and provide customer convenience.

Automated vehicles (AV) have a great potential to change travel and transport fundamentally. Not only will the technology reduce crashes, increase values of travel time, and reduce energy consumption and pollution, but also increase mobility and accessibility for all. Several studies have been reported to explore the potential applications of automated vehicles in many areas of urban transport (e.g. Amey *et al.*,2011, Anderson *et al.*, 2014, Begg 2014, KPMG 2012, Lutin *et al.*,2013; Schoettle *et al.*, 2014).

Automation in public transport is increasing globally, and it includes both automated voiceovers at bus stops and real-time updated schedules and even driverless buses. Many projects are underway to develop driverless buses to work alongside existing public transport options. However, there have been challenges to the development so far, as it relates to city streets being such an incredibly complex place to navigate.

For instance, in La Rochelle, an Automated Road Transport System (ARTS) was demonstrated, including a fleet of 6 automated buses, station/stop facilities and a control centre. The buses had a riding capacity of 10 passengers and were equipped with GPS and other sensors for vehicle positioning and radar and laser for obstacle detection. A pioneering EU-funded project, "CityMobil2", has begun testing automated road-transport systems to improve mobility in cities. The system operates using GPS, cameras, radars and obstacle-avoidance technology, enabling them to function using existing infrastructure (Adriano *et al.*, 2014).

The most popular signalling system used is communications-based metro control, which means the exact positioning of the train is monitored and regulated at all times. This information increases efficiency and capacity by safely reducing the headway between trains on the same line. The train's location is determined using track and onboard data wirelessly transmitted to a central control facility, which manages all trains in the system. Central control means that service can be adjusted quickly to respond to delays or accommodate crowds and better real-time information (Adriano *et al.*,2014).

ITS technologies applications vary from basic management systems such as car navigation, traffic signal control systems, container management systems, variable message signs, automatic number plate recognition. This is also speed cameras to monitor applications, such as security CCTV systems. It also varies from more advanced integration of live data to feedback from several other sources, such as parking guidance and information systems, weather information, bridge systems, and the like. More so, predictive techniques are being developed to allow advanced modelling and comparison with historical baseline data. Some of the applications are described below (Adriano *et al.*, 2014).

Vehicle Re-Identification

Vehicle re-identification methods require sets of detectors mounted along the road. A unique serial number for a device in the vehicle is detected at one location and then detected again (re-identified) further down the road. Travel times and speed are calculated by comparing the time when pairs of sensors detect a specific device. This can be done using the MAC (Machine Access Control) addresses from Bluetooth devices, Research Board Annual Meeting (2009)

GPS Based Methods

An increasing number of vehicles are equipped with in-built GPS (satellite navigation) systems that have two-way communication with a traffic data provider. Position readings from these vehicles are used to compute vehicle speeds, as illustrated in figure 6.

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Figure 6: Advanced Real-Time Information Technology Applications in Transport
Source. After Sultan Zhankaziev, 2017

Generally, partial or full vehicular automation will enhance traffic safety by reducing the driver‘s workload regarding vehicle manipulation, vigilance, and human errors; since it has been established that 95% of road accidents are human error-related. By using the full potential of intelligent traffic management systems, where the vehicle is of a high degree of automation, it is estimated that traffic congestion can be reduced by about 50%, 8% fewer traffic accidents and a 5% reduction in CO_2 emissions and fuel consumption in urban situations. In the long run, traffic congestion will be reduced; safety will be enhanced to produce a virtually collision-free environment; driving will be predictable and reliable, James *et al.*,(2016).

The public transport system in Nigeria

Vehicle ownership has increased tremendously in Nigeria for the past decades. Vehicle ownership was 35.3 million in 2018. It will increase to 48.7, 66.2, and 76.1 million in 2030, 2040, and 2050, respectively (NBS 2017). Therefore, car owners do not realize the important role of public transportation in society as against the other Nigerians who rely on public transportation to take them to work, shop, and worship. For many people, especially low-income and welfare-dependent families, public transportation is the only source of mobility. There is, therefore, the need for adequate, affordable and efficient public transportation in the country.

Following the growth in transport demand and consequent negative effects, sustainable transport policy has been adopted in many parts of the world to deal effectively with the threats and simultaneously provide optimal mobility and access. In this vein, the Federal Government of Nigeria (FGN) in 1993 introduced National Transport Policy (NTP), which aims to achieve sustainability in the transport system. From every indication, Nigeria’s transport infrastructural facilities reveal that the NTP has not positively impacted the transport policy formation.

With a land area of about 910,768 sq. km, a population estimate of 170 million people and a GDP-growth rate of 6% per annum, it becomes obvious that real-time mobility advancement is none negotiable if the country would ever compete with the rest of the world. Although, given the glaring deficit in the transport infrastructure, the government has adopted the Public-Private-partnership (PPP) initiative in alignment with global trends in transportation infrastructure development. Road infrastructure development via the PPP model remains in the infant stages while rail is still in the conception/design phase. Only one successful example of concession exists in the Nigerian Aviation industry, ITS infrastructure in the country is still a mirage.

The public transport system in Nigerian urban centres has been facing numerous challenges despite the effort of the various government levels in improving the sector. The complex and heterogeneous traffic pool largely dominated by private vehicles and substandard public transport systems is the bane of the long waiting time, heavy congestion and pollution of the urban environment in our cities. This situation is further exacerbated by the declining service delivery and the inefficiency of the existing urban mass transit bus services. Figure 7 demonstrated a typical public transport passenger boarding scene in Lagos, Nigeria, before the radical intervention of the government with BRT and the Light-rail system.

Figure 7: Passengers boarding public transport and congested street in Lagos before the present Light-rail, Nigeria

Source: Google 2020).

Public transport service in Nigeria is provided by both the government and private operators. While the government’s fleet is well organized, the private transport service providers are poorly organized. Due to the complex problems associated with the private operators of public transport in the country, the Federal Government established the Federal Urban Mass Transit Programme in 1988 to alleviate the transport situation in Nigeria urban centres. Through this programme, State Transport Corporations were established and assisted with buses and training to actualise the programme's objectives. The diversity of vehicle models in the fleet of operation is the major problem affecting vehicle maintenance. Therefore, government-owned transport corporation services are better patronized by travellers because of the comparatively lower fares and security compared to private operators.

Bus services offer several advantages compared to other public transport modes, such as high accessibility and mobility, operating costs that are beneficial for short trips, easy and uninterrupted lane movement and relatively low maintenance costs. Bus service is best in meeting the transport requirements in terms of fare and flexibility and is thought to be especially favourable to the poor. Before introducing mass transit in 1988 in Nigeria, several urban centres were already being served by conventional: mini-buses, taxis and adapted vehicles known as "*molues*", particularly in Lagos (Ikya, 1993). Many public transport problems include severe deterioration of roads, insufficient and poor public transport vehicles with poor maintenance, high rate of breakdown, very low speed and insufficient capacity, which produces inadequate services (Tyson 1991). All these throw light into the demand-supply imbalance. Then, there were the informal public transport vehicles offering more flexible service than mass transit.

Typical public transport demands vary dynamically over time, as shown in Figure 8, indicating the peak period frequency distribution per day. The demand typically has a pronounced peak in office resumption hour and a more extended peak in-office closing hour, with demand slowly tapering out into the daytime, night, and dawn.

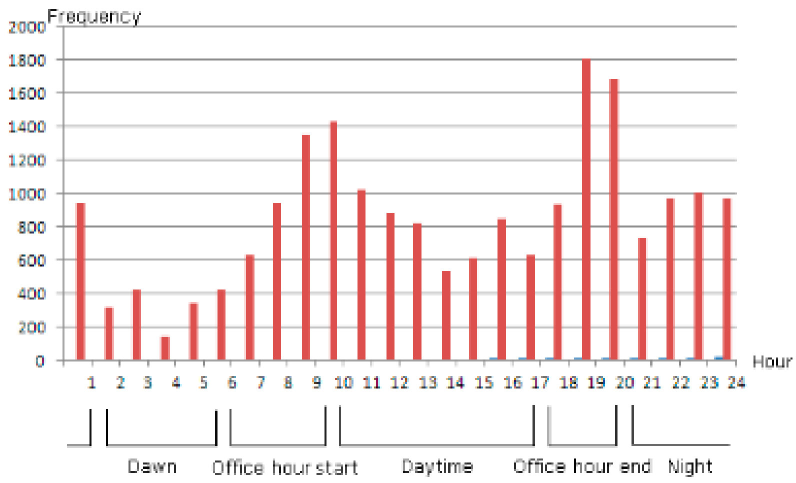

Figure 8: Daily hour clustering (Google, 2020)

However, many of the vehicles used as informal public transport are noisy, smoky, rickety and jolting, posing specific environmental problems to the road users and non-road users alike (Fadare 1998). In most cases high accident rate was recorded among para-transit operators (Bolade 1991), revealing the operators' carelessness and low level of skillfulness. Studies have revealed that 95% of public transport vehicles in Nigeria are second-hand vehicles, some of which are rickety with smoking engines that emit poisonous gases. These

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include carbon monoxide, nitrogen oxide, volatile compounds, and lead into the environment, posing health risks to motorists, commuters and even the ecosystem.

Nwaogbe et al. (2013) evaluated the overall efficiency of the transport system quality in Abuja in terms of efficiency. They observed that the current efficiency of the organized bus transit operators in Abuja was poor. In another related study, Ugboaja (2013) observed that the extent to which the Transport Policy enhances Social Sustainability in Nigeria was below average. This implies that the policy had little or no influence in reducing Nigeria's transport system’s negative social impact.

Public transport governance

Transport economics have generally established the relationships among transport, growth, income and governance, which require no further investigation. Therefore, as a major factor in transport management, governance requires special attention to enhance transport delivery and services (DBSA, 2008). The concept of transport governance is closely linked to the theory of social capital. The OECD defines (transport governance) social capital as ‘‘(transport governance) networks, together with shared norms, values and understandings that facilitate co-operation within and among groups’’ (Helliwell, 2003, p. 9). The transport infrastructure sector is often viewed as susceptible to corruption (World Bank, 2008); Corruption in transport projects can account for as much as five to twenty percent of transaction costs (TKP, 2008).

Globally, mixed experiences of public transport governance systems exist, although good governance, inclusive transport and socio-economic development are closely intertwined (Keefer and Knack, 1995). Inclusive transport fosters growth and enhances the contribution of civil society in promoting a more equitable distribution of transport infrastructure assets and services, including their accessibility (Mashiri *et al.*, 2008). Transport governance can perhaps be viewed as ‘‘the single most important factor in eradicating isolation, deprivation, access problems of marginalised, peripheral and disadvantaged communities in developing countries (Mashiri *et al.*, 2007; Chakwizira, 2008).

However, the poor understanding of public transport governance arrangements belies its importance. In 2005, a team of experts from the University of Toronto in Canada reviewed the factors that contribute to ‘best practice’ in urban transport and concluded that the most critical requirement is effective governance, and even more important than finance, infrastructure and urban land-use planning (Kennedy *et al.*, 2005). A failure in governance will often lead to poor decision-making processes, compromised accountability and sub-optimal service delivery (Chakwizira and Mashiri, 2008). Although, the question that begs for an answer is “which comes first”, economic development, then transport investment or

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transport investment, then economic development or good transport governance before both transport investment and economic development? This perhaps underpins why most African countries are still underdeveloped.

Governmental policy on transport is paramount in general mobility and national development. For instance, in March 2011, the European Commission adopted the White Paper - Roadmap to a Single European Transport Area 2, which proposes a series of policy measures to achieve the 60% GHG emissions reduction goal to 2050 compared to 1990 levels. For the transport sector, this translates to a reduction in GHG emission to about 20% below their 2008 level while still meeting up with the mobility demand (EU White Paper on Transport, 2011).

2. Discussion

In African countries, particularly Nigeria, the transport system is lopsided as more than 80% of goods and service movement depends on the road system. The level of urbanization in those countries does not correspond to the transport infrastructure development, hence the poor level of mobility and poverty in the continent. Diverse activities in the urban area led to the development of different functional spaces within the urban area. The urban population lives and works in these spaces, whose spatial characteristics can be expressed by its spatial location. Daily travel activities always happen between different functional paces. To some degree, urban functional space distribution determines the spatial characteristics of urban population travel behaviour characteristics.

Nigeria does not manufacture vehicles even though there are some moribund assembly plants in the country. More so, the value system encourages private car ownership aggravated by the oil boom of the 70s. Public transport is relegated to the background due to the lack of inclusive governance. The few available public transport operators are bleeding financially due to lack of access to capital and therefore operate outdated second (tokunbo) vehicles that are not environmental friendly in the country.

The spate of global warming and climate change impacts across the world and the urban traffic gridlocks necessitated the crusade for the Smart city in the form of green mobility and ITS technologies. Nigerian roads lack basic infrastructure amenable to automated vehicles for efficient service delivery and real-time transport management. The existing public transport operating system is least desired as it is characterized with all forms of negativities even though the poor masses are captive to it.

The advancement in ICT and its adoption in the transport sector has metamorphosed into the present-day global village, smart city, smart mobility, smart economy, smart people, and smart government. This is a crusade that no African city has attained and can attain shortly, going by the present technological advancement and political system.

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3. Recommendations

Based on the discussion above, the following recommendations are hereby given:

i. As a matter of urgency, the government should invest in the economy's public transport sector to enhance modal split; while introducing transport policies that discriminate against private vehicles intermittently during the traffic peak hours.
ii. The government at all levels should create an enabling environment for a more robust functional public-private partnership in the transport system.
iii. As a matter of urgency, the government should formulate a realistic transport policy that graduates into an automated transport system for the country.
iv. Smart city crusade should be seen by African countries and Nigeria in particular as a panacea to the major environmental challenges and not as a continental discriminator tool.
v. Inclusive city planning should be enhanced for a sustainable transport management system, particularly in the transport sector.
vi. The Federal Government should begin implementing strategies to help the country attain Automated Highway System (AHS) that will dovetail into the smart city system.

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DII-2021-032

FRAMEWORK FOR OPTIMISING COMMERCIAL PROPERTY INVESTMENT OPPORTUNITIES IN AFRICA

Jan Jacobus Gouws[1] and Brink Botha[2]

Abstract

Property development and property investment is traditionally a fundamental pillar for economies, a significant contribution towards the GDP, and an asset class for several organisations and individuals who seek to increase or protect their wealth. Currently, several indicators promote that the African conditions may provide a high yield for investors. Yet when visiting many African countries, one regularly finds numerous incomplete projects and dilapidated buildings. The purpose of the study is to find a scientific basis of measurement and provide a practical framework to use in the analysis for market entry or for the established developer to assess the current environment towards strategic choices within their property portfolio. The research proposes an investigative framework with the leading independent variables of; Risk management, PESTEL, and Benchmark, External Influences, African Philosophy, Demographics, Strategic Path, Viability, and Feasibility. The methods adopted in this scientific study to test the framework are measured both on a qualitative and quantitative mixed-method approach. The primary data relies on a questionnaire distributed to build environment professionals and investors. The qualitative data collection involved an interview with a director and head of Africa Real estate with Momentum Global, an established organisation highly invested in African commercial property. The secondary data relies on an extensive literature review and a property conference and travels to Nairobi and Kigali. The measurements indicate the impact of the eight independent variables concerning the dependant variable of perceived successful optimisation of commercial property investment opportunities in Africa. The study results guide a tailored approach in managing the commercial property conditions on the continent. With high trend forecasts and a high potential for economic growth, the opportunities are evident for some countries on the African continent. It is critical to identify the numerous risks when investing in Africa. A resourceful property investor will be able to make an informed selection of where these opportunities are and benefit from some of the highest yields in the world. Africa is changing at a rapid rate. A developer who analyses and understands these essential aspects could optimize commercial property investment opportunities in Africa successfully.

Keywords: African Real Estate; Commercial Property; Property Development; Property Investment Framework; Property Optimisation

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1.0. Introduction and Background

In the last two decades, the World Economic Forum states that half of the fastest-growing economies have been Africa. (Signé, 2018) The World Economic Forum also predicts that by 2030 the African middle class will have increased from 39.6% to 43%, which will grow the household consumption from $1.1trillion in 2015 to $2.5 trillion. Africa has substantial room for growth (Signé, 2018)

The African Union aims to empower many countries (AU) by establishing the African Free Trade Area (AfCFTA). (African Development Bank, 2019).

Data from the United Nations Economic Commissions for Africa predicts that by establishing such a union, intra-African trade can potentially increase by 52% in less than five years, where it is currently less than 20% (Jadesimi, 2019). Trends also suggest that the African marketplace is expanding, powered by rapid improvements to technologies, infrastructure and mobile penetration. Together with this, an ambitious generation is on the rise, with high potential for developments and business growth (Jadesimi, 2019).

The commercial property market is extremely competitive because of the high potential for capital growth. These fixed property assets can generate wealth and empowerment for many years. However, it can also create significant financial loss if not well controlled or developed without considering risks. (Signé, 2018)

It is essential that developers and organisations within the continent successfully control and implement projects to comprehend the current circumstances and requirements first hand. Alternatively, the market and resources are exploited by external developers who do not necessarily assist in reducing poverty and the inequality gap. (African Development Bank, 2019)

African countries have frequently been exploited for raw materials, minerals and even human capital (Lovejoy, 2012, pp.1-3).

Commercial property investments in Africa is not optimised to their full potential. Africans understand the local marketplace, conditions and trends, best. Financial institutions are starting to see the potential and offer entrepreneurs support if a viable and feasible business case arises. Companies with high financial standings could invest capital within the continent rather than abroad to uplift the continent. Thereby increasing skills, access to technology and creating opportunities, attempting to reduce the poverty gap. Developers should also not just

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focus on capital gain but also need to address the humanitarian strategies. Planning a sustainable strategy for development can offer the majority of the United Nations sustainable development goals. (dpicampaigns, 2018)

In the last two decades, the World Economic Forum states that half of the fastest-growing economies have been Africa. (Landry Signé, 2018)

A Harvard Business Review describes Africa's markets as filled with a new possibility to be cracked open. It also highlights that it has some of the world's most significant opportunities. However, Western business is not yet exploring this potential and losing ground fast to countries like China. (Chironga et al., 2016)

The World Economic Forum also predicts that by 2030 the African middle class will have increased from 39.6% to 43%, which will grow the household consumption from $1.1trillion in 2015 to $2.5 trillion. Africa has substantial room for growth. The commercial property market is extremely competitive because of the high potential for capital growth. These fixed property assets can generate wealth and empowerment for many years. However, it can also create significant financial loss if not well controlled or developed without considering risks. The rising marketplace in developing African countries with high GDP rates might offer the potential for investment, where there are right political and economic conditions provided and risks managed well. Supported by an African Union and implementation of the Continental Free Trade Area, it may improve inter-trade between the countries and enhance opportunities. (Landry Signé, 2018)

Commercial property investments in Africa are not optimised to their full potential. The study aims to investigate traditions of property development and assess how these factors are applicable or adapted for African conditions. The application of eight variables which include: a system of Risk Management; PESTEL and Benchmark Analysis; External Influences on the African continent; African Philosophy; Demographic Trends Analysis; Strategic Path; Feasibility Studies, and Viability Studies, will have a positive influence on the optimisation of commercial property investments opportunities in Africa. In order to test the hypothesis, extensive consultation and preliminary investigation toward the existing body of commercial property was undertaken. The study aims to test the relationship between the variables in order to establish dependability.

The essential objective is to provide a resource for the property investor to undertake an informed investigation of opportunities and provide guidance on selection or optimising their existing commercial property assets in Africa. This research aims to investigate opportunities and formulate a sustainable strategy from a local African perspective.

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2. Literature Review

Framework for optimising commercial property investment opportunities in Africa

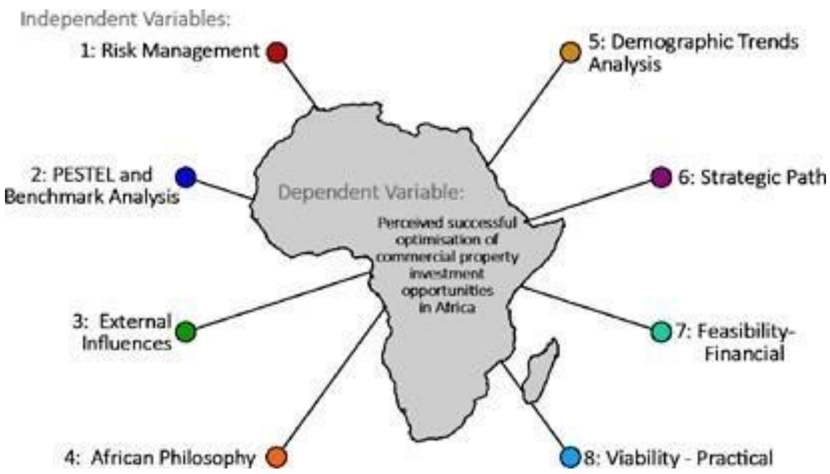

Illustration 1: Methodology structure of the theoretical framework for the treatise.
An illustration of the eight Independent Variables concerning the Dependent Variable.
Source: by Author

2.1. Risk Management

Property investment and property developments projects attract various forms of risks. Risk management forms the first construct for the framework, and it is perceived to be a critical element. When risks are not understood and there is no process to manage risks, a project may be perceived as having a low chance of success and not meeting the objectives per the initial intention. (Project Management Institute, 2017)

Deloitte Risk Advisory formulated a strategy and framework titled: ***de-risking Africa, unlocking Africa's value for potential investors and organisations who enter the African marketplace***. The opening statement: "Doing business in Africa is successful only when you do so with your eyes wide open and by deliberately managing risks and opportunities". (Deloitte & Touche., 2016)

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From an organisational level of managing risks, one can note that the minute an organisation moves outside the operations' borders, the risk exposure will increase. (Deloitte & Touche., 2016)

The framework reviewed for this research and applied to most risk strategies is Project Management Body of Knowledge (PMBOK) principles, discussed further.

The process diagram below is adapted and interpreted by the author from the PMBOK® guide. It is specifically illustrated to visualise a spider web. A spider web symbol can be threatening for the victim yet provides opportunities for food provision if it is positioned in the correct catchment area. The web could be broken or challenged in areas, but the structure remains if it remains maintained and repaired. It provides a visual interpretation of the Project Risk Management process, as outlined in the PMBOK® guide.

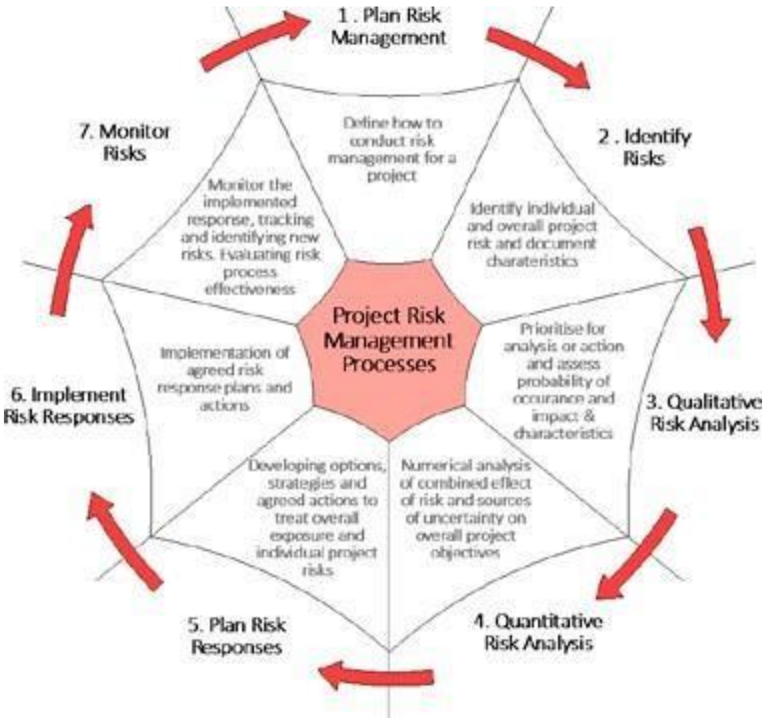

Illustration 2.1: PMBOK Project Risk Management Process
Source: By author interpretation on the PMBOK® guide for a risk management process. (Project Management Institute, 2017)

2.2. PESTEL & Benchmark

Macro Environments

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Corporations use frameworks such as PESTEL and Benchmarking to identify key trends and market environments.

A current example of a significant disruption is the COVID-19 pandemic, which can be described as wreaking havoc worldwide. It reshaped the immediate demand, and there are definite winners and losers as a severe effect. Unfortunately, the hospitality industry and face-to-face interaction are one of the hardest hits and the demand for services that can be done remotely, in contrast, saw a significant surge. The effect on some businesses will be long lasting, and others may not be able to recover. (Abay et al., 2020)

The future can never be entirely predicted, but organisations, entrepreneurs, property developers, and investors need to analyse the markets and environments carefully to take advantage and anticipate such changes. (Johnson et al., 2017, pp.33)

Pestel Analysis

The PESTEL analysis can examine six significant political, economic, social, technological, ecological, and legal factors. This list of factors underlines the market and the non-market environment. (Johnson et al., 2017,34) The PESTEL framework is also fundamental to compare countries' market characteristics of entry. It is a standard procedure to rank country markets against each other on the framework criteria and choose countries with the highest relative scores. (Johnson et al., 2017, pp.289)

The objective of the PESTEL is to provide a comprehensive overview and analysis of the broad macro-environment and feed into forecast and scenario analysis.

Benchmark Analysis

While a PESTEL analysis provides organisation guidance on the strategic position in the macro environment, Benchmarking analysis may indicate strategic choices.

Strategic choices indicate organisations to how they relate to competitors in terms of business strategies. It can also compare the organisation in terms of its corporate portfolios. It can primarily indicate how far organisations should extend internationally and provide guidance to products, industries, and markets to peruse.

There are mainly two approaches to benchmarking:

- Industry benchmarking measures an organisations' performance with other organisations in the same industry or sector.
- Best in class benchmarking can compare the organisation against another that is considered best in class performance.

The benchmark is useful as it is simple, and in cases, the data is relatively easy to extract for comparison. It provides a good baseline and can be used to measure improvements or deteriorations.

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2.3. External Influences

Slavery

Slavery has been a critical phenomenon and shaped the socio, economic and political order of Arica. Slavery occurred in many places from antiquity, but it has been connected to African history and has lasted long into the continent's twentieth century. (Lovejoy, 2012, pp.1-3)

Colonialism

Colonialism impacted underdeveloped African countries in many ways. Many argue that it brought about western education and western civilisation to the African shores for positive development. On the surface level, aspects of it may be accurate. However, once a critical analysis is performed, it will highlight the adapted colonial education's hollowness.

Previously Africans were good technologists and advancing within their own resourced of sculpting, carving miners and blacksmiths. They were able to provide for various African societies. However, the education provided abandoned some of these skills and focused on reading and writing to promote production and exports. (Ocheni and Nwankwo, 2012)

Neo-colonialism

Since the second world war, many African countries have become independently governed, yet a new term erupted called neo-colonisation. It traces back to colonialism in many forms, where the colonies' dominance remains present, but there is no longer direct political leadership. The countries still needed some capital inflow, and in many forms, this was debt from former countries, and as surety portions of land, resources and labours were provided. (Makhanya, 2019)

Globalisation

Globalisation refers to increased integration through economic exchanges, political configurations, technological advances, and cultural influences, which are integrating globalisation factors today.

Through the centuries, the African continent has been very susceptible to external forces. Currently, there are significant influxes, and it is viewed by many as the last developing frontier. (Shepard, 2019)

African Philosophy

Background on African Philosophy

According to the African, man is not half natural or half supernatural but wholly natural, and man's philosophical principles are equality and brotherhood of men. With these philosophical principles in mind, it is clear that socialism and communism are not groundbreaking for Africa. For other societies with stern class culture and firm social position, the transition to socialism is radical. (Kebede, 1999, p.5)

Existing Models in African Philosophy

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Four schools of thought exist in African Philosophy, namely: 1) ethnophilosophy; 2) philosophic sagacity; 3) national and ideological philosophy 4) professional philosophy (Kebede, 1999, 4)

Ethnophilosophy

Ethnophilosophy proves that African philosophy exists in the same right as all the world's philosophies, literature. In ethnophilosophy, individuals' interpretations are hidden under a collective blanket and recognised with an ethnic group. This communal philosophical school of thought aims to give the philosophy more authority by getting the approval of an entire society or ethnic group, thus enforcing the philosophical statement's belief and truthfulness more powerfully. (Kebede, 1999, 7)

Philosophic sagacity

Philosophic sagacity developed from the shared, fundamental, conventional beliefs of a society or culture. These beliefs include a variety of critical human concerns, topics and questions such as God's existence, the nature of time, freedom, death and education. (Hallen, 2002, pp.52-53)

National and ideological philosophy

National and ideological philosophy focuses on traditional African socialism and the notion of Ubuntu, the communal welfare of society, to achieve a trustworthy and effective liberation of Africa. (Kebede, 1999, p.4)

Professional philosophy

Professional philosophy rejects the notions of Ethnophilosophy, which is based on collective thinking. In professional philosophy, only works based on rational and critical reflection is worthy of being called philosophy. (Kebede, 1999, p.4)

African Philosophy and Property Investment

Philosophy does not only exist to communicate or capture wisdom. Philosophy also provides practical guides to life and human experience. (Hallen, 2002, p.28)
According to Nyerere, "the creation of wealth is a good thing and something we shall have to increase. However, it will cease to be good the moment wealth ceases to serve man and begins to be served by man." An attempt to restore Africa will only be successful if the focus is on humanistic values rather than Western capitalism's exploitative interactions. (Kebede, 1999, p.6)

If development stands for proving oneself, Africans have nothing to prove. Instead, they only have desires which they must overpower to look after the welfare of the community. Real development would require a competitive spirit urging Africa not to copy the West but rather to realise itself through ordinary takeovers. (Kebede, 1999, p.11).

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Demographics And Property Investment

Demographic trends provide multiple challenges to commercial development; however, they provide lucrative opportunities. A developer who understand the changes in demographics will have a competitive edge. These demographics include current age groups, population, gender, income, migration patterns, and unemployment rates. (PNC Insights, 2019)

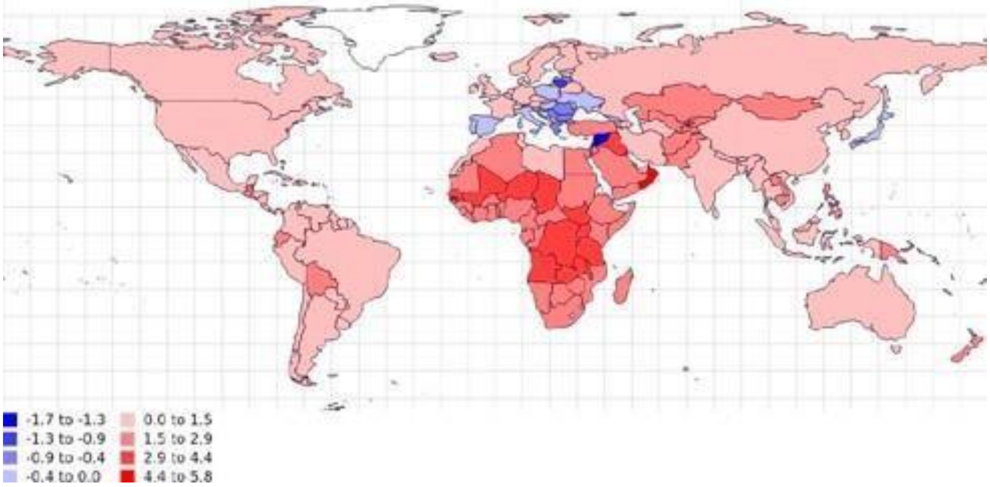

Illustration 2.2: 2015 Fertility World Map, Indicate the high fertility rates on the African continent compared to others.

Source: https://www.populationpyramid.net/hnp/population-growth/2015/
Image source: https://www.populationpyramid.net/africa/2019/

The graph below indicates the historical and projected population growth rates. Africa will likely be one of the continents with the highest populations and close Asia's gap at the current rate.

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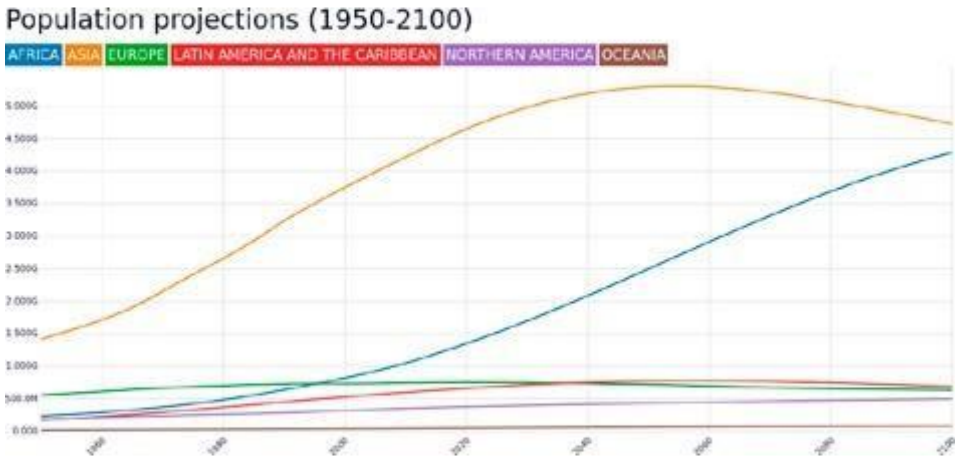

Illustration 2.3: Population Projections 2100 for Continents
Image source: https://www.populationpyramid.net/population-projections/africa+asia+europe+latin-america-and-the-caribbean+northern-america+oceania/

Impact of current demographics for commercial property investment in Africa
Africa, in the long term, certainly have some of the most significant opportunities. In the following 30 years, the world population is expected to increase by 2.2 billion people, and more than half of this growth will be from Africa. (O'Dea, 2018)

It is estimated that by 2034, Africa's working population will reach 1.1 billion and overtake China and India. This boom and consistent urbanisation could give rise to megapolitan areas. Industries will have to develop products closer to demand. (Lowe, 2018)

Strategic Path

Purpose of Strategy
All the people involved with an organisation generally require motivation and purpose to ensure a business's long-term prosperity. It generally answers the two fundamentals of how is the organisation making a difference and for whom?
In this regard, a statement of purpose can guide in terms of mission, vision, values and objectives, and there are generally four ways in which organisations typically define it:

- A mission statement describes what the organisation is fundamentally there to do and clarifies the employees and shareholders.
- A vision statement provides direction and the future the organisation seeks to create.
- Statement of corporate values is used to communicate how the organisation should operate and define the underlying and enduring core principles.

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- The objective statement guides specific outcomes which an organisation seeks to achieve. These are often targets that can be expressed in financial terms, profits, level of sales, or the organisation's value down the line. (Johnson et al., 2017, pp. 7-8)

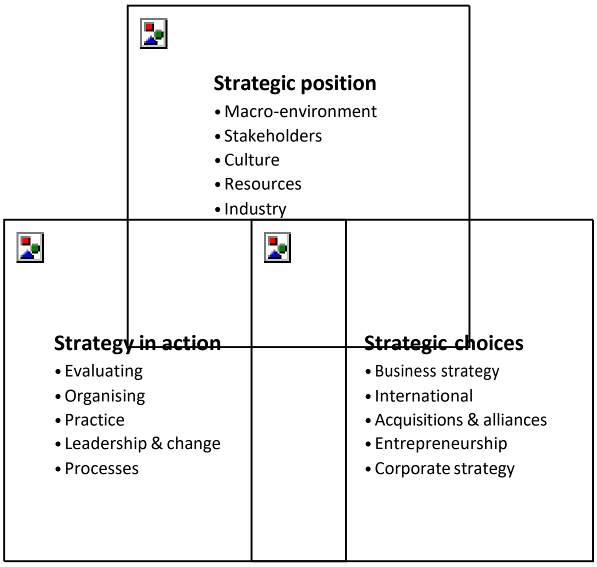

Illustration 2.4: Exploring Strategy Framework
Images source: By author, adapted diagram from the Exploring Strategy Framework (Johnson et al., 2017, p.12)

Strategic path for property development and investment.

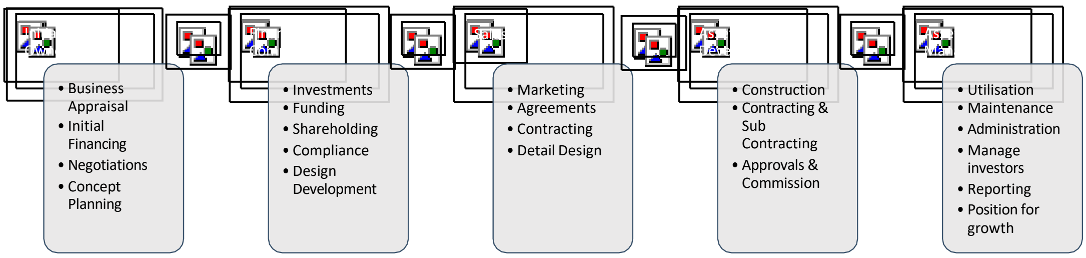

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Illustration 2.5: Real Estate Value Chain Model
Source: Developed by the author from Mladenow, Novak and Strauss, 2015. p.122. Real estate value chain and value-creating activities.

Feasibility

Introduction and Principles of feasibility studies
A feasibility study is the instrument used to evaluate the development's possible success during the planning stage. It is an analytical procedure and an aid for the decision-making process and not a guarantee for success. (Cloete, 2006, p.3)

Purpose of a feasibility study
The feasibility study should provide sufficient information to the client to decide whether the project should proceed. If deemed feasible, it should also provide the form in which it should proceed. (Cloete, 2006, p.8). The feasibility study further provides support to a development proposal, should the finance be sourced. However, the feasibility can only conclude if a project is financially feasible if the feasibility measurement is predetermined. (Cloete, 2006, p.8). In the book feasibility studies Principles and practice, Cloete guides the main components of the feasibility studies, which will be summarised below:
Feasibility of the developer's objectives
The objectives are the determining factor to determine a satisfactory outcome (Cloete, 2006, p.12)

Socio-economic feasibility
Factors of importance to property development include; demographic factors, urban growth patterns, property tendencies, microeconomic factors, trends in the building industry, income and expenditure patterns, local economic conditions and political factors. (Cloete, 2006, p.13)

Physical and legal feasibility
The physical feasibility study will analyse the proposed site for the development and review the physical factors that may influence the site's ability (Cloete, 2006, pp.22-24)

Marketing Feasibility

Cloete recommends a marketing feasibility study to study the demand and supply to determine if the property is marketable. (Cloete, 2006, p.24-25)

Demand analysis analyses the current and future needs relative to a specific type of property.

Supply analysis reviews the amount of space available for the current and future market at given price levels.

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Merchandise analysis identifies the marketability or the uniqueness.

Financial Feasibility

The feasibility study's final component is to determine if the project satisfies the developer's financial requirements. This analysis is regarded as the culmination of the feasibility process, and it is important not to manipulate the figures at this stage to obtain the desired result. (Cloete, 2006, p. 27)

Profitability

For most businesses, profit is the organisation's primary objective, unless their strategy is to take initial losses to gain market share with postponed profits. On average, an ideal profit margin is between 16 and 20% for successful development. (Anderson, 2018)

Finance for Commercial Property in Africa.

South Africa and financial institutions in African countries are moving further into First World best practices. As these markets become more attractive, it will increase competition for the local clients from the increased international competition. Failure of any financial institution to compete in the global sector will harm the African sentiment. (Wight and Ghyoot, 2005, p.183)

Viability

The distinction between feasibility and viability

Botha indicates that both feasibility and viability are vital factors that affect the property development process's success. He further found in research that there is often a misconception between the two concepts. (Botha et al., 2016. p.136)

Feasibility and viability are both tools utilised in the investment appraisal of a project and its sustainability. Feasibility aims to assess the workability and profitability of a business. Feasibility paves the way for viability as it depends on a business's profitability to survive amidst tough competition. In a business sense, feasibility is characterised by analysis, estimated projections, calculations and several other factors. In comparison, viability deals with business tactics, objectives, and strategies to ensure its sustainable life. Where business growth and sustainability are some of the main aspects of viability, feasibility is concerned mainly with profitability and workability. (Aron, 2011)

One often encounters that feasibility is used in financial factors, whereas viability is often coupled with economics and the physical implementation of a project.

3. Method

Rationale of the Study

The outline of the study is formulated around the guidelines of Leedy and Ormrod of Practical Research Planning and Design (Leedy and Ormrod, 2014).

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The methodology seeks to gather data for the framework and measure the eight independent variables; Risk management, PESTEL and Benchmark, External influences, African Philosophy, Demographic Trend analysis, Strategic path, Feasibility and Viability against the Dependent Variable; Perceived successful optimisation of commercial property investment opportunities in Africa. The essential rationale for the study is to evaluate these eight independent variables and measure the relevance of the relationship against the dependant variable.

Research Method, Approach And Design

Property development in its nature is not an exact science. Architecture and developing the building product is, in a sense, a form of creative art and will always be subjective to opinions and differences in objectives. These aspects and opinions can only be measured in qualitative measures. As the sector constantly changes and advancements in technologies increase, a property development that made sense a decade ago might not make sense in the current circumstances. (Edwards B. and Naboni E., 2013)

On the other spectrum, property development produces an object and an asset, which is required to perform based on the economic and socio objectives. Various physical aspects are quantifiable, such as development costs, gross area and profits. These aspects form a significant part of the reporting on the performance and management of the property. (Landry Signé, 2018)

The constructs, such as African philosophy and external influences, have very complex nuances and are opinion- and experience-based. (Kebede, 1999, p.11)

In contrast, analytics and evaluation constructs such as feasibility and demographics are based on performance measurement and statistics. (Botha et al., 2016. p.129)

Therefore, the measurement of the eight independent variables is structured around both a quantitative and qualitative method.

This decision is substantiated in the writings of Leedy and Ormrod. The research problem must drive decisions regarding the method design. Some problems can call for qualitative data, and some call for quantitative data, but some call for both. (Leedy and Ormrod, 2014, p. 258)

The research also draws from Bryman the following reasons for using the mixed method (Bryman, 2006).

"Complementarity: Quantitative aspects of the study can compensate for weaknesses in qualitative research, and vice versa. For example, the results of unstructured interviews with only a small number of individuals can be replicated by administering a questionnaire to a larger, more representative sample."
"Triangulation: A researcher can make a more convincing case for particular conclusions if both qualitative and quantitative data lead to chosen conclusions."

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"Resolution of puzzling findings: In a quantitative study, various results can sometimes seem inconsistent or contradictory; qualitative data may reveal underlying nuances and meanings that can help the researcher make sense of the numbers." (Leedy and Ormrod, 2014, 259)

The research is not necessarily formulated with regards to a customary research question and sub-questions. However, it does formulate a research tool that is a form of scientific measurement of 'cause and effect' and testing the hypothesis. The writing of Leedy and Ormrod also defines the variable and the independent variable. They describe the variables as the investigation questions and an integral part of the investigation and focus of the research's hypotheses and research questions. (Leedy and Ormrod, 2014, 40)

Research Area and Targeted Respondents

Primary Data - Survey outline and results

The web-based survey provided a tool for reaching respondents involved with property development and investments in Africa. The survey targeted various directors in the built environment, property developers and high-level strategic positions in the built environment sector. The total number of responses received for the survey was 58. The sample group consisted of the following disciplines:

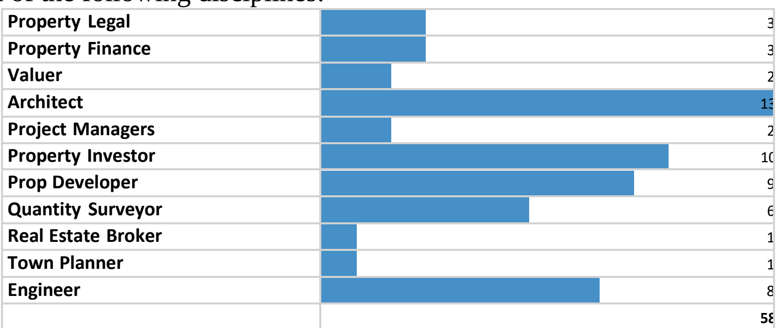

Illustration 3.1: Survey sample group and disciplines

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Source: by Author

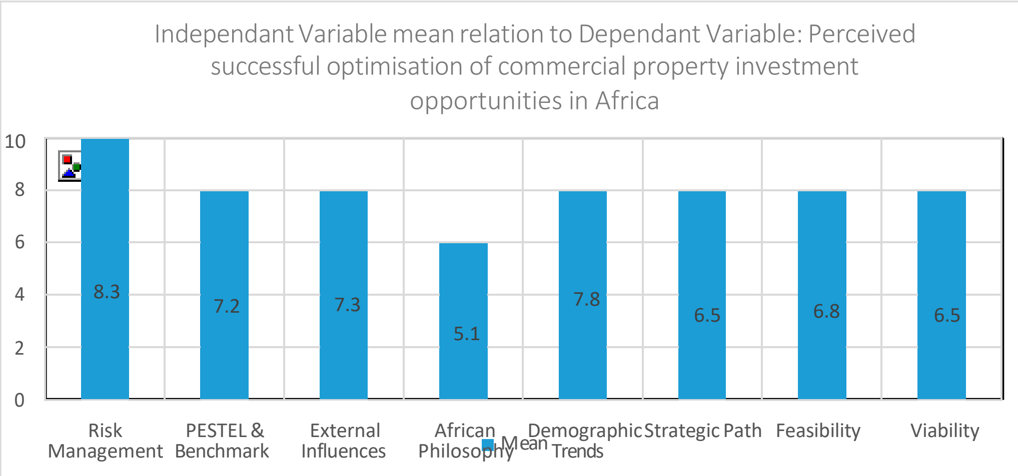

Illustration 3.2: Summary chart of the survey mean
Source: by Author

Primary Data - Interview outline and results

Although during the research, various conversations were held with property developers and investors. The researcher was fortunate to contact and conduct an interview for primary data with David Lashbrook, the Director and Head of Africa Real Estate at Momentum Global Investment Management. This interview was selected as a primary source due to Momentum's vast experience in property investment and commercial property development in Africa.

To provide a brief background, Momentum Metropolitan Holdings Limited is the third-largest life insurance organisation in Africa. It is listed on the Johannesburg Stock Exchange (JSE), and as of January 2019, the market capitalisation was over $1.5 billion. (Momentum Metropolitan Holdings Limited, 2020)

Momentum Global Investment Management (MGIM) has been the international asset management and investment arm of Momentum Metropolitan Holdings Limited. Around September 2019, MGIM was responsible for the excess of $5.2 billion in institutional and retail investors worldwide. Together with Eris Property Group, it is a leading property and management company in Africa. Eris is a 73.75% subsidiary of MMI Holdings Limited and develops and invests in commercial property in many countries on the African continent. (Momentum Metropolitan Holdings Limited, 2020).

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Secondary Data- Literature review

An extensive literature review was conducted at the beginning of the research, as per the mixed methods process in the writings of Leedy and Ormrod (Leedy and Ormrod, 2014, p. 262). The related literature review provided the concrete foundation and fundamentals on which the primary data collections were based.

Secondary Data- Nairobi property conference

On the 4-6th of December 2019, the researcher travelled to Nairobi to attend a conference. The benchmark's early findings indicated that Kenya had extensive GDP growth and viable socio-economic and political conditions for development. The travels were also extended towards Kigali in Rwanda, which indicated high rankings in the Economic Freedom Index, GDP growth, and business rankings.

Data Analysis

The research is based on the four essential qualities outlined by Leedy and Ormrod. (Leedy and Ormrod, 2014, p. 76) These four qualities discussed below indicate how the researcher meets these.

Universality: An equally knowledgeable individual should be able to carry out the research project and essentially obtain results on the independent variables on the dependant variable.

Replication: A competent researcher should use the framework and collect data under the same circumstances and parameters to obtain comparable results.

Control: The research is controlled by focusing on the eight independent variables that can impact Africa's perceived successful optimisation of commercial property investment opportunities.

Measurement: The practice of obtaining the primary and secondary data is measured with appropriate academic and scientific mixed-method research tools.

Delimitation

Although the nature of the study is extensive, some delimitations define the parameters of the research.

1. In order to reach the objectives of the study, it only covers the aspects of the African continent.
2. The target population is limited to the African continent.
3. The study is limited to commercial property investment
4. The study was limited to the eight independent variables

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5. The same amount of questions or weighting was assigned in the survey collection process.
6. The same amount of questions or weighting was assigned in the interview collection process.
7. the focus was placed on obtaining high quality and relevant data rather than large volumes to obtain relevant results and measurements,

4. Discussion

Risk Management

From the primary data gathered, two main aspects can be discussed. The first aspect is the perception of risk in Africa, and the second is managing the risks.

The survey indicated that Africa's risk conditions are regarded as high, and this was substantiated by the interview data that indicate that investing in Africa is still a risky environment. The interview data also stated that their organisation had found no significant improvements in these risks in the past two decades. A contributing factor is that it is difficult to obtain sufficient information on properties and tenants.

The banks also deem the environment risky, and their policies will not allow development finance without a substantial tenant. A significant risk factor for the commercial property investor is the quality of tenants and obtaining long term tenants. The various aspects of financial risks are present, and a significant factor to consider is currency and foreign exchange risk for an entry and exit point.

A contributing factor to the perceived risk is that most countries are still regarded as developing. Many commercial organisations are still establishing while the economy is growing and finding stability. Many international organisations are testing the conditions before committing in full and increasing operations for increased space.

The risk management process discussed in the literature review is the process of PMBOK. Slightly more than half of the responses deemed it a practical process to manage risks. Mr Lashbrook indicated that Momentum Global had developed a process that seems less complicated than the PMBOK process. The data reports an average adoption rate, perhaps because the PMBOK is more tailored and standard toward project managers. The survey had limited responses from professional project managers, which could be why the process is a lower adoption rate.

The interview data indicated a very high demand for competent professionals and the management of the risks during the planning and construction phase of the projects.

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Both data sets indicated that the COVID-19 pandemic had greatly strained the economies and property sector. A high percentage of responses indicated that it would require adjustments or affect long-term strategies. Even a well-established role player in the sector, such as Momentum Global Investment Management, has been affected by an external risk that organisations cannot mitigate until a vaccine is available to all.

Every project is deemed to have its own set of risks. The framework aims to prove necessary in the aspect of identifying and management of risks throughout the process.

Therefore, the data collected dictates that the independent variable of risk management is highly important to the perceived successful optimisation of commercial property investment opportunities in Africa.

Pestel & Benchmark

The primary data collected from the interview indicated that Momentum Global Invest has already adopted a similar process to a PESTEL analysis and evaluated all the Macro factors of Political, Economic, Social, Technology, Ecological and Legal. The survey's primary data indicated the factors of high importance in the African macro conditions: political, Economic and Social to a lesser extent, Legal and the remaining factors of Ecological and Technology.

Mr Lashbrook mentioned that another macro factor to consider is the financial aspects in the country, specifically towards the foreign or local currency and the ease of extraction. In cases, the extraction could be highly delayed and have a high impact on organisations.

There was a high adoption of the PESTEL analysis for property development and investment and can, therefore, be considered an important construct.

Proposed aspects to consider in the Benchmarking that stood out was the GDP per capita, GDP growth rate and the ease of doing business rating.

In the survey, when the question was raised to adopt both the PESTEL and Benchmark, it increased from 67% to 72% on responses compared to the earlier question posed toward the adoption of only PESTEL. As such, there is an adoption and inclusion of both analytical frameworks.

These tools can quickly provide the investor with a strategic position and direction and are already adopted in Africa's commercial property sector. The PESTEL and Benchmark analysis form an essential independent variable regarding the perceived successful optimisation of commercial property investment opportunities in Africa.

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External Influences

Without identifying the influences, the question was strategically asked first in the survey regarding the commercial property's susceptibility towards external influences. This tested high, with 73% of responses deeming it a significant factor.

It can further be extracted from the data that commercial property and Africa's economies are highly susceptible to foreign investments. This is not necessarily a negative aspect and might be essential toward growing the economies. Mr Lashbrook states that Africa needs external support and funding.

In a business environment where small enterprises seem to disappear more often, it could be a significant boost for a smaller developer and investment company to form relations with an external organisation and seek alternative funding.

From the onset, External Influences were regarded as an essential variable and have affected African conditions for many generations. It is fair that external investors should be able to extract profits for risks and investments. However, being part of a global society, the modern corporation must simultaneously pursue social upliftment and protection of the environment for sustainable developments.

The research could further have investigated the formation of public and private partnerships. However, this would be a study where the structures are analysed to assess if development agreements and projects benefit society or only individual parties.

African Philosophy

From the onset, African philosophy's inclusion in the framework has been provided with an evident discourse. Historically, African philosophy has been challenged, and there are still many rejections and debates today between professional philosophers. The discourse further continues in the primary data and is a true testament to the mixed-method approach.

The data collected from the survey indicated that only 45% of responses deem it applicable or relevant to commercial property development. Only 37% considered Ethnophilosophy or philosophical concepts such as Ubuntu considered in commercial property development. About 51% of responses indicated that it could contribute to optimising the property investment strategy.

On the other hand, Mr Lashbrook described African Philosophy as a massive factor. He also provided evidence of the social-economic aspects and challenging philosophies their corporation have found in practice.

From the objective viewpoint of a professional in the built environment, the study of Philosophy is not a regular occurrence. Apart from some notions within the architecture

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schools, the built industry is not primarily focused on studying these concepts. Individuals who pursue the study of philosophy do so in a manner of self-development or reflection.

This mixed-method approach relies on the convergent design and a similar weighting factor applied to African philosophy's independent variable. Thus, the data indicate that African Philosophy is a construct that cannot be disregarded and will have a moderate to high effect on the perceived successful optimisation of commercial property investment opportunities in Africa.

As outlined in the literature review, the survey's limitations could have been addressed by providing more information and clarity of the African philosophy concepts, specifically towards property investment. However, it could also have influenced and skewed the results unfavourably. The respondents might have perceived the researcher to promote a construct if more information were provided on African Philosophy than with the other independent variables.

4.1. Demographic Trends

Studying demographics and conducting a demographic trend analysis is nothing new to property development, where it is regularly used in Urban planning and city infrastructure development.

The survey resulted in a very high adoption, with 78% of the responses viewing demographic trend analysis to provide insight into the target markets. The interview data also provided insight, with Mr Lashbrook stating that it is essential in their analysis and reporting structures. However, the interview data also provided reservations and raised that demographics and economic trends in GDP per capita are vital links.

Both data sets also substantiate that population growth with a weak economy will not contribute much towards commercial development.

67% of the survey responses consider that the large youthful population in Africa can provide a competitive edge and opportunities compared to other established countries with declining population trends. The Interview data substantiate Africa's need to grow the GDP and keep the trend with the US Dollar and beat inflation. The literature also indicated that for Africa to make a demographic dividend possible, there should be supportive government policies, empowerment of women, and increased education and knowledge.

Most of the survey responses considered the available data and demographic statistics to be inaccurate and not readily available, with most finding it inadequate. The interview data also stated that access to information and statistics in Africa is challenging.

The data indicates the significance of a study in the Demographic trends, and the role in commercial property development is evident. Therefore, it forms an essential independent variable towards the perceived successful optimisation of commercial property investment opportunities in Africa.

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The limitation of demographics trend analysis is that it should be done in conjunction with other studies, where consideration is also given to political and socio-economic environments.

4.2. Strategic Path

From the survey data, 64% of responses considered it is challenging to develop a tailored strategy for commercial property in Africa. The interview data confirmed that a strategy should be adaptive and evolving all the time. The interview confirmed that a strategic path is susceptible to external demand and supply factors and requires consistent review. A successful strategy implemented by Momentum Global Investment Management is adopting a build to suit specific long-term tenants.

As results indicate in the survey data, the perceived success rate for development is very average in the industry. The interview data collected substantiate this view and provide various reasons. Mr Lashbrook points out that many developments fail due to the speculative nature of some development. He states that the procurement of a good tenant is essential and that proper due diligence should be performed towards having finance available and the correct management thereof.

Interestingly, both sets of data found that the developers are approachable and transparent about their strategies. This could be attributed to the continued marketing of developments in which they are involved. These building products and the performance of developments often need to be reported to stakeholders, and as such, the information is regularly available.

This discussion is mostly reliant on the interview data, and the limitations on the survey should be noted. The researcher had a negatively phrased question that did not sufficiently test the adoption of a strategic path towards perceived success. More information could have been extracted regarding process models and the influence of strategy in companies. Information could have been obtained to verify the application of business plans, governance and quality management processes.

The data collected from the interview would contribute to an upward adjustment to the strategic path. Therefore, it should be considered an essential independent variable towards the perceived successful optimisation of commercial property investment opportunities in Africa.

4.3. Feasibility

Feasibility studies are also not a new occurrence in the property sector. It is often compiled and coordinated by the quantity surveyors or by project managers in cases.

The literature review highlighted that a feasibility study is not a guarantee for success. It was highlighted in the survey data, with only 28% of responses perceiving it as an instrument for guaranteed success. However, it was regarded high towards decision-making, with 68% of responses indicating the adoption of this process a regular occurrence in practice.

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The interview data substantiate that the feasibility study is used to raise funds. It forms an important aspect, specifically in Africa's perceived risky environment, where investors require due diligence in the reporting.

Confirmation from the survey can be considered that a high percentage of developers, investors, and built environment professionals utilise the feasibility regularly and aid in the decision-making process. The interview data provided a view into the study's application and that aspects such as a merchandise analysis are not always performed for all commercial developments. However, it is highly used with retail developments with numerous tenants, and their product sectors and tenant mixes need investigation.

Feasibility was a founding independent variable of the framework, and the signs have tested high within the industry. Therefore, it is regarded as a high independent variable towards Africa's perceived successful optimisation of commercial property investment opportunities.

4.4. Viability

The data collected for the application in the viability of 65% compared to the finding of 68% for feasibility is very similar. This is also indicative of the literature review, where the co-dependability of these two studies and reporting structures is evident.

The question about subjectivity was explicitly included in the survey to test prejudice in reporting structures. In the interview, Mr Lashbrook also stated that consultants who mostly compile these studies are involved during the planning and construction phase of development. The investor and developer depend more on the buildings' future performance concerning the micro and macro environment. The consultants earn fees on the stages, and if the project is deemed viable and implemented, they would be able to earn more fees. It is, therefore, concern and caution that some subjectivity might become present. The survey data confirm that there is subjectivity found in reporting. Although the ultimate decision remains with the developer, these aspects should be noted.

Investors should approach and appoint reputable consultants to mitigate subjective reporting, build on a sustainable business relationship, and not be short-sighted.

The interview data indicated a high measure by stating that feasibility and viability are equally important on a development proposal. For development to proceed, a project should both be financially feasible and physically or practically viable.

Viability considerations can, therefore, not be eliminated from the framework and indicated high significance. It is a critical aspect and also found to be interdependent of the feasibility. Therefore, it is regarded as a highly variable towards Africa's perceived successful optimisation of commercial property investment opportunities.

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5. Summary, Conclusion and Recommendation

5.1. Summary

After completing the research, it was found that none of the independent variables could be removed as there was sufficient data obtained which substantiated the relevance of all eight variables. However, there was a slight difference in the significance of each variable.

5.2. Conclusion

In Africa, commercial property is unique with its circumstances, as substantiated by the research data. It is not a subject often covered in the literature and, therefore, a critical study. With high trend forecasts and a high potential for economic growth, the opportunities are evident for some countries on the continent. A resourceful property investor will be able to make an informed selection of where these opportunities are. The investor will be elevated to a position of benefitting from some of the highest yields in the world.

However, investments and development in Africa do come with high risks. It is critical to identify these numerous risks and have a process to manage the approach. The risk management process will position an investor to decide on mitigating, adapting or accepting the risks.

An analytical framework developed in the business school, such as a PESTEL analysis, can provide insight into the macro-environment and areas' conditions. A benchmark analysis can be adopted to provide initial indicators towards strategic choices and the social-economic and political performance of countries or areas.

Historically Africa has endured extensive amounts of external influences, from slavery, colonialism and neo-colonialism. The impacts and scars are still evident from the exploitation of resources and human capital, and they will remain with Africa for several years. The new influence of globalisation creates a global society, and people are more interconnected than ever. However, organisations must perform and are held accountable for social and environmental protection and not just extract profits and resources off the land once more.

The African philosophies can differ vastly from the perception of the West. However, ethnophilosophy and ubuntu concepts have significant influences on the economy and developments in African countries. A developer who understands this will have an in-depth understanding of society and thought processes that influence everyday decisions for Africa.

Africa has a high potential to reap the benefits of a demographic dividend in the future. Pending that countries can sustain and provide the right economic conditions and control the fertility rate with increased education, knowledge, and empowering women.

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The strategic path is critical for organisations to direct long-term objectives and targets, specifically for the property sector. All role players must adopt the strategy and follow a collaborative approach to achieve the vision, mission, and objectives.

A thorough feasibility study can provide substantial support for a development proposal. It can limit and mitigate several risk factors and analyses future financial performance. The viability reporting is equally significant and interdependent, which can guide the physical and practical viability of implementing a property development or investment.

Africa is changing at a rapid rate. A developer who analyses and understands these important aspects could be able to optimise commercial property investment opportunities in Africa successfully. Commercial property in Africa will also provide social aspects towards uplifting and advancing the continent significantly.

In the end, the framework is a guide that could be adopted for the approach or alternatives could be developed for a tailored approach for African conditions. In the words of Leedy and Osmond: "No single highway leads us exclusively toward a better understanding of the unknown. Many highways can take us in that direction. They may traverse different terrain, but they all converge on the same destination: the enhancement of human knowledge." (Leedy and Jeanne Ellis Ormrod, 2014, p.95)

5.3. Recommendation

Commercial property in Africa has started to abruptly adapt. In the past decade, the quality of the developments has improved drastically. It is time that investors start to re-look at the investment potential. However, the risk is imminent with every construction project and property investment. Risk management is a significant factor in achieving the objectives within time and budget. Adopting a well-developed process, such as PMBOK, will provide guidance when there is little guidance.

Countries in Africa must invest in infrastructure and urban planning to create environments that can attract foreign investment. African cities do not conform to the West's standards; they are organic and not necessarily developed by the same parameters. It is essential for investors to consider the Macro environment and to plan a strategic direction. A PESTEL analysis is recommended for new entrants or investors who wish to stay relevant within changing environments. External companies need to form joint ventures with local organisations and consultants who understand the conditions. There is a demand for more information to be made available for project investigations and studies. The information could greatly assist with valuation and feasibility studies.

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Most South African financial institutions have started to provide funding for developments in sub-Saharan Africa. By following due diligence and developing business models, new entrepreneurs in the commercial property sector can access finance.

Many new technologies are available in the built environment industry. Buildings that do not consider new technologies and green building aspects will be considered old in a short duration. The African Property awards provide a good platform for developers to engage. However, a Pan- African organisation could be formed to associate property investment on the continent.

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DII-2021-048

Renewable Energy: The Catalyst for a Sustainable Energy Distribution Sector in South Africa

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Abstract

The purpose of this research paper with practical focus is to analyse the potential of renewable energy (RE) as the catalyst for a sustainable energy distribution sector in South Africa (SA) and promote collaboration between the manufacturers, government, and all relevant stakeholders. The research design is a systematic literature review. It uses a qualitative research method through a questionnaire to evaluate the knowledge and views of professionals from the energy distribution sector, managers or leaders in the energy sector, and energy sector experts. The sample size selected is between 350 and 400 participants. The literature reviewed noted that photovoltaic (PV) energy is one of the primary RE sources for sustainable energy generation. Furthermore, installing capacity and investment continue to grow throughout SA. Of note is the value-added through distributed RE systems in respect of electricity provision. The energy poverty in SA is high, and the impact of the Covid-19 pandemic further contributes to the challenges experienced. The general conclusions are that due to global warming and increased large-scale pollution, the use of RE for power generation has become evident. The paper offers the potential opportunities of RE as the catalyst for the sustainable energy distribution sector in SA. Criteria were developed to include or exclude relevant scientific literature by identifying subject relevance, type of technology, geographic scope, intervention scale, and data type.

Keywords: Renewable energy, photovoltaic, sustainable energy, poverty reduction

1. Introduction

Due to advances in information and communication technologies, the world faces a strong evolution, placing knowledge technology based on productivity, competition and power. The world is more interconnected than ever (Vezzoli *et al.*, 2019: 3). Renewable energy sources, such as solar energy (photovoltaic and solar thermal), hydroelectric energy, wind energy, and biomass-derived fuels, have made great contributions to the sustainability of certain countries and have brought various environmental and socio-economic benefits to countries. According to Aliyu *et al.,* (2018: 1), the greatest and broadest benefit is the contribution of renewable energy to reducing local and global pollution, thus helping to alleviate the climate change promised by industrialised and developing countries in the Kyoto Protocol. The rapid expansion of South Africa's renewable energy sector has gained local appeal and international recognition, enhancing the prospects for a low-carbon transition. This requires integrating large-scale renewable energy into national policies and goals related to energy and climate change (Davies *et al.*, 2018: 1). In South Africa, the transition to

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renewable energy is intrinsically linked, to history and contemporary territorial politics, creating new territories. The renewable energy transition acquires an experimental form in the new territory, unfolding spaces and zones of political and administrative exception, allowing political and economic participants to exercise authority and commercial power (McEwan, 2017: 10).

In 2008, the first time in human history that more people lived in urban areas than in rural areas, a phenomenon that had a much greater impact on developing regions of the world (such as those found in Africa and in particular South Africa (Vezzoli *et al.*, 2019: 7). The increasing involvement of citizens in the production, storage, distribution, and use of energy and potential ownership of distribution networks, participation in energy markets and energy service supply is key (Nolden *et al.*, 2020: 1). This paper aims to contribute by analysing the transition that leads to long term RE sustainable energy systems as the global society is faced with a shortage of supply. In so doing, the elimination of greenhouse gasses in all participating energy sectors proves beneficial for all. The relevance of the transition to long term RE sustainability is important in the context of the developing country for economic development. We analyse the existing distribution sector that heavily relies on the generation capabilities of large fossil fuel-based primary energy sources and present our research on RE as the catalyst for a sustainable energy distribution sector in SA. This includes the discussion of implications and the impact of the distribution sector. In particular, solar photovoltaic application systems will be of focus in this paper.

2. Research methodology

According to Mishra and Alok (2017: 1), research methods encompass all techniques and methods used to conduct research, and research procedures are a technique for solving research problems in an orderly manner. It is about learning properly. Therefore, the scientific method for investigations is a methodology (Mishra & Alok, 2017: 1).

It recognises that various role players in the energy distribution industry articulate different views on the needs to be prioritised to mitigate climate change and increase deployment of RE technologies as a catalyst for energy sustainability in SA. This is an attempt to review the initiatives towards the ultimate maximum utilisation of RE. In this regard, most of the published papers fell short in providing comprehensive assessment and contextual critique to address the South African scenario. The main keywords utilised: Cumulative Installed Capacity, Demand Side Management, Emerging New Technologies, Financial Gains, Cost Volatility, Advanced Metering Infrastructure, Fossil Fuels, and Smart Grid Technologies.

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The review draws data and experience from extensive local and global scientific research. This article adopts a systematic evaluation method that combines empirical analysis and qualitative synthesis. To this end, this article attempts to help policymakers, researchers, and practitioners in South Africa make use of the research outcome in pursuance of further development and deployment of renewable energy technologies.

2.1 Systematic review

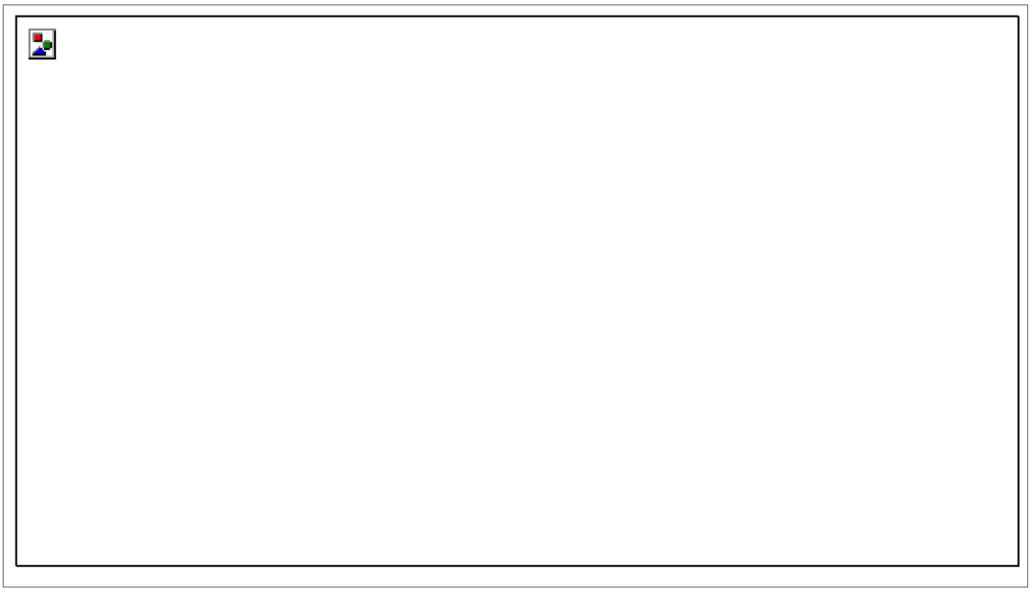
A systematic review is a process of data collection, modelling, and analysis to extract information that will aid decision-making. Depending on the industry or purpose of the analysis, there are several options for performing the analysis (Calzon, 2021: 1).

The systematic review method should locate existing research, select and evaluate contributions, analyse and synthesise data, and report evidence to draw reasonable and clear conclusions about known and unknown (Denyer & Tranfield, 2009:1).

2.2 Research questions for the paper

Figure 1 below depicts the six research questions utilised in this review paper.

Figure 1: Research Questions



Source: Author

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2.3 Criteria for inclusion and exclusion

This review focuses on existing literature covering RE technologies and, in particular photovoltaic that is either unpublished or published in non-commercial forms like a policy statement, government reports, and papers issued for the South African environment. A criterion was developed to include or exclude relevant scientific literature by identifying subject relevance, type of technology, geographic scope, intervention scale, and data type.

2.4 Data sources and search methods

The data collection technique is imperative because the evidence gathered and its interpretation will depend on the researcher's procedures and analytical methods (Paradis *et al.*, 2016: 264). In a study by Meho and Yang (2007: 1), they found that Google Scholar stands out for its coverage of conference proceedings and international non-English magazines. The data collected in their research found that the citations obtained through Google Scholar came from many different types of documents, including journal articles, conference papers, doctoral theses, master's theses, technical reports, research papers, chapters and books (Meho and Yang, 2007: 20).
This observation was supported by Martin-Martin *et al.*, (2017: 1), who concluded that Google Scholar could effectively identify frequently cited articles. This, coupled with the unique coverage of Google (Martin-Martin *et al.*, 2017: 1). Databases of internet search engines like google scholar, various academic websites, published journals of scientific nature, industry-specific experienced and knowledgeable individuals were consulted in search of data sources.

2.4.1 Unpublished material

According to Shekelle *et al.*, (1999: 594), the first step in gathering evidence is to check whether an appropriate and up-to-date systematic review has been published. If no systematic reviews are currently available, computer search is the usual starting point for search strategies tailored to the relevant research type. Unpublished materials usually lead to additional research, but the resources required for such activities is quite impressive. (Shekelle *et al.*, 1999: 594). Blackhall (2007: 359) believes that including unpublished grey literature is essential to minimise the potential impact of publication bias.

In the interest of researching the broad spectrum of renewable energy as a catalyst for sustainable energy distribution in South Africa, the data search included both published and unpublished research material available from scientific journals in google scholar, Emerald and other academic institutions databases. This was specifically done to ensure the search is

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robust and reaches as wide parameters as possible. Structured methods were used to search for ring-fenced related keywords, sentences, and phrases summarised to track related material.

2.4.2 Accessed articles

Once the studies have been identified, relevant to questions of research interest, the detection of relevance is often possible from the summary/abstract. The set of studies is reduced to those who need a more detailed evaluation. The use of explicit criteria instead of implicit must improve the reliability of the process (Shekelle et al., 1999: 594).

The literature review for this study first sought to establish existing studies in publications published between 2016 and 2021 as renewable energy is a rapidly developing form of energy. The data search sought to access articles related to the research subject matter, i.e. "implementation model of photovoltaic application for sustainable energy in South Africa". In addition to the main research subject matter, articles were accessed related to the eight (8) constructs analysed in the study. This includes future technology, demand-side planning, distribution management systems, design, foresight, financial management, capacity building and regulatory environment. Unpublished studies conducted in the subject mentioned above matter were considered for a broader perspective. The primary data search was conducted on the Google Scholar link database. The main journal editors and links visited were, amongst others, from Science Direct, Springer, Elsevier and ResearchGate. In addition to Google Scholar, a secondary data search of university publications was conducted on SEALS, OpenUCT and SUNScholar databases. The keywords and phrases included in the search algorithm were:

a) sustainable renewable energy,
b) solar photovoltaic energy,
c) renewable energy (future technology, demand-side planning, distribution management systems, system design, foresight, financial management, capacity building and regulatory environment)

Figure 2: Flow diagram for new systematic reviews

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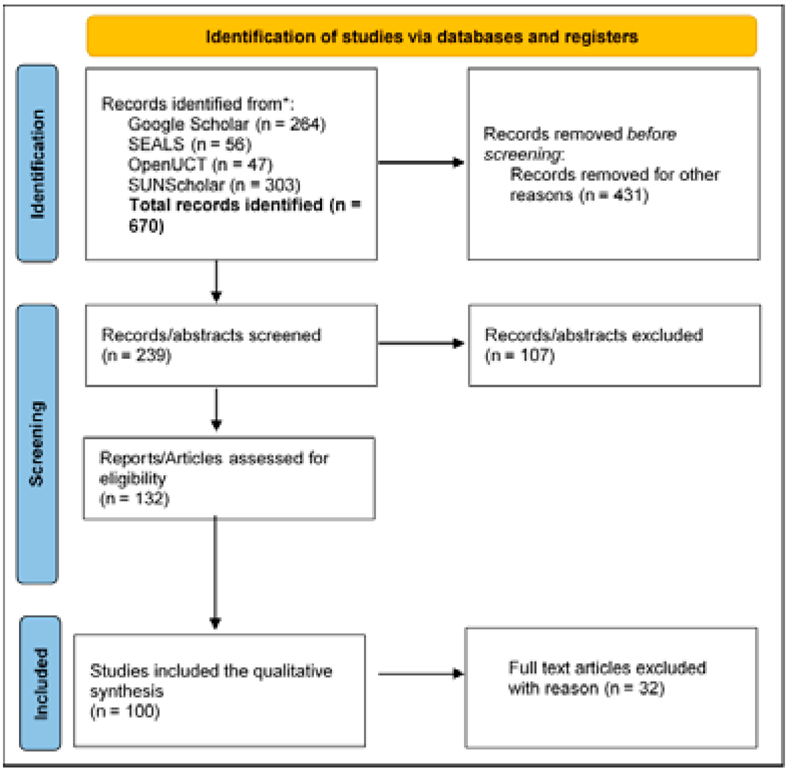

Figure 2. Source: Author

The literature review search returned a total of 26 306 out of which 26 067 were removed for non-eligibility to the content required, thus leaving 239 records/abstracts for preliminary screening. The 239 records/abstracts were analysed and explored to determine their eligibility to the study's subject matter, thus leaving a total of 100 records included in the qualitative synthesis of this study. Figure 2 above depicts the adapted PRISMA 2020 flow diagram for new systematic reviews, including searches of databases and registers for this study (Page et al., 2021).

3. Discussion

The discussion will focus on regulatory parameters, including the role of Small-Scale Embedded Generation (SSEG) within the energy mix, environment management, and its impact on reducing Green House Gases (GHG), its benefits, and sustainability in SA.

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3.1 Role of Renewable Energy as Part of the Energy Mix

According to Barth *et al.*, (2017: 1), the increase in the proportion of renewable energy generation in the power system has brought major challenges, such as the volatility of renewable energy. In order to meet these challenges, demand-side management is a frequently mentioned remedy (Barth et al., 2017: 1). Therefore, integrating increasingly dispersed renewable energy in the energy system is one of the two most important research areas in energy informatics (Goebel et al., 2014; Barth et al., 2017: 1). Therefore, an optimal supply strategy can be achieved by providing greater flexibility on the demand side (Barth et al., 2017: 1).

3.2 Reduction of Green House Gases in South Africa

In Yusuf, Abubakar & Mamman (2020: 1), environmental degradation remains a serious challenge in Africa, especially oil-producing African countries. Aliyu, Modu and Tan (2018: 4**)** postulate that the SA's renewable energy resources have enormous and significant potential and contribute to its energy sector, society, and economy. The cost of energy is an important factor in determining the profitability of renewable energy technologies.

3.3 Benefits of Roll-Out of Small-Scale Embedded Generation

Klaaaren *et al.*, (2019: 190) The impact of the roof PV program depends on the three factors. That is the potential for Solar Resources of a Specific Area, the technical possibility of systems from the number of kilowatts of electricity that electricity can generate. This is considering the performance of available solar resources and their specific system and the economy of the program in terms of whether it is an economic meaning for SSEG clients and practical/local governments.

3.4 Renewable Energy as a Catalyst for Sustainable Development

The signing of the Kyoto Protocol enabled many countries to reduce fossil fuel-related energy and switch to alternative energy sources (Baloyi *et al.*, 2016: 1). This strengthens the search for more sustainable energy systems to reduce our high dependence on fossil fuels (Baloyi et al., 2016: 1).

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3.5 Theoretical Model of Rolling out a Solar Embedded Generation

Some steps that apply to the implementation of the SSEG installation through the development of procedures and systems to incorporate photovoltaic solar energy in the municipal energy distribution business include:

- Regulatory environmental awareness;
- Understanding of the technical standards that govern SSEG (NRS 097 series among others);
- In addition to the existing NRS097 and other NRS standards, clarify any technical issues or conditions that the municipal government wants to raise against SSEG clients;
- Establish rates for SSEG to protect municipal revenues (whether necessary depends on the central buyer NETFIT1 SSEG Possibility of compensation plan going into effect);
- Modification of the billing system to adapt to net power generation (if net power generation is allowed);
- Develop the necessary documents: SSEG Prospective Applicant Guide / Request SSEG Customer Form / Contract (Supply Contract) and
- Municipal Staff Competency: Train municipal staff to handle installation requests and inspections (if applicable) to provide clear explanations to the political leadership (SAMSET, 2014: 2).

3.6 Analysis of Validity and Reliability of the Constructs

Validity is the grade to which a measure's mark signifies its predictable variable. However, how do researchers make such judgments? We have considered a cause that they considered: reliability. When a measurement has good test-retest reliability and internal steadiness, researchers should be more self-confident that these marks embody their expectations (Chiang *et al.,* 2015: 99). In quantitative research, reliability refers to the steadiness, solidity, and repeatability of outcomes. If dependable outcomes are found under the same situations but different situations, the researcher's results are reliable (Twycross and Shields, 2004; Mohajan, 2017: 10). Construct validity refers to the gradation to which researchers transform or transform the perception, knowledge, or behaviour of a paradigm into functional and operational realism and operationalisation (Taherdoost, 2016: 31).

3.6.1 Future technology

Van der Merwe (2017: 227) pointed out that limitation issues are more empirical than theoretical because different social technology sectors have different views on the functions

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of social systems. The benefit of clearly observing the socio-technical system is that the co-evolution of technology and society, arrangement and purpose has become the attention of devotion (Geels, 2004: 902; Van der Merwe, 2017: 227). Therefore, it is recommended that municipal renewable energy regulatory agencies that have the fiscal capability to grow or procure such systems continue developing such systems. In turn, regulators or municipalities can allow the community (renewable energy developers and property holders) to contact the web-based system and resolve whether it is exposed or exclusive data (Adeleke, 2018: 169).

3.6.2 Demand planning

Komlanvi (2018: 251) concluded that more research and experimental work is needed to take full advantage of the capabilities of the developed renewable energy system and its unique control system. The scale of the system should reach almost all the possibilities. The topography of the artificial intelligence system is integrated with a single control system in its architecture to make it mobile and promote use by end-users (Komlanvi, 2018: 251). If the artificial intelligence system can realise automatic adjustment and system stability has various requirements for charging and automatic evaluation of the system for maintenance purposes (Komlanvi, 2018: 251). Renewable energy investments and demand-side energy efficiency improvements play a key part in decreasing greenhouse gas releases (Barbose et al., 2013; International Energy Agency, 2014; Callaway, Welfare & McCormick, 2018: 2).

3.6.3 Distribution management

Current energy schemes are not intended to care for large-scale amalgamation of photovoltaic energy and respond to grid codes (Mansouri, Lashab, Guerrero & Cherif, 2020: 2122). The bid of able and online control methods is very important for improved coordination between the various parts of modern electrical systems (Mansouri et al., 2020: 2122). (Chihota, 2019: 167). In grid-connected mode, collaborative energy management is where microgrid participants can cooperate and use resources effectively (Oladejo, 2018: 126). If each participant's peak energy demand and consumption patterns differ, it will bring more benefits (Oladejo, 2018: 127).

3.6.4 System design

Statistical technologies were evaluated in the proposed 1 MW PV system energy performance estimates installed in South Africa PE, PE and South Africa NMMU Summer Strand South Campus (Clohessy, 2017: 183). These components and intervals scattered

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within the tolerances suggested that they are used to evaluate the energy generation process of the ready PV systems. The evaluation of the energy generation process of the photovoltaic system that uses an acceptable range is not carried out before (Clohessy, 2017: 183). The modelling of renewable energy systems is a great computational challenge due to increasing the height of the offer and demand time series (Kotzur, Markewitz, Robinius & Stolten, 2018: 1).

3.6.5 Foresight

Incorporating this development perspective into government policy and practice frameworks to promote energy democracy will require ongoing partnerships of knowledge and practice (Davies, 2021: 229). Therefore, deepening the social logic of renewable energy development will allow public institutions such as state companies, public services, community cooperatives, or municipalities to play multiple roles in the energy transition to support the deployment of the renewable energy infrastructure (Davies, 2021: 229).

3.6.6 Financial management

Ducie (2017: 293) stated that unlocking investment requires cooperation. Therefore, local governments, the private sector and communities can help unlock investment potential. The key to knowing when to promote these processes directly and only those processes (Ducie, 2017: 293). While the public sector will always be the main driver of infrastructure development, various financing mechanisms and applicable financial partners and investment bases are needed to solve future sustainable urban problems (Ducie, 2017: 296).

3.6.7 Capacity building

Regarding the commitment of the Comprehensive Renewable Energy Producer Program (REPPP) to include a gender perspective by empowering women with socio-economic empowerment, unlike the traditional PPI, REIPPPP risks the development of an independent energy producer (IPP) led by women (Keown, 2019:448). There is nothing to lose in the renewable energy industry, but it has gained a lot. It is necessary to replicate and amplify the good experience gained in the mining industry. It is a crime for the renewable energy industry to repeat the same mistakes, mainly from a social perspective. This funding aims to train our future leaders (Keown, 2019: 450).

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3.6.8 Regulatory environment

Roux (2018: 244) questioned how, in his case, urban transformation affects or restricts the country's transformation. What impact will the limited transformation of the city have on impoverished regions and cities? Who is excluded from the benefits of the reconfiguration process by defining the transition along the city line? The impact of energy policy has prompted the need to determine the policy recommendations necessary to help achieve sustainable development and the objectives of various energy policies in South Australia (Julius, 2018: 214). There is a need to raise the awareness of local communities/regions of the benefits of green energy. Then, include and implement access to green energy in the housing policy, and improve existing houses that do not have access to green energy (Julius, 2018: 215).

4. Conclusion and recommendations

In conclusion, from the literature, we can conclude that there is substantial room to grow the deployment of renewable energy in South Africa. RE provides a much-needed solution to energy diversity and could directly contribute to a better energy mix. An increase in renewable energy deployment will offset the use of fossil fuels in electricity production. In turn, this will directly contribute to improved environmental management and realise the associated benefits. Furthermore, an improvement in the energy mix will also reduce the dependency on a single supplier for the bulk energy requirements in the country. Renewable energy, therefore, will reduce energy costs and assist in hedging against the predicted energy tariff increase path. The latter will be of great value to the economy but also to low-income customers.

The percentage of energy provided to the respective networks in South Africa is relatively low compared to the energy supplied from fossil fuel power stations. The window of opportunity to accommodate renewable energy without significant system stability risks is now. Deploying renewable energy and energy storage closer to load nodes will improve network voltage levels from a technical perspective. This will further contribute to better load management, improved load profiles and the reduction of technical losses. The factors referred to above are challenges confronting many distributors of electricity in South Africa.

Recommendations, based on the research done and having considered relevant inputs, it is recommended that:

- Municipalities are encouraged to promote the use of renewable energy,

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- The regulator incentivises the deployment of SSEG and energy storage in the electricity distribution networks,
- Municipal by-laws are aligned to encourage end customers to become prosumers, i.e. that they install renewable energy solutions, remain grid-tied and feed surplus energy back into the network,
- Energy wheeling from renewable energy installation through established networks be promoted,
- Micro-grids supplied from renewable energy sources be advanced,
- Resources are trained to manage and meet the renewable energy transitional requirements effectively, and
- Renewable energy solutions, be leveraged as a catalyst for a sustainable energy distribution sector in South Africa.

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DII-2021-008

Construction Waste Management Practices in the Construction Industry

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Abstract

The purpose of this paper is to evaluate the knowledge of Construction Waste Management (CWM) among contractors in Gqeberha and establish what legislative shortcomings are there in terms of CWM regulations. The reduction in landfilling could decrease the waste management cost for construction companies and reduce negative impacts on the environment. This paper used a qualitative design approach, and the primary data for this paper was obtained through structured interviews with a selected number of main contractors in Gqeberha. The study focused on on-site agents, contracts managers, and HSE officers through a non-probability sampling technique. The paper found that the lack of government legislation to discourage the landfilling of waste was the main catalyst. The primary data also stated that the lack of recycling facilities also contributed to the abundance of landfilling waste among contractors in Gqeberha. The paper's findings also showed that contractors in Gqeberha were knowledgeable on several construction waste management strategies. Suggestions for future research will require contractors to research the potential economic benefits of CWM, as well as minimisation and recovery CWM strategies, and the local municipality to explore methods of discouraging landfilling waste within the construction industry and in other sectors, as well as the economic and environmental benefits of CWM. The paper provided insight concerning the CW and CWM practices among contractors in Gqeberha, including identifying the interventions required to address shortcomings.
Keywords: Construction Waste Management, Recycling, Reuse, Recovery, Prevention.

1. Introduction

The 2017 South Africans construction industry's contribution of 3.77% towards the country's GDP and employment of about 609 000 people in the first quarter of 2018, respectively, indicates that the industry plays an important role for economies like the South African Economy. (South Africa's GDP Page, 2020) and (Construction Industry Development Board, 2019:2).

However, the generation of construction and demolition material is a reality for all construction sites, but the recycling and demolition waste generated is not. In 2017, construction and demolition waste accounted for 13% of South Africa's general waste, while 6% of that waste was recycled (Department of Environmental Affairs, 2018:18). South Africa is undergoing potential economic and social benefits as the above figures suggest insufficient planning and management of

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construction waste (Richardson, 2013:1). Cost-saving is a favourable outcome that may be brought about by waste reuse, reduction, and recycling (Hwang and Yeo, 2011:396). They further stated that the result, as mentioned above, is a reduction of unnecessary material being purchased, reduction in disposal and landfill costs which eventually leads to reduced project costs and can lead to maximized profits.

Furthermore, construction waste disposal usually results in environmental and sustainability issues, including an imbalanced eco-system (Maruf, 2017:1). The process of collecting and reprocessing waste into a recycled product reduces the diminishing of landfill space, saves natural resources, supplies products, and provides economic benefits like other waste management strategies (Roslan *et al.*,2016:65). Landfill waste may suggest a belated intervention in terms of waste management.

Construction activity changes the environment and landfilling its waste further pollutes the water, soil, and air beyond the construction site. Construction waste can be produced during the inception, design, and operation phase of the construction process, as Haile and Hartono (2017:6) indicated, implying that a holistic strategy is required to manage construction waste adequately. A study in Nigeria found that poor construction waste management was due to a deficient understanding of construction waste management among construction professionals Dania *et al.*,(2007:128). The lack of sufficient space on the construction site was a challenge in managing construction waste based on observations on a Swedish construction site (Haile and Hartono 2017:59). Additionally, Abukhader (2015:43) observed that the lack of eco-friendly waste management practices in Dubai could be due to the high number of ex-patriots that form roughly 90% of the population. The differing backgrounds and beliefs can be tremendously influential in waste management behaviours. This research aims to understand the present construction waste management practices in Gqeberha and propose solutions to improve the current situation.

2. Literature Review

2.1 Construction Waste Management

Construction Waste Management (CWM) is an aspect of waste management that ideals construction waste management through reducing, reusing, and recycling. It is also an aspect of sustainable development driven by the impact of humankind's activities on the environment (Dania *et al.*,2007:120). Aleksanin (2019:1) states that the coordination of the methodical handling of construction waste is one of the most important resources and environmental saving factors. He

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further observed that waste management aligns itself with protecting the hydrosphere and atmosphere from pollution and correcting land and biological resources conservation issues. Fundamental waste management steps have been integrated into various waste management hierarchies by different researchers, and they range from 4 to 6 strategies. For instance, Poon (2004:461–470) discussed a waste management hierarchy that contains 4 chronological steps to ensure the maximum conservation of resources to be avoiding waste, re-using materials, recycling materials, and finally waste disposal if the first .three steps are not possible. Additionally, the hierarchy proposed by Nagapan (2012:332) is prevention, minimisation, reuse, recycling, recovery, and disposal.

2.2 Prevention of waste

Prevention of waste is the most important aspect of the waste management hierarchy as it achieves the highest sustainability of the environment. Nagapan (2012:332) avers that studies have shown frequent design errors and changes will always lead to waste generation. Hence designers need to consider technical information at the pre-construction phase to prevent waste through good communication amongst the professional team of a construction project to curb waste.

2.3 Minimization/Reduction of waste

Waste minimisation or reduction is the second-best strategy to reduce the impact of waste on the environment. As a reduction in the amount of waste generated, enhanced economic savings can reduce the amount of raw material consumed and the transportation cost of material and waste. Contractors need to set out waste reduction programs and targets and a planned waste management approach, part of an overall environmental management plan and good housekeeping practice. They are also advised to establish waste management monitoring and audit programs utilised throughout the construction process, as stated by Solehah (2015:15).

2.4 Reuse of waste

Reuse of waste is the next strategy, and it has many techniques for construction waste. Reuse is an important approach to rerouting construction waste away from landfills, according to Ajayi *et al.* (2015:6), who state that reuse involves a minimal alteration to the materials, either in their chemical or physical state. This strategy uses the same construction material more than once (Yuan and Shen, 2011:670–679). At times, construction waste materials that cannot be reused directly can be converted to new products through recycling (Roslan *et al.*, 2016:65). This is the process of collecting, reprocessing, and manufacturing the waste into a recycled product and putting it to

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use again. Like other waste management strategies, this phase reduces landfilling of waste, saves natural resources, supplies products, and provides economic benefits.

2.5 Recycling of waste

Recycling waste is placed fourth in the hierarchy, and it is the most preferred method to use when the material is used within the construction sector. Mulders (2013:28) asserts that recycled material lowers the overall embodied energy as such materials have a lower embodied energy than virgin materials. It should be noted that without significant economic incentives directing waste management towards recycling, it will be difficult to get the desired behavioural change. The advantages of recycling construction waste are extensive but have been summarised as; the conservation of precious land areas, the extension of the lifespan of landfills, the cost-effectiveness of recycled products, improvement of the general environmental status in terms of energy and pollution, the minimisation of resource consumption, the utilisation of waste which would be lost to landfills, and job creation.

2.6 Recovery of waste

As the fifth strategy, recovery of waste can be defined as the reuse of waste materials that allows them to maintain their original form to be re-used in a similar state (Nagapan, 2012:333). An example of this is the incineration technology utilised in Germany to assist in the recovery of metal waste. The incineration process eliminates harmful metal from the waste, and the gases produced from the incineration are used to produce electricity, thus reducing landfill waste. This strategy does require extensive governmental support, as the establishment of an incineration facility does require a substantial financial contribution.

2.7 Disposal of waste

Disposal of waste is the final option in the hierarchy, and the most common disposal method is landfilling. This is the least favourable strategy as it goes against sustainable waste management, which reduces the amount of waste disposed into the environment (Nagapan, 2012:333). It is concluded that the waste management hierarchy should be implemented in all construction sites. A waste management strategy, such as those mentioned above, can effectively integrate sustainability while managing waste. If combined with the correct legislation/policy, it can help reduce the negative issues related to construction waste.

2.8 Benefits of Construction Waste Management

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Proper implementation of construction waste management can provide various benefits across the lifecycle of the material from its generation to its conclusive disposal. According to Hwang and Yeo (2011:396), apart from economic advantages, construction waste management may have a positive input in the following aspects: cost-saving and profit maximisation, reduced demand for landfill spaces, improved resource management, image improvement, productivity, and quality improvement.

2.9 Barriers to Construction Waste Management

A study on overcoming the barriers to construction waste reuse in Australia noted that the key barrier in promoting construction waste management is the additional cost of processing, recycling, or reuse and the quality of the recycled or reused waste materials (Park and Tucker, 2016:2–3). Park and Tucker (2016) state that the shortage of information is said to contribute as the main cause of the limited effectiveness of construction waste management, particularly the conflicting interests and differing perspectives of key stakeholders involved in the management of construction waste. Internal stakeholders such as contractors and project clients tend to emphasize the monetary aspects of construction waste management. In contrast, the external stakeholders, such as the general public, non-state organisations, and legislative authorities, are more concerned with minimizing the quantities of waste entering the landfills and the environmental impacts (Park and Tucker, 2016:2–3). The lack of information stance is further corroborated by Abarca-Guerrero *et al.* (2017:6–8), who cited inadequate knowledge about implementing eco-technologies and the insufficient training of workers on waste management issues as some of the barriers to implementing the reduction of construction waste.

2.10 Alternative uses for Construction Waste Materials

The rapid growth in construction has led to the construction and demolition waste (Shahidan *et al.*, 2017:1029). This section of the research will elaborate on waste management solutions for such waste(s) that have been produced through various stages of your typical construction project. Such waste will be discussed hereunder.

2.11 Concrete Waste as Recycled Concrete Aggregate

The depletion of natural aggregates globally can be attributed to rapid industrial development, which creates an enormous amount of construction and demolition waste. This problem can be reduced by using recycled aggregates sourced from demolished concrete to reduce environmental

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pollution and protect. This will help reduce environmental pollution and protect naturally occurring resources (Shahidan *et al.*, 2017:1029).

2.12 Reuse and Recycling of Masonry Waste

Waste masonry bricks from demolition work can be reused for their original purpose once the bedding mortar is removed manually or through temperature treatment (Mulders, 2013:27). Temperature treatment strains the bond between the mortar and the brick surface interface, causing shear stress, setting the brick free of the bedding mortar. After the treatment, the brick retains the quality it had before its initial construction use. Waste masonry bricks may also be recycled into a fine grain with or without removing the bedding mortar and are formed when the masonry is crushed to a fine grain smaller than 0.5mm and mixed with clay in a fired kiln to produce clay bricks (Mulders, 2013:29).

2.13 Elongating the Lifetime of Timber Waste

Timber waste can be re-used, then recycled or recycled after its intended use on site. Mulders (2013:34) suggested that timber can be used for various functions once its initial intended use is obsolete, and this process can be repeated every time the new use for the timber waste once again becomes obsolete. For example, a timber beam can be processed into a floorboard once it is no longer needed as a beam. After that, it can be made into a window frame. Once the window frame is no longer needed, the timber can be processed into an oriented strand board which can be used for loadbearing applications in construction.

2.14 Environmental Impact of landfills

The landfilling of construction waste results in a wide range of environmental costs, including the use and degradation of land, the release of methane gas, the destruction of habitats, and the contamination of soil and groundwater. The manufacture of construction materials involves the extraction, processing, and transportation of natural resources, resulting in pollution and greenhouse gases. The disposal of these construction materials at landfills results in the loss of useful materials (Crawford *et al.*, 2017:831).

2.15 How Government discourages Landfilling

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According to Ajayi *et al.* (2015:9), several legislatures, together with tax measures, have been made obligatory by governments to diverge waste away from landfills. An example of such measures is the "Pay as You Throw" (PAYT) system, where a polluter pays fees to dispose of waste at a landfill through which governments have diverted substantial volumes of waste from landfills. PAYT charges are paid per unit volume or weight of all waste that is landfilled. It has the final aim of discouraging waste landfilling while encouraging alternative waste management solutions. The latest Nelson Mandela Bay Municipality Integrated Waste Management Plan highlighted that the municipality does not operate any formal recycling system. However, it does facilitate recycling through other initiatives that target only domestic household waste and not commercial construction waste (Nelson Mandela Bay Municipality, 2016:33).

3. Research Methodology

3.1 Research method

Data collection is the process of collecting and measuring information on variables of interest. It is established systematically, enabling the researcher to answer stated research questions, test the hypotheses, and evaluate outcomes (Leedy & Ormrod, 2015). Methods vary by discipline, but the emphasis is on ensuring that the accurate and honest data collection remains the same (Kabir, 2016:202). Semi-structured interviews were conducted with individuals who construction companies in Gqeberha employ. The interviewees were selected based on their expertise, responsibility, and years of experience within the company. These interviewees consisted of the following construction industry professionals such as contractors, project and construction managers. The criteria mentioned above were selected based on Ajayi's (2017:94) assertion that a participant would be deemed information-rich if their job description fell within them working for any contractor, civil or civil or structural engineer, architect, construction project manager, and site waste manager. The interviews were conducted in English, and they had a duration of about 8 to 15 minutes. The interviews were recorded and transcribed to avoid any misinterpretation of the data.

3.2 Data Collection

This study used the non-probability sampling technique to acquire 5 participants as it was not possible for the researcher to interview all the individual units within the population (Leedy and Ormrod, 2015:182). It was impossible to hold interviews in person; semi-structured interviews were conducted via video-call through the Microsoft Teams application. The interviews were recorded through the application before being exported and manually transcribed.

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Table I Participant Details

Participant No.	Age	Gender	Sector	Experience
1	32	Male	Private	8 years
2	40	Male	Public	15 years
3	28	Female	Private	4 years
4	33	Female	Public	11 years
5	39	Male	Private	12 Years

Due to the large number of participants who turned down the request to participate in the video conference interviews, participants in this paper were limited. The research interviews were conducted using video conferencing software during the data collection phase due to the level 4 covid19 restrictions. The covid19 pandemic increased the number of video conferences and telephonic meetings among construction industry employees. Out of the twenty contractors that were approached to participate in this research, only five responded. Creswell (1998) proposes a sample size of 5 to 25 for a qualitative study using interviews. A study by Hennink *et al.* (2017) realized a saturation point at the 9th interview, where additional issues were not raised. Therefore, following Creswell's suggestion, the 5 participants used in this study are justifiable.

The would-be participants that declined stated that they were too busy to participate in any additional telephonic or video interviews as their schedules were already overwhelmed due to the pandemic, which limited in-person meetings within their work environment. A study on employee wellness and productivity while working remotely during Covid-19 suggested that the high use of platforms such as Microsoft teams, Zoom, and e-mail were best for productivity and social connection and the most frustrating (Shockley *et al.*,2020:46). Only participants who operated as principal contractors and registered with regulatory bodies such as the Construction Industry Development Board (CIDB), the National Home Builders Registration Council (NHBRC), and Master Builders South Africa (MBSA)were selected.

3.3 Ethical Consideration

The researchers ensured that the participants' confidentiality was protected and their consent was obtained to record the interview. The participants were also assured that the recorded information was kept confidential and that their personal information was not accessible by anyone except for the researcher.

4. Results, Analysis and Discussion

4.1 Results

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A sample of 5 interviewees was selected and interviewed to ascertain the root cause for contractors in Gqeberha to be so reliant on landfilling their construction waste. The paper used a qualitative study approach, as the researcher aimed to obtain the views and opinions of the interviewees. The data was then compared against the literature that was found in the literature review.

4.2 Analysis and Discussions

This section dealt with the data analysis, where the research participants' views, which were exhibited through quotations, stated their opinions on construction waste management. The data was then analysed and compared against the content of the literature review in this research. The comparison's alignment or lack thereof will ultimately be used to conclude this research paper.

Participant 2- "Construction waste management is important because it decreases the negative impact on the environment because it ultimately reduces the amount of waste that is illegally dumped and the waste that ends up at the landfill where it would do harm to the environment"

Participant 5- "…the fact that construction waste is not biodegradable means it will pollute the environment when it leaves our construction site and it is detrimental to the environment if it is not managed properly, this is quite important because construction projects generate large volumes of waste"

Keywords 1
Environmental Impact Reduction

Keywords 2
Landfill Waste Reduction

Theme 1
Environmental Impact

Research Objective 1
To examine Objective 1

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Figure 1: Thematic Analysis for Research Objective 1: To examine how knowledgeable are contractors on the importance of construction waste management.

4.3 Research Objective 1

Construction waste management is driven by the need to underscore humankind's activities in the environment. It is also an aspect of waste management concerned with minimizing and managing construction waste by reducing, reusing, and recycling it (Dania *et al.*,(2007:120). CWM also aims to protect the hydrosphere and atmosphere from pollution and issues of land conservation and conservation of biological resources (Aleksanin 2019b:1). The goals as mentioned above of CWM, which is minimizing and managing construction waste stated by Dana *et al.* (2007:120), together with protecting the hydrosphere and atmosphere from pollution as stated by Aleksanin (2019b:1), agree with the opinion of what CWM is according to participant 2 who stated the following:

> "…Construction waste management is important as it decreases the negative impact on the environment because it ultimately reduces the amount of waste that is illegally dumped and the waste that ends up at the landfill where it would harm the environment" (Interview conducted with Participant 2).

Another Participant alluded to similar reasoning on the importance of construction waste and indicated that:

> "…the fact that construction waste is not biodegradable means it will pollute the environment when it leaves our construction site, and it is detrimental to the environment if it is not managed properly" (Interview conducted with Participant 5).

Construction waste management is driven by the concern of humankind's activities on the environment. It is also an aspect of waste management concerned with minimizing and managing construction waste by reducing, reusing, and recycling it (Dania *et al.*, 2007:120). CWM also aims to align itself with protecting the hydrosphere and atmosphere from pollution and solving issues of land conservation and the conservation of biological resources (Aleksanin 2019b:1). The goals as mentioned above of CWM, which is minimizing and managing construction waste as stated by Dana *et al.* (2007:120) together with protecting the hydrosphere and atmosphere from pollution, as stated by Aleksanin (2019b:1), agree with the opinion of what CWM is according to participant 2, who stated the following:

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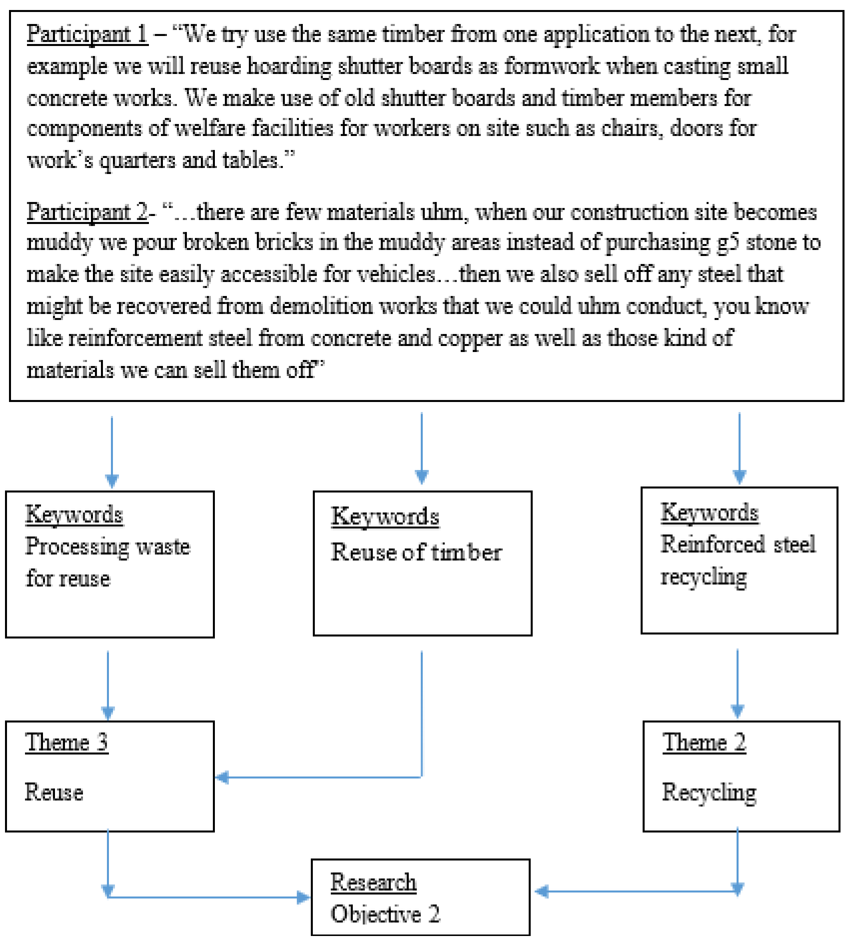

Figure 2: Thematic Analysis for Research Objective 2: To establish if contractors are aware of alternative construction management solutions.

4.4 Research Objective 2

The possible strategies for managing waste in order of importance and desirability for maximum environmental sustainability were summarized into the following strategies by Nagapan (2012:332): Prevention, Minimization/Reduction, Reuse, Recycling, Recovery & Disposal. The

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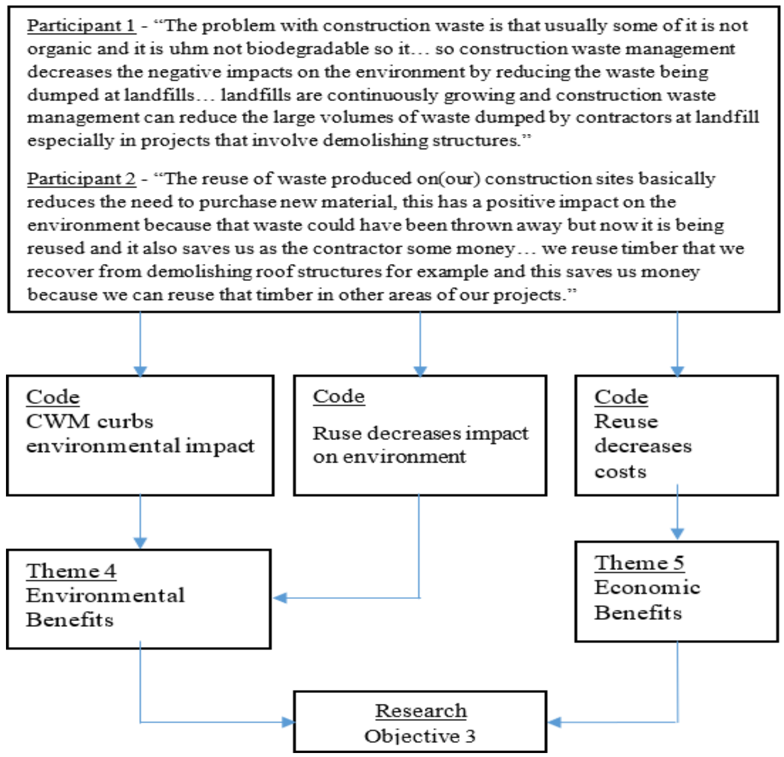

primary data revealed that contractors did practice recycling and the on-site reuse of certain construction waste materials.

The reuse of construction waste usually indicates using the same material in construction more than once instead of using the material once and discarding it for the use of new virgin materials. Reusing is preferable over recycling as it requires very little processing because the material undergoes little to no change for reuse (Park and Tucker 2016:2).

This definition is in agreement with how participant 1 utilizes reuse in managing their construction waste as stated below:

> "We try to use the same timber from one application to the next; for example, we will reuse hoarding shutter boards as formwork when casting small concrete works. We make use of old shutter boards and timber members for components of welfare facilities for workers on site such as chairs, doors for work's quarters, and tables." (Interview Participant 1)

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Figure 3: Thematic Analysis for Research Objective 3: To investigate if contractors realise the potential positive impact of construction waste management

According to Ajayi *et al*. (2015:6), reuse is an important approach when rerouting construction waste away from landfills. He further states that reuse involves minimal alteration to the materials' chemical or physical state; this statement is in line with how participant 1 implements the reuse of their timber waste because the timber undergoes minimal alteration to its physical and chemical state, with the timber material being reused as timber material. These research participants displayed knowledge of recycling solutions, and one participant even mentioned recycling activities that their company practices. It can thus be concluded that contractors in Gqeberha are aware of alternative waste management practices.

4.5 Sub-Research Objective 3

Hwang *et al*. (2011:396) stated that CWM saves on costs and maximizes profit for contracts. This is achieved by reducing the continuous unnecessary acquisition of new materials that could be substituted by recycled or reused waste materials, further reducing costs.

The previous sentence was in agreement with research participant 2, who stated the following:

> “The reuse of waste produced on(our) construction sites reduces the need to purchase new material, this has a positive impact on the environment because that waste could have been thrown away, but now it is being reused, and it also saves us as the contractor some money… we reuse timber that we recover from demolishing roof structures for example, and this saves us money but also protects the environment because we can reuse that timber in other areas of our projects" (Interview Participant 2)

The statement mentioned above is concurred by research participant 3, who stated that:

> "We make sure to reuse or recycle timber instead of throwing it away; it would make no financial sense to buy something that we have readily available on-site."

The above statements by participants 2 and 3 are in agreement with the Allen *et al*. (2019:84), who suggested that, upon the demolition of a timber building, the large timber members from the demolished building can be recycled into a frame for another building or the large member can be sawed into new boards for the new building. Participant 2, in the statement mentioned above, asserts that the reuse of waste produced on the construction sites reduces the need to purchase new

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material, which has a positive impact on the environment because the waste could have been thrown away. The statement also agrees with Ajayi *et al*. (2017:6), who mentioned that the reuse of waste materials is a quintessential approach to diverting waste from landfill sites.

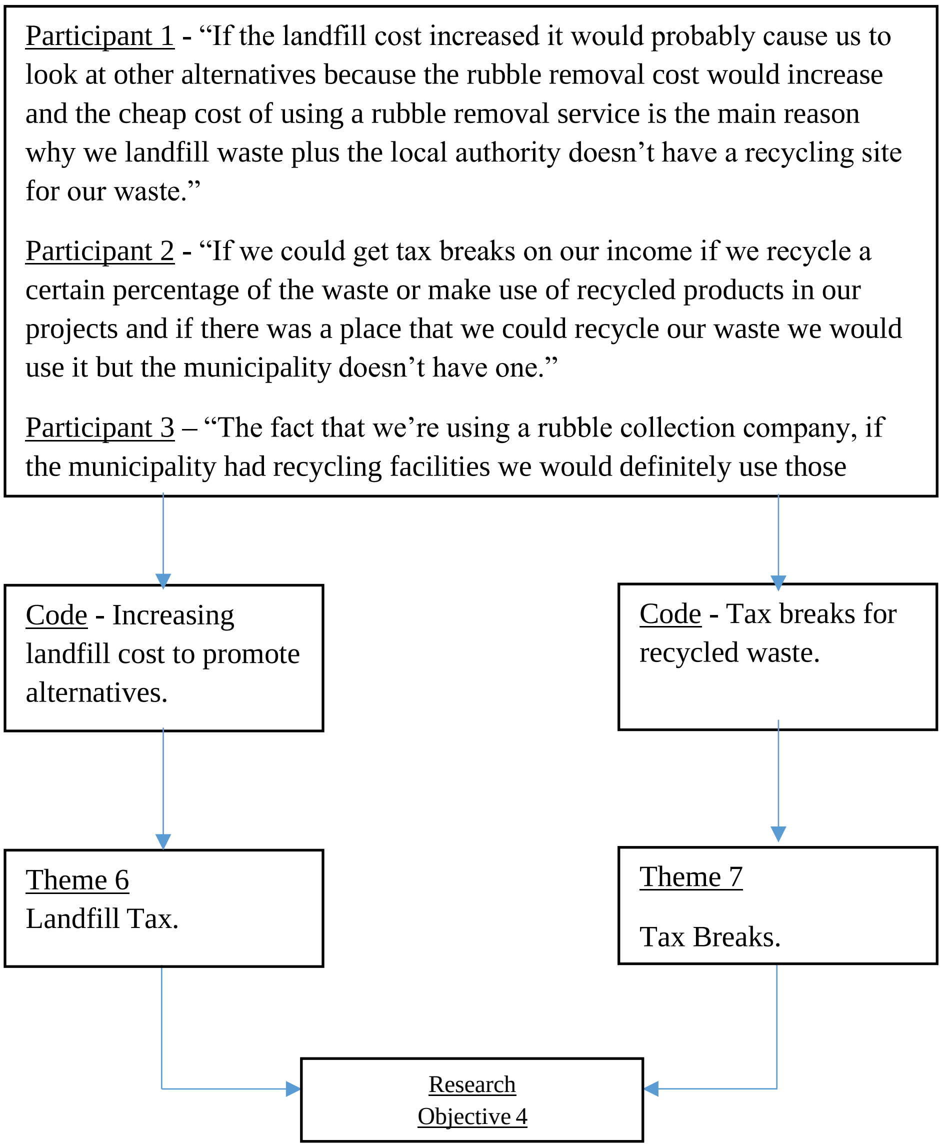

Figure 4: Thematic Analysis for Research Objective 4: To scrutinize the presence or lack thereof of incentives and legislation to discourage the landfilling of construction waste.

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4.6 Research Objective 4

Jain (2012:5) proposed that the government provide some sort of recycled construction product government subsidy to encourage alternative waste management solutions, and this was in agreement with research participant 2, who stated:

> "If we could get tax breaks on our income if we recycle a certain percentage of the waste or make use of recycled products in our projects…."

The literature review found very little motivation from the local authority to encourage contractors to move away from landfilling their waste. As mentioned in their Integrated Waste Management Plan, the local authority has no recycling operations that cater to construction waste (Nelson Mandela Bay Municipality 2016:33). The absence of municipal recycling facilities is further confirmed by research participant 2 when they said that they would make use of a municipal recycling facility if it were implemented, and this was seconded by research participant 3, who stated that they would utilise rubble removal companies to take their waste to municipal recycling facilities.

5. Conclusions

The paper found that contractors were indeed knowledgeable of the importance of construction waste management. It also found that contractors were indeed aware of alternative construction waste management solutions and established that contractors showed limited knowledge of the potential positive impact of construction waste management. Finally, it was established that interventions to curb landfilling construction waste were not present in the local municipality's waste management plan. It was confirmed that the lack of government legislation to discourage the landfilling of waste was confirmed as the main catalyst in the landfilling of waste. The primary data also stated that the lack of recycling facilities contributed to the abundance of waste landfills among contractors in Gqeberha.

6. Recommendations

Based on the primary data analysis and the contents of the review of related literature, the following recommendations can be made to decrease the amount of landfill waste produced by contractors in Gqeberha.

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Recommendations based on the first objective

Contractors should further research and study the potential economic benefits of CWM.

Recommendations based on the second objective

Contractors must further their knowledge of CWM practices, particularly regarding minimisation and recovery. Additionally, contractors need to research applications of recycled brick aggregate as a substitute for the natural aggregates in concrete.

Recommendations based on the third objective

The local municipality should investigate the economic and environmental benefits of CWM.

Recommendations based on the fourth objective

The local municipality should research methods to discourage the landfilling of waste within the construction industry and other industries.

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